Bernardino Baldi's *In mechanica Aristotelis problemata exercitationes*

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Elio Nenci

Communicated by
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Communicated by Jürgen Renn and Antonio Becchi
Translated from Italian into English by Adriano Carugo
Copyedited by Lindy Divarci

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Part 1: On this Book

Chapter 1
The Author

Bernardino Baldi was born in Urbino on June 6, 1553. After studying ancient languages, he joined the group of scholars around the famous mathematician Federico Commandino.[1] For many years Commandino had been preparing editions of the most important works of ancient mathematicians, translating them into Latin and providing them with textual commentaries. Baldi himself took part in this enterprise. In his *Life of Commandino* he recalls: "when I was young and dedicated to these studies, I drew many of these geometrical figures with great labor."[2] And again, in the preface to his Italian translation of Hero's[3] *Automati* (*Automata*) he wrote:

> Hero wrote *Spiritali* (*Pneumatics*) as well as these *Automati*, and recently Federico Commandino translated *Spiritali* into Latin and illustrated it with figures.[4] What Hero then wrote concerning *Semoventi* (*Automata*), fallen into oblivion since antiquity, was rescued and brought to light by me, at the suggestion of Commandino.[5]

Baldi studied under Commandino from 1570 to 1575, though between 1573 and 1575 he also attended the University of Padua to study medicine. But in Padua, as he himself states in one of his unpublished works, instead of dedicating himself to medical studies he followed the lectures on philosophy[6] and those on classical literature given by Emanuel Margunios[7] with whom he became friends. He also attended lectures on mathematics given by Pietro Catena,[8] though without much benefit, as he himself states in his *Cronica de' matematici*:

[1] Federico Commandino, 1509–1575.
[2] Baldi (1998, 518).
[3] Hero of Alexandria, first century CE.
[4] Commandino (1575).
[5] Baldi (1589, 9r).
[6] *Genio, overo la misteriosa peregrinatione*, Serrai (2002, 174–175).
[7] Emanuel Margunios, 1549–1602.
[8] Pietro Catena, 1501–1576.

> Pietro Catena (1573), Padua. He was giving lectures on mathematics during the time I was at the University of Padua, and I attended his lectures on Aristotle's *Mechanics*. He was old and facetious so that his classroom was filled with people who wanted to laugh rather than learn. He was not a man of great learning, and published just a small and simple work on the *Sphere*.[9]

Baldi's most important work from that time was the Italian translation of Hero's *Automati*, which he had already finished, as can be seen from the dedication to the Venetian Giacomo Contarini:[10]

> When Federico Commandino was still alive, I translated from the Greek text these two books of Hero's *Semoventi*, thinking of publishing it at the time Commandino himself published *Spiritali* by the same ancient author. But other unexpected business as well as Commandino's sudden death forced me to postpone the publication of the work.[11]

Soon after Commandino's death, Baldi began to collect material for the composition of his work *Vite de' matematici* (*Lives of Mathematicians*), while continuing his study of mathematics under the guidance of Guidobaldo del Monte.[12] In 1580 he found a permanent position at the court of Guastalla, where he was employed as a court mathematician by Ferrante Gonzaga.[13] The first biographer of Baldi, Fabrizio Scarloncino,[14] states that in 1582 Baldi wrote a commentary on the *Mechanical Problems* ascribed to Aristotle. This might have been the first draft of what was later published in the *Exercitationes*, which are presented here.[15]

During the next period of his life, Baldi produced many literary works as well as a series of studies on Vitruvius.[16] About these works he wrote in his *Life of Vitruvius*:

> As to *Scamilli impares*,[17] I wrote a little treatise where I rejected the opinions of all those who wrote about it before me;

[9] Baldi (1707, 135–136).
[10] Giacomo Contarini, 1536–1595.
[11] Baldi (1589, segn.A2r).
[12] Guidobaldo del Monte, 1545–1607.
[13] Ferrante II Gonzaga di Guastalla, 1563–1630.
[14] Nothing is known about Fabrizio Scarloncino.
[15] Baldi (1621, segn.):():(3v).
[16] Marcus Vitruvius Pollio, first century BCE.
[17] Baldi (1612b).

> but I do not say anything more, leaving judgement to those who will read it. I also started another work on that author, at the suggestion of Vespasiano Gonzaga Duke of Sabbioneta[18] since he was pleased to agree with me on the interpretation of this author's work. It was a *Dittionario Vitruviano*[19] where all the obscure terms contained in his *Architectura* were explained. This I did with no great difficulty because since childhood I have had a natural inclination for languages and other things. I carried on this work up to the sixth book, but I could not finish it because of my new employment; so I put it aside.

With the support of Ferrante Gonzaga, in 1586 Baldi was made Abbot of Guastalla. This provoked a basic shift in focus from scientific topics to the study of oriental languages and theological matters. In the following year he began the composition of his *Vite de' matematici*, starting with the biography of Commandino. Occasionally, though, he resumed his study of mathematics, for example, in the course of the further publication of part of his own works, or when Guidobaldo del Monte's son asked him to attend to the publication of his late father's unpublished writings. On November 3, 1608, Orazio del Monte[20] wrote to Baldi:

> Signor Pier Matteo Giordani[21] is going to send me some short treatises written by my father so that you can have a look at them, since I am planning to publish these as well, as soon as the printing of *Astronomici Problemi*[22] is finished. Following your thoughtful advice, I agree that it is better to first issue these *Problemi*, and then *Cochlea*[23] and other short treatises left unpublished by my father.[24]

But Baldi's main interest had already turned to other literary fields, as is evident from the works he wrote between 1592 and 1600. In 1596 Baldi went to Rome where he was a guest of Cardinal Cinzio Aldobrandini until the beginning of 1598.[25] At the cardinal's court he took up the study of Arabic with Giovan Battista Raimondi,[26] an accomplished mathematician

[18] Vespasiano Gonzaga di Sabbioneta, 1531–1591.
[19] Baldi (1612a).
[20] Orazio del Monte, ca. 1570–1614.
[21] Pier Matteo Giordani, ca. 1556–1636.
[22] Guidobaldo del Monte (1609).
[23] Guidobaldo del Monte (1615).
[24] See Affò (1783, 222).
[25] Cinzio Aldobrandini Passeri, 1551–1610.
[26] Giovan Battista Raimondi, 1536–1614.

and scholar of this language. In this period Baldi became interested in works of Arabic authors, a new activity which resulted in the translation of a large geographical work.

At the beginning of 1600 Baldi tried to publish some of his literary works, but only some of these were published, in Pavia and in Parma. In the meantime he became acquainted with Francesco Maria II Duke of Urbino,[27] who commissioned him to write a biography of Federico of Montefeltro.[28] The favor he had found with the Duke, and the problems caused by his position as abbot, provoked him in 1609 to leave Guastalla and take up employment at the Duke's court. In his new position he was charged with important tasks: in 1612, as ambassador of the Duke, he traveled to Venice to attend the ceremony of the proclamation of the new Doge. In those years some of his works were published in Germany, including his two books on Vitruvius – thanks to the intervention of Marcus Welser[29] – and his translation of Hero's *Belopoeica*, the last of his works to be published while he was still alive.[30] During the last years of his life Baldi wrote a biography of Guidobaldo I Duke of Urbino,[31] who succeeded Federico of Montefeltro, and dedicated all his efforts to the composition of a massive geographical encyclopedia, which remained incomplete at the time his death on October 10, 1617.

[27]Francesco Maria II della Rovere, 1549–1631.
[28]Federico da Montefeltro, 1422–1482.
[29]Marcus Welser, 1558–1614.
[30]Baldi (1616).
[31]Guidobaldo I da Montefeltro, 1472–1508.

Chapter 2
The Context

During the Renaissance many works from Greek and Roman antiquity were recovered, studied, and expanded with commentaries. At first, this process of acquisition and assimilation of the classical cultural heritage concerned mainly the fields of literature, history and philosophy. Later, in the sixteenth century, this process began to include works on scientific and technical subjects as well. The study of ancient Greek texts in the original language and their new translations directly into Latin – replacing the much criticized extant Arabic translations – as well as the comparative study of different sources became one of the main activities of mathematicians and astronomers.

In this general movement a number of ancient texts on mechanics were also discovered and studied: the *Mechanical Problems* ascribed to Aristotle; a work by Archimedes entitled *On the Equilibrium of Planes*, which according to Baldi's testimony was regarded by Guidobaldo as "the book of Elements of the whole field of mechanics"[1] and which he published in 1588 under the title *In duos Archimedis aequeponderantium libros Paraphrasis*; *Pneumatics* by Hero of Alexandria; and Book Eight of Pappus' *Mathematical Collections*.[2] Among these works, it was the text ascribed to Aristotle which received the greatest attention of the scholars: the studies and commentaries of this work made during the Renaissance were essential for the development of mechanics before Galileo and Descartes.[3]

In *Mechanical Problems*, which was generally considered to be a work by Aristotle himself, though it is now thought to have been produced within the Peripatetic School,[4] the author tried for the first time to base the explanation of the working of 'simple machines' (such as the lever, the windlass, the wedge and the pulley) on a single mathematical principle,

[1] Baldi (1887, 54–55), Guidobaldo del Monte (1588, 4).
[2] Pappus of Alexandria (1588).
[3] See Drake and Rose (1971); Micheli (1995).
[4] The text cannot be ascribed to Aristotle with any certainty, but for the purpose of clarity, we will nevertheless quote him as its author since almost all Renaissance authors agree on this attribution.

and to solve a series of questions which are answered by referring to the same mathematical model. The starting point of the whole treatise was the astonishment caused by operations carried out by means of a lever, such as the lifting of great weights which man was unable to move without that instrument. But even greater astonishment was caused by the fact that, by adding weight to weight, that is, by adding the weight of the lever to the weight to be lifted, the whole thing could be moved more easily. This fact seemed to challenge the obvious relation between the force needed to move a certain body and its weight. In fact, experience clearly shows that things 'weighing less' are easier to move than things 'weighing more.'

The author of *Mechanical Problems* moved on to formulate the principle that could explain this remarkable fact: this principle is directly related to the movement of the lever, so that the working of the simple machines can be reduced to the properties of a circle. He also considers it remarkable that the circle is made up of opposites, a fact that becomes obvious when the circle is generated by a rotating line fixed at one end:

1. The circle is made by what is stationary, i.e., one end of the radius, and by what is moving, i.e., the other parts of the radius that move round and produce the surface of the circle.
2. The circle is concave inside the circumference, as well as convex outside the circumference.
3. The rotating circle moves simultaneously in opposite directions, for it moves simultaneously forwards and backwards.
4. The circle is made by the movement of a line drawn as a radius from the center, but no two points on that line move at the same pace: the point which is further from the fixed center moves more rapidly.

This idea of the circle differs remarkably from that which is contained in Definition 15 and 16 of Book One of Euclid's *Elements*. Here the figure is already given, without any reference to its generation. In *Mechanical Problems*, on the other hand, the whole argument seems to be based on properties derived directly from the way in which the figure is produced: it is traced not by means of a pair of compasses, but rather by means of a line rotating around a fixed point at one end.

From the property of the circle, according to which points marked on the rotating radius move at different speeds, the author of *Mechanical Problems* explains why bodies placed on the radius at different distances from the center each move at different speeds, increasing with their distance from the center. He regards the motion of the points on the radius as composed of a natural downward motion along the vertical tangent, and a lateral motion against nature toward the fixed center of the rotation, and shows that this lateral component of the motion increases the closer it is to the center. This moving closer to the center was perceived as obstructing the natural motion, which in consequence is slowed down.

Having thus explained why the point more distant from the center moves more quickly than the point closer to it, though impelled by the same force, the author of *Mechanical Problems* moves on to explain why larger balances are more accurate than smaller ones: the extremity of the balance scale must move at a greater speed, under the influence of the same weight, the greater its distance is from the pivot upon which it turns. Consequently in a larger balance the same weight makes a more visible movement.

Many sixteenth-century authors studied the *Mechanical Problems*. Some, such as Niccolò Leonico Tomeo[5] and Alessandro Piccolomini,[6] translated this work from the original Greek into Latin and added brief linguistic comments. Others, such as Girolamo Cardano[7] and Niccolò Tartaglia,[8] discussed only a few questions in detail: they examined the theory of the balance presented by the author of the ancient text in light of the new concepts and methods of demonstration introduced by the medieval science of weights (*scientia de ponderibus*). Tomeo was one of the leading scholars to study Aristotle's works during the first decades of the sixteenth century. After translating *De parva naturalia*, *De motu animalium* and *De incessu animalium*, around 1525 he turned to the task of translating the *Mechanical Problems*. His translation was so good that it replaced a previous translation made in 1517 by the Venetian humanist Vittore Fausto and became the text used by most of the commentators of *Mechanical Problems* from the mid-sixteenth to the mid-seventeenth century. The first and second editions of this translation, published in Venice in 1525 and in Paris in 1530, were provided with a commentary which was not reprinted in later editions.[9]

The text of *Mechanical Problems* is often so obscure and compact that from early on it required explanatory notes and commentaries. Alessandro Piccolomini chose to make it more accessible by publishing a paraphrase of the work in 1547 in Rome: *In mechanicas quaestiones Aristotelis, paraphrasis paulo quidem plenior* shows both his erudition in the use of avail-

[5] Niccolò Leonico Tomeo, 1456–1531.
[6] Alessandro Piccolomini, 1508–1578.
[7] Girolamo Cardano, 1501–1576.
[8] Niccolò Tartaglia, ca. 1500–1557.
[9] Leonico Tomeo (1525, 1530).

able manuscripts as well as his practical knowledge of the contemporary mechanical technology.[10]

Tomeo's translation and Piccolomini's paraphrase were the main channels through which the knowledge of the *Mechanical Problems* spread during the sixteenth century. Baldi himself made use of both of these works in his commentary. Other authors discussed only some of the questions of the Aristotelian text and made important criticisms of the principles and arguments presented in it.

Niccolò Tartaglia, in Book Seven of his *Quesiti et inventioni diverse*, published in 1546, analyzes the general principles stated in *Mechanical Problems* and argues that they were not adequate for the correct solution to the problem of the equilibrium of the balance in the first two questions of that work.[11] Tartaglia's criticism preluded a new approach to the problem of the balance, which was developed in Book Eight of *Quesiti et inventioni diverse* on the basis of the concept of *gravitas secundum situm* formulated in several writings ascribed to the medieval author Jordanus Nemorarius, dating back to the thirteenth century.[12]

A similar discussion of the Aristotelian text can be found in *De subtilitate* by Girolamo Cardano,[13] who also favorably considered the medieval science of weights. For Cardano, the study of the balance was part of a general discussion on motion in connection with technical contrivances: the analysis of the working of a machine was for him an important means for understanding natural principles. It was within the context of a general theory of motion and rest that Cardano studied heavy bodies in motion and at rest in the balance and in other machines. Though he considered many arguments in *Mechanical Problems* as inadequate and superseded by the medieval science of weights and by Archimedes' work, the Aristotelian text exerted a remarkable influence on Cardano, and supplied a considerable amount of topics for discussion in his *Opus novum de proportionibus*.[14]

Compared to these approaches, Baldi's *Exercitationes* represent a different way of discussing the contents of *Mechanical Problems*: the *Exercitationes* contain a systematic analysis of this work in light of Archimedean mechanical principles such as the concept of center of gravity. In his discussion of the Aristotelian text, Baldi makes frequent use of Guidobaldo's *Mechanicorum liber*,[15] which offers a new systematic theory of the simple

[10] Piccolomini (1547).
[11] Tartaglia (1546).
[12] Jordanus Nemorarius (1565).
[13] Cardano (2004).
[14] Cardano (1570).
[15] Guidobaldo del Monte (1577, 1581).

machines. In many important digressions from the text, Baldi extends his study to include new mechanical problems similar to those presented in the ancient work.

This new approach was made possible by the recovery and study of Greek geometry and mechanics by Federico Commandino and Guidobaldo del Monte. In the mid-sixteenth century Commandino started a systematic program of Latin translation of works by great Greek mathematicians such as Euclid, Archimedes, Apollonius and Pappus. These translations were supplemented with important notes, but did not add anything new to the original texts. In some cases, however, the lack of a textual tradition resulted in the production of a new work. The most important example is *Liber de centro gravitatis solidorum*, conceived as a reconstruction of a lost ancient text containing a theory of the center of gravity presupposed by some theorems in other works of Archimedes.[16]

After this reconstruction Commandino did not continue with mechanical topics, apart from his translation of Pappus' *Mathematical Collections*, which in Book Eight contains a summary of Hero's *Mechanics*. But he did not work on the main ancient text concerning the theory of the center of gravity, i.e., Archimedes' *On the Equilibrium of Planes*, which was not included in his 1558 edition of Archimedes' works.[17] The task of studying and commenting this text was left to the most famous of Commandino's pupils, Guidobaldo del Monte, who first used the law of the equilibrium of the balance given in this text as the foundation of a rigorous theory of the simple machines in *Mechanicorum liber*, and then expounded and explained Archimedes' work in the form of a paraphrase.[18]

These works established the Archimedean method of dealing with static problems as superior to those used in *Mechanical Problems* and in the *scientia de ponderibus*. Though the tradition of the medieval science of weights followed by Tartaglia and Cardano was sharply criticized by Guidobaldo in the treatise on the balance inserted in *Mechanicorum liber*, the Aristotelian work was still considered to be relevant to the study of mechanical problems, and the principle of equilibrium formulated in this work was regarded as true and fundamental, and simply in need of a better explanation.

This explanation was given by Guidobaldo within the context of the general development of mechanics described in the preface to Book One

[16] Commandino (1565).
[17] Archimedes (1558).
[18] Guidobaldo del Monte (1588).

of *Paraphrasis*,[19] where Archimedes' work is considered as laying the true foundation of mechanical science, but at the same time as being closely connected to the Aristotelian work. The general theoretical principle presented in *Mechanical Problems* needed to be specified by determining the exact proportion between weights and distances in the lever. This idea was clearly expressed by Baldi in his biography of Archimedes, included in *Vite de' matematici*:

> Since Archimedes (as is probable and as Guidobaldo himself guessed in the preface to Book One of *On the Equilibrium of Planes*) regarded this Aristotelian work as based on solid principles, but not very clearly explained, he wanted to make it more explicit and more easily understandable by adding mathematical demonstrations to physical principles. Aristotle solved the problem concerning the reason why the longer the lever, the easier it is to move the weight, by saying that this happens because of the greater length on the side of the moving power; this was true according to his principle, in which he supposed that things which are at a greater distance from the center move more easily and with greater force; the cause of which he saw in the greater speed with which the larger circle moves compared to the smaller circle. This cause is indeed true, but lacks precision; for given a weight, a lever and a power, I do not know how I should divide the lever at the point where it turns so that the given power balances the given weight. Archimedes accepted Aristotle's principle but went further; he was not satisfied with saying that the force would be greater on the longer side of the lever, but he determined how much longer it should be, that is, what proportion it should have with the shorter side, so that the given power would balance the given weight. [...] He established this with a brilliant demonstration in Book One of *On the Equilibrium of Planes*, which, as Guidobaldo pointed out, was the book of *Elements* of the whole field of mechanics. In the preface of his paraphrase of Archimedes' work, Guidobaldo showed that Archimedes had followed Aristotle entirely, as far as the principles were concerned, but to them had added his own exquisite demonstrations.[20]

[19] Guidobaldo del Monte (1588, 4).
[20] Baldi (1887, 54–55).

This is the program of Baldi's *Exercitationes*: to supply the Aristotelian *Mechanical Problems* with Archimedes' principles and demonstrations.

Chapter 3
The Book

Bernardino Baldi most probably began his study of ancient texts on mechanics when he was young. With Guidobaldo del Monte he continued the mathematical studies he had started under the guidance of Commandino and soon turned to study Archimedes' and Pappus' works. He produced a new Latin translation of Pappus' Book Eight of *Mathematical Collections*, and then moved on to work on the *Mechanical Problems*.[1] Biographers of Baldi, such as Affò and Crescimbeni, mention the titles of at least three works on the Aristotelian text: *Discorsi sopra le Meccaniche d'Aristotile*, *Dissertationes in mechanica problemata Aristotelis*,[2] and *Exercitationes*, but unfortunately none of the manuscripts containing these works have survived and the only available text is that of the 1621 edition of *Exercitationes*.[3]

It is likely that this work had already been written around 1582, but it was taken up again in 1614[4] and eventually entrusted in 1615 to Adriaan van Roomen so that he could have it printed in Germany.[5] Van Roomen's death on May 4 of the same year delayed the publication of Baldi's work, which was published only in 1621, four years after the death of its author who had been unable to recover it. The text was full of misprints and

[1] This part of the introduction benefits from the Italian translation and commentaries of Baldi's *Exercitationes* undertaken in Milan from 2006–2008 by a research team comprising Sergio Aprosio, Antonio Becchi, Adriano Carugo, Ferruccio Franco Repellini, Enrico Gamba, Romano Gatto, Gianni Micheli and Elio Nenci. See Baldi (2010).

[2] Crescimbeni (2001, 120–122, 142), Affò (1783, 198).

[3] The manuscripts of *Dissertationes* and *Exercitationes* were previously kept at the library of the Accademia Toscana di Scienze e Lettere *La Colombaria*, but were destroyed during World War II. Some interesting notes on mechanics related to the topics discussed in *Exercitationes* are extant (ms XIII.F.25, 129r–136r) in the National Library in Naples. They are now being studied by Antonio Becchi.

[4] In a letter addressed to Pier Matteo Giordani on November 17, 1614, Baldi wrote: "I shall bring with me the original text of my work on mechanics so that we can look at it together" (Oliveriana Library in Pesaro, Cod, 430, 59).

[5] On September 3, 1615 Baldi wrote to Johann Faber asking for his help in recovering the work that had been sent to Germany. See Serrai (2002, 111–112, 142).

incorrect figures, so as to require the addition of eight pages of *errata corrige*, which are extant in only a few of the surviving copies.[6]

To give a clear idea of the contents of this important work of Renaissance mechanics, the various questions contained in it have been arranged in groups according to similar topics. Some of these groupings appeared as such in the original text; others have been formed in order to give a clearer structure to the whole treatise. Since Baldi's work has the form of a commentary, it has been necessary to quote the questions as originally stated in the ancient text.

The general principle: the figure of the circle.
The balance (*Questions 1–2, 9–10, 20*).
The lever (*Questions 3, 21–22, 28*).
The problems concerning sailing (*Questions 4–7*).
The easy movement of bodies with round shapes (*Question 8*).
The simple machines: the axle in a wheel, the pulley and the wedge (*Questions 11, 13, 17–18*).
The sling (*Question 12*).
The breaking and deformation of materials: pieces of wood and pebbles (*Questions 14–16*).
The force of percussion (*Question 19*).
The composition of motions (*Questions 23–24*).
The construction of beds (*Question 25*).
The placement of weights carried on the shoulders (*Questions 26–27, 29*).
The rising from a sitting position (*Question 30*).
Problems concerning motion (*Questions 31–34*).
The motion of bodies in eddying water (*Question 35*).

3.1 *The General Principle: The Figure of the Circle*

Baldi criticizes some of the main principles of Aristotelian mechanics, that is, those concerning the 'marvellous' peculiarities of the circle, and shows that they are not based on the combination of opposites with each other. Following Archimedes he considers the entire mechanical science as based on the theory of the center of gravity, of which he gives a definition different from those given by Pappus and Commandino.[7] In his definition he specifies that the center of gravity of a body "is a point placed inside or outside its magnitude."[8] He shows that in the case of arches, which

[6] Becchi (2009).
[7] Pappus of Alexandria (1588, 306v), Commandino (1565, 1r/v).
[8] See the figure in Baldi (1621, 3).

are discussed in Question 16, the center of gravity is indeed placed in the outside space enclosed by the object and not inside the shape of the object. Within the discussion of the principles of the circle, Baldi was the first to determine the exact ratio in the composition of motions resulting in a circular motion. When Baldi discusses the reason why, according to Aristotle, the weight of the lever added to the weight to be moved makes the action of the moving power easier, he points out that this is true only in the case of the type of lever considered in the text, that is, a lever in which the fulcrum is placed between the weight and the moving power.

3.2 *The Balance*: Questions 1–2, 9–10 and 20

The first question, which asks why larger balances are more accurate than smaller ones, was presented by the author of *Mechanical Problems* in order to give an example of the fourth peculiarity of the circle, that is, that the points on the diameter describing the circle move more quickly the more distant they are from the center. This peculiarity of the circle is only stated, but not demonstrated in the Aristotelian text. Baldi gives a rigorous geometrical demonstration of this using the example of the astrolabe, which is more precise the greater its radius.[9]

In the second question it is asked why, if the support of a balance is fixed from above, does the balance revert back to its original position of equilibrium after the beam has inclined and the weight is removed; on the other hand, if the support is placed below the beam after it has been inclined, why does it not return to its original position. Baldi points out that the possible cases are not two, but three, according to the support being placed above the beam, below it or at its center of gravity.[10] He then explains, on the basis of the theory of the center of gravity, the different ways in which the three types of balance behave and adds some interesting theorems concerning their different sensitivities. He discusses the situation of equilibrium of different bodies, such as the *sarissa* or long lance and the spinning top, as well as the wonderful case of the equilibrium of a little cardboard figure representing a tightrope-walker holding as a balancing pole a wire with two little lead spheres fixed at either end. Finally he gives an explanation for the great power of the battering ram.

[9] The assumption that larger balances are more accurate than smaller ones had already been criticized by Tartaglia in Book Seven of his *Quesiti et inventioni diverse*, 1546.

[10] This fact had already been remarked by Tartaglia, who in Book Eight of his *Quesiti et inventioni diverse* explains the equilibrium of a balance with its support at the center of gravity on the basis of the principles of the medieval science of weights.

The ninth question can be connected with a question discussed at the beginning of this work. It asks: "why can weights be raised more easily by means of larger pulleys than by smaller ones?" The explanation given is that pulleys with greater diameters work like balances with longer arms: in both cases things are moved and raised more easily and more quickly by means of greater diameters, which at the same time describe greater circles. Baldi agrees with the idea to relate the pulleys to the balance, but disagrees with the other aspects of the explanation. Referring to a proposition in Guidobaldo's *Mechanicorum liber*,[11] he points out that ease of motion is contrary to the speed (with which it is done), that is, in modern terms, in machines the product of the force and the distance is constant. However, Baldi agrees with Aristotle that in practice pulleys with larger diameters work better. This is due to the ratio between the diameter of the pulley and the diameter of the axis: the greater this ratio, the easier the motion. The friction between the axis and the wheel of the pulley is also to be considered: such friction is more easily overcome by pulleys with larger wheels.

In the second part of his commentary to this question, Baldi discusses a topic so far ignored, that is, the case of wheels turned by a crank operated by hand or by foot. As with the lever, here as well the greater the ratio between the crank arm and the radius of the wheel axe, the easier the movement. There are two types of crank: those moved by hand with a straight arm, and those moved by foot with a bent arm. Referring to the example of the knife-grinder and his grindstone, Baldi asks why the grindstone moved by foot is fitted with a bent arm: he points out that, in modern terms, the bending of the arm helps to overcome the upper dead point. Finally, he examines two wheels of equal dimensions but of different weights turning on equal axes: he asks why the lighter wheel is moved more easily, but stops earlier. The reason given is that the heavier wheel at the beginning has greater resistance to the impressed force, but afterwards retains it for a longer time.

Question 10 asks: "why is a balance moved more easily when it is without a weight than when it has one?" Here the author of *Mechanical Problems* introduces an idea that later in the seventeenth century would be treated with the help of the concept of *inertia*. He asks why a balance with a lighter arm is more easily moved than one with a heavier arm. The reason given is that a heavier weight is more difficult to move, not only in the opposite direction, but also when it is at an angle. The Aristotelian explanation is considered insufficient by Baldi, who points

[11] Guidobaldo del Monte (1577, 105v).

out that the argument is in contrast to the experience of adding a given weight to two balances which are in equilibrium with different weights. In the Aristotelian work, the question was raised not only in connection with balances, but also in relation to wheels and other similar bodies. The Latin text presented by Baldi ought to be corrected by checking Tomeo's translation.[12]

Textual problems also occur in Question 20 concerning the steelyard, where a whole line of the original text is missing.[13] The steelyard is a balance with unequal arms: the body to be weighed is suspended from the shorter arm and a counterpoise can be moved along the longer arm until equilibrium is reached. The author asks why a steelyard can weigh heavy pieces of meat with a small weight. The answer given by the author is that the steelyard can be considered as both balance and lever at the same time, and be reduced to the figure of the circle. Baldi has no objections to the reduction of the steelyard to the lever and simply points out that in theory this instrument can be used in two different ways: either by keeping the fulcrum fixed and making the counterpoise slide to a different position, or by keeping the counterpoise fixed and changing the position of the fulcrum. But he warns that in practice the steelyard is used in the first way.

3.3 *The Lever*: Questions 3, 21–22, 28

Recalling what has been said at the beginning of the work, Question 3 asks why small forces can move heavy weights by means of a lever. The Aristotelian solution consists in making the lever equivalent to the beam of a balance with its support placed below and stating that the greater the distance of the power from the fulcrum, the more easily the weight can be moved because, under the impulse of the same weight, the greater the radius is from the center, the more rapidly it moves. Baldi, however, rejects the idea that speed can be considered as the cause for the working of the lever because it was inconceivable for him to explain the equilibrium of the balance by referring to motion. The Aristotelian distinction between 'actually' (*actu*) and 'potentially' (*potentie*) did not allow something at rest to be considered as 'potentially' in motion. The true explanation, according to Baldi, had been given by Archimedes in Proposition 6 of Book One of his work *On the Equilibrium of Planes*, though it would be necessary to indicate the cause of the inverse proportion stated in that

[12] Leonico Tomeo (1530, 37).
[13] Leonico Tomeo (1530, 41).

proposition. For Baldi, the ultimate justification for the Archimedean law of the lever is the 'equality of status' resulting from placing equal powers at the ends of a straight line in a given position.

As to the working of the dental forceps and nutcrackers analyzed in Questions 21 and 22, both instruments were regarded by the ancient author as formed by two levers working in opposite directions, having the point of junction as the fulcrum. Baldi follows here the explanation of Piccolomini.[14]

In Question 28 the author analyzes the working of the swing-beam (*shaduf*) used to draw water from a well, but without relating the structure of this machine to the lever.[15] He points out that the operation normally occurs in two stages and that the empty bucket can easily be let down whereas it is difficult to draw it up when it is full. The disadvantage of letting it down more slowly with the help of this machine is balanced by the advantage of reducing its weight when drawing it up: this result is produced by a stone attached to the end of the swing-beam. Piccolomini and other authors after him felt the need to give a true mechanical explanation of the working of this machine, showing that it is based on the principle of the lever.[16] To this explanation, Baldi added the remark that one also has to take into account the weight of the body of the man who lets down the empty bucket by lifting the loaded end of the beam.

3.4 *Problems Concerning Sailing*: Questions 4–7

In Question 4, the author asks why the rowers placed mid-ship are those who mostly move it. This is explained by considering the oar as acting like a lever where the thole pin is the fulcrum, because it is fixed, the sea is the weight, and the sailor is the force that moves the lever. The explanation is again based on the principle of the lever: in proportion to the increasing distance of the moving force from the fulcrum, the weight will move more. Baldi points out, however, that the fulcrum is not actually the thole pin, but the sea, whereas the ship is the weight placed at the thole pin, that is, between the power and the fulcrum. This is the kind of lever discussed by Guidobaldo in Proposition 2 of his treatise *De vecte* contained in *Mechanicorum liber*:[17] here the weight is placed between the

[14]Piccolomini (1547, 45r/v).
[15]This machine is made of a long beam pivoting on top of another beam vertically driven into the ground: the bucket hangs from one end of the pivoting beam, whereas a load or stone is attached to the other.
[16]Piccolomini (1547, 61r/v).
[17]Guidobaldo del Monte (1577, 39r–40v).

fulcrum and the power, and the ratio of the power to the weight is the same as that of the distance of the weight from the fulcrum to the distance of the power from the fulcrum. However, Baldi points out that Aristotle's argument would be conclusive if the ship were kept still by some hindrance: in this case the oar would move in the way described in the text, that is, the fulcrum would be placed at the thole pin and the weight would be the sea. Baldi argues moreover that it would be more correct to say that the rowers move the ship 'more easily' rather than 'mostly.'[18]

The following Question 5 asks why the rudder, which is small and at the end of the vessel, has such great power that the large mass of the ship can be moved by a small tiller and by the strength of one single man exerting just a small effort. The answer given is that the rudder is a lever, the sea the weight and the helmsman the moving power. The rudder works differently from the oar because it does not strike the sea at right angles to its length, and it does not drive the ship forward, but turns it while it moves, receiving the sea at an angle. It is placed at the end and not in the middle of the ship because a moved body can move most easily when the moving power acts from the end. Baldi criticizes the relation between the movement of the oar and that of the rudder as established by the author of *Mechanical Problems*, who applies to the rudder the same argument used for the oar, putting the rowlock at the middle of the oar and considering the rowlock as moving along the oar. Baldi prefers to consider the sea as the fulcrum, and the rowlock or the hinge on which the rudder pivots as the weight. This explains why, when the ship is motionless, the rudder has no effect on the ship's movements to the left or to the right, whereas its effect is great when the ship is moving, because the movement of the ship at an angle is caused by the very movement of the sea which presses against the blade. The rudder works effectively only if it is positioned at an angle and the ship is moving.

To make his point clear Baldi resorts to his personal observation of the way in which boatmen transport goods and people from one bank of a large river to the other. He describes the case of two pontoons joined by means of a plank, with the rudder placed between the two sterns, and the pontoons tied to a rope fixed to one of the banks. If the rudder is turned at an angle, its blade is pushed by the flowing water and drags the boat to the other bank. It is clear that the cause of this movement is not just the percussion of the water against the blade of the rudder, as Aristotle thought, but the pressure exerted by the flowing water upon the blade. The same explanation can be given for the sails of windmills which, by

[18] Baldi (1621, 41).

receiving wind at an angle, move the grindstones, and for the tails of birds and fish, which also function like rudders.

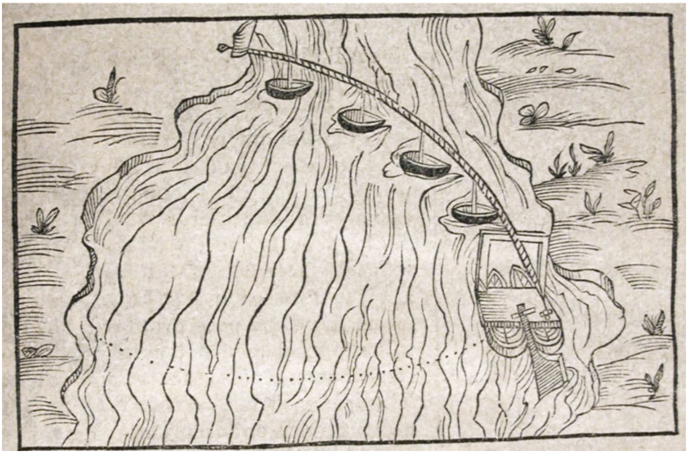

Figure 3.1: Pontoon, Baldi (1621), 48

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Question 6 asks why it is that the higher its yard-arm, the faster a ship moves, even though the sails and the wind are the same. The author of *Mechanical Problems* answers that this is because the mast acts as a lever and the fulcrum is where the mast is fixed, whereas the ship is the weight and the wind in the sails is the moving power. Baldi points out that, though it is true that the higher its yard-arm, the faster a ship moves, this causes at the same time a rising of the stern and a sinking of the prow. In fact, the kind of lever to be considered here is the bent lever, similar to that which operates in a pair of tongs for extracting nails, where the fulcrum is the joint. The mast of a ship, when bent by the wind, shifts and raises the weight of the ship. Since it is a bent lever, the power of the wind acting on the yard-arm is to the distance from the fulcrum as the distance from the fulcrum is to the weight of the ship. The center of gravity of the ship is placed toward the prow because of the arrangement of the cargo. As a consequence, the smaller the ratio between the two sides of the lever and the larger the weight, the less the power will prevail in raising the weight.

Question 7 asks why it is that when the sailors wish to sail before the wind, even if the wind is not blowing from the stern, they reef the sail in the direction of the helmsman and slacken the part of the sail toward the bows. The explanation given is that this happens because the rudder cannot act against the wind when it is strong, but it can when the wind is so light that they can catch it. Thus, the wind carries the ship forward, but the rudder forces it to blow from the stern, acting against the sea as a lever.

Baldi explains this short and obscure text by resorting to Piccolomini's commentary, where this case is reduced to that of a lever in which the wind is the weight, the rudder is the power, and the fulcrum is placed not at the middle of the ship, but toward the prow.[19] Baldi however points out that this explanation raises the objection that the fulcrum should be steady, whereas here it is moving.

3.5 *The Easy Movement of Bodies with Round Shapes*: Question 8

In connection with the principle stated at the beginning of the work, Question 8 asks why round figures are the easiest to move. This problem gives Baldi the opportunity to make the first large digression. Aristotle distinguishes between three different types of circular motion: the motion of a circle on a plane, the motion of a circle around a fixed horizontal pivot, and the motion of a circle around a fixed vertical pivot. Baldi examines the following cases: the motion of a circle and an ellipse on a horizontal plane, the motion of a circle on an inclined plane, the impact of a wheel against an obstacle, and the motion on the bend of two wheels having the same axle. Then he discusses the problem of the motion of a cylinder and of a cone on a horizontal plane. The digression ends with an analysis of Aristotle's third type of rotating motion, that is, the motion of a circle around a vertical pivot. Baldi includes the case in which the axis of rotation is at an angle with the vertical line.

These cases are discussed in detail as follows: a circle or a sphere is at rest on a horizontal plane for the same reason that explains the equilibrium of a balance with equal arms loaded with equal weights. In a circle or sphere, the equal weights are the two equal parts of the figure on the right and on the left of the point of the plane on which they are standing and which acts as a fulcrum. Baldi makes the important observation that the motion on the horizontal plane is easiest because the center of gravity is neither raised in relation to the plane, nor with respect to the center of the earth. In the case of figures which are not circular, such as the ellipse, the

[19] Piccolomini (1547, 29r).

center of gravity is raised and lowered during the motion on the horizontal plane. Furthermore, the effort made to push an ellipse forward is not constant, but changes constantly because the center of gravity goes up and down in varying ways. This happens also in the case of figures with sides such as polygons. In the case of the motion of a circle or sphere on an inclined plane, Baldi points out that the vertical line passing through the center of gravity of the figure does not go through the point of the plane on which the figure is placed, but further down, so that the figure is no longer supported by the plane, but rolls down the plane. In this case the two sides of the figure on the right and on the left of the point at which it touches the plane are not symmetrical. Baldi then shows that the equilibrium of a circle or sphere on an inclined plane is determined by the type of lever on which the weight of the figure, which is concentrated in the center of gravity, is placed between the fulcrum and the power that keeps the circle or sphere in equilibrium. He also shows that the smaller the angle of inclination of the plane, the less power is needed to keep the equilibrium. Baldi also mentions Pappus' Proposition 9 of Book Eight, which deals with the problem of determining the power needed to pull a weight up an inclined plane, but he does not discuss it since it was based on different hypotheses and arguments.[20]

Baldi questions why wheels with a larger diameter overcome an obstacle more easily than wheels with a shorter diameter. He presents two solutions to the problem, one based on the displacement of the center of gravity, the other on the law of the lever. The first solution shows that in overcoming the obstacle, the center of gravity of the two wheels are both raised to the same height, which is that of the obstacle; but the center of gravity of the larger wheel moves through a greater distance to reach the same height, so that the centers of gravity of the two wheels actually move on two different inclined planes, which have the same height but a different inclination. The second solution to the same problem shows that the two wheels can be considered as two levers of the second type, in which the weight is placed between the fulcrum and the power: the lever corresponding to the larger wheel needs less power than the lever corresponding to the smaller wheel.

Baldi then discusses the problem concerning the motion of two wheels with the same axle: when they turn, both wheels describe two concentric circular paths and the external wheel describes the circumference with a greater diameter, whereas the internal wheel could even remain at rest when it is at the center of the rotation. Baldi goes on to analyze the

[20] Pappus of Alexandria (1588, 313r).

motion of a cylinder which rolls on a horizontal plane: if the bases of the cylinder are perpendicular to the axis, the cylinder moves in a straight line and describes two parallel lines; if the bases of the cylinder are not perpendicular to the axis and therefore elliptical, the lines described by the cylinder are still parallel, but curved rather than straight. Considering then the motion of a cone placed on a horizontal plane, Baldi shows that when the vertex remains in the same place, the lines traced by the points touching the plane are concentric circles. When the base of the cone is not perpendicular to the axis, Baldi wrongly believes that the line traced by the motion of the cone is an ellipsis.

Lastly, Baldi considers the case of a rotating motion around a vertical axis, such as the motion of a potter's lathe or the motion of a top. In this kind of motion the center of gravity remains still so that a small force is needed to start the motion and to keep it going, whereas the motion continues for a long time after the force has ceased to act. Baldi also points out that in this kind of motion the axis of rotation keeps its position unless an external cause interferes. Even when the axis of rotation is at an angle with the vertical line, it retains this position because the center of gravity moves neither up nor down. When the center of gravity is not on the axis of symmetry of a circular figure, during rotation it would not be at rest but would also be rotating and would move up and down: since the movement of the center of gravity upward is a violent motion, it would quickly stop.

3.6 *The Simple Machines. The Axle in the Wheel, the Pulley and the Wedge*: Questions 11, 13, 17–18

Though in the text of *Mechanical Problems* there is no mention of the axle in the wheel, Baldi discusses the properties of this machine in Question 13. By the end of his commentary on Question 11, he already briefly mentions an important aspect of the working of this machine. There the question was why heavy bodies are more easily carried on rollers than on chariots, though the latter have larger wheels than the former. Baldi agrees with Aristotle that the cause was the lack of friction in the case of rollers, whereas in the case of chariots there is the axle against which the wheels rub. He then adds that enormous weights are most effectively moved by means of rollers if levers are fixed to them, though in this case the resulting motion will be very slow. The slowness is compensated, however, by the ease in moving heavy loads. He gives a geometrical demonstration of this, but without relating it to the theory of the axle in the wheel. But in Question 13, he refers directly to this theory. In this question it is asked:

> why are the longer bars (*collopes*) more easy to move round a spindle (*iugum*) than smaller ones; and likewise why are less bulky windlasses (*suculae*) more easily moved than thicker ones by the same force?[21]

Aristotle teaches that this is possible because both the spindle and the windlass are at the center, whereas the length of the bars sticking out from them represents the distance from the center, which is the radius. Now the radii of greater circles move more quickly and a greater distance is traversed by effect of the same force than the radii of smaller circles. In the case of less bulky windlasses, given an equal length of the bars, the part outside the wood is greater. After giving a geometrical demonstration of Aristotle's argument, Baldi explains the etymology of the Latin word *sucula*, meaning windlass, and adds that this was called axle in the wheel (*axis in peritrochio*) by the ancient writers on mechanics.[22] Among the modern authors, Baldi mentions Guidobaldo del Monte who discusses this mechanical power in his *Mechanicorum liber*, where the functioning of this machine is explained on the basis of the principle of the lever.[23]

Question 17 asks: "why are great weights split by a small wedge, and why is great pressure exerted by it?" Aristotle and more recently Guidobaldo tried to reduce the wedge to the lever.[24] Baldi declares that in order to find the true solution, he will not follow their opinion. But first he illustrates Aristotle's solution, showing that it is false and unworthy of such a great philosopher. He then mentions Guidobaldo's solution, which is certainly very clever but, in his opinion, presents a difficulty: he wrongly compares the wedge to an inclined plane. Baldi points out that when an inclined plane is reduced to the lever, the fulcrum is fixed, whereas in the case of the wedge reduced to the lever, the fulcrum continuously changes position.

Considering these difficult aspects of the problem, Baldi tries to explain the strength exerted by the wedge from a different point of view. He distinguishes two types of wedges: those that can be reduced to the nature of the line, and those that can be reduced to the nature of the surface. The former are shaped like lines ending in a point, such as needles, nails or daggers; the latter are made of two surfaces ending in a cutting line, such as knives, swords or axes. Baldi adds that wedges operate in two ways: either they are driven by a hammer, like axes, or they penetrate under the

[21] Baldi (1621, 89).
[22] Pappus of Alexandria (1588, 329v–330v).
[23] Guidobaldo del Monte (1577, 106r/v).
[24] Guidobaldo del Monte (1588, 112v–113v).

action of a push and under pressure, such as swords, daggers, chisels and awls, etc.

At the end of this chapter, Baldi analyzes the action of the lever in the act of splitting a thing with a wedge by considering the thing that is being split rather than the wedge itself. He shows that the fulcrum is continuously changing position so that the splitting becomes easier and easier. As a last case he analyzes the action of splitting a thing by means of a chisel used as a lever shaped like a wedge: the larger the ratio between the part of the chisel outside the split and the part inside it, the easier it is to split the thing.

The topics discussed in Question 18 are systems of pulleys and the ratio between power used and weight lifted. Baldi begins by quoting Aristotle's opinion according to which the greater the number of pulleys, the easier it is to lift weights. He corrects the way in which Aristotle had reduced the pulley to the lever and points out that the pulley is a lever with equal arms, which can be further reduced to a balance. On this basis, he rejects the Aristotelian statement that by augmenting the number of pulleys it would be easier to lift weights and shows that in a system of five pulleys the power applied is equal to the weight lifted. This is a system where the rope tied to the weight passes over fixed pulleys.[25] In this system the force of the weight is not reduced, but power and weight are equal. Then Baldi argues that in a fixed pulley, power and weight are equal, whereas in a mobile pulley the power needed is half the weight. He shows how this principle works in a system of four pulleys by reducing it to four levers with equal arms, and calculates that a weight of 1000 librae is reduced 16 times so that the power needed to hold it would be a weight of 62.5 librae.[26]

3.7 *The Sling*: Question 12

The general problem of the motion of projectiles is discussed in Questions 32–34, whereas in Question 12 it is asked: "why are missiles thrown by a sling at a greater distance than those thrown by a hand?" Aristotle solves the question by saying:

> perhaps this happens because the thrower hurls the missile which is already moved by the sling, since he throws it after swinging the sling round in a circle; but when projected from

[25] Baldi (1621, 123).
[26] Baldi (1621, 126).

> the hand it starts from rest. For everything is moved more easily when it is already set in motion than when it is at rest.

He adds moreover:

> can it perhaps also be because in the case of the sling the hand becomes the center, and the sling the radius of the circular motion? Thus, the greater the radius, the faster the movement. But the circular movement made by throwing by hand is smaller than that made by the sling.[27]

Baldi approves Aristotle's solution, but adds more precisely that when the missile is thrown by the sling, the center of the circular motion is not the hand, but rather that part of the arm that is joined to the shoulder. He is also surprised that Aristotle did not notice that the thrower, in the very act of hurling, slowly rotates the sling around his head. He also adds that the speed of the missile is not acquired by just the rotation of the sling, but by the *impetus* generated in the very act of throwing the missile.

3.8 *The Breaking and Deformation of Materials. Pieces of Wood and Pebbles*: Questions 14–16

In Question 14 it is asked why the same piece of wood held at equal distances from the knee is more easily broken if one holds it far away from the knee than if one holds it quite close to it. The problem of the resistance to the breaking of a piece of wood is first discussed according to the law of the straight lever: the breaking depends on the greater or shorter distance of the point of application of the power from the fulcrum. To this obvious explanation Baldi adds another one, based on the law of the bent lever: one arm of the lever corresponds to the length of the piece of wood, the other arm to its thickness. This explains the importance of the ratio between the length and the thickness of a piece of wood in order to assess its resistance to breaking.[28]

Question 15 is the only one which is similar to a problem discussed in another work ascribed to Aristotle. Earlier, in *Problemata* (XXII, 36), it was asked why stones on the seashore become rounded. There, the answer does not refer to the circular figure. The explanation given by the author is based on the concept that the further an object is from the center, the more rapidly it moves. As a consequence, the parts further from the

[27] Baldi (1621, 88).

[28] For a discussion of Questions 14 and 16, see Becchi (2004) and Valleriani (2009).

middle must be worn down and become rounded. Baldi points out that if it were a question of distance, the larger stones should be rounder than the smaller ones. But this is not the case. The problem is to be related to the natural brittleness of sharp edges and protuberances, which break easily so that the stones become smooth and rounded. As examples of the fragility of small projecting parts, he mentions the protruding parts of a statue (ears, nose, fingers, hands, feet), which can easily be broken, and the round shape of towers as well.[29]

Question 16 contains an important digression concerning the resistance of timbers and stone arches: Baldi's treatment of this subject is beyond comparison to previous studies of the matter. The Aristotelian text asks why pieces of timber are weaker and bend more easily the longer they are. After quoting the explanation of the author (based on a reasoning already described in the comment to Question 14), Baldi engages in a detailed analysis of the resistance of a rod (resistance of different materials such as glass, wood, steel) and of the different ways in which the breaking power operates (along the axis, as in the case of a column; or in a slanting or perpendicular direction). His analysis of the resistance to breaking is based on the law of the lever (which is already used in the comment to Question 14) and on the idea that in the case of the bending of a rod a rarefaction or condensation of matters occurs. Baldi is aware of the importance of this analysis for the art of building and devotes the rest of his commentary to a discussion of the way in which the principles of mechanics can be applied to the practical knowledge of architecture: he analyzes the resistance of floors, trusses, flat arches and vaults. By relating the resistance of a timber to static problems of more complex structures, Baldi aims to "make architects more prudent."[30]

3.9 *The Force of Percussion*: Question 19

In Question 19 the author asks:

> why, if one places a large axe on a block of wood and adds a large weight on top of it, does the axe not cut the wood to any extent; whereas if one strikes the wood after raising the axe, he splits it, even if the axe weighs much less than the weight that is placed on it and presses down on it?

He solves the question by saying:

[29] Vitruvius (1567, 32).
[30] See Becchi (2004).

> it is because everything is produced by motion, and a heavy object acquires more motion due to its weight when it is moving than when it is at rest. When the weight lies on the wood, it does not move by effect of the motion, which is inherent to it by nature; but when it is already in motion, it is moved by effect of both this inherent motion and the motion of the striker.[31]

According to Baldi, what Aristotle has said up to here is brilliant; but what the philosopher adds concerning the operation of the axe acting like a wedge is refuted by him in Question 17. For Baldi the discussion of the effect of a blow with an axe must refer to the nature of falling bodies and of projectiles. He considers the example of a balance which is in equilibrium because it has equal heavy bodies lying on its scales: if other equal heavy bodies are added on both sides, the balance remains in equilibrium; but if one of these additional heavy bodies is dropped on one scale, this will cause it to go down. In the heavy body that is dropped there are two weights: one is its natural weight; the other is the weight that it acquires owing to this motion. If the additional heavy body were not just dropped, but thrown down, to its natural weight and to the weight acquired owing to its natural motion a third weight would be added, that is, the weight produced by the violence with which it is thrown.

Baldi then analyzes the circular motion of the axe during the act of striking, and the different weights that are produced in the different subsequent stages of that motion. Afterwards he points out the difference between splitting a piece of wood by striking it with an axe and splitting it by means of a wedge struck by a hammer. Finally, he discusses a "most beautiful question" (*pulcherrima quaestio*), that is, whether a blow from a sword is more effective near the tip or in the middle or near the hilt.

3.10 *The Composition of Motions*: Questions 23–24

At the beginning of *Mechanical Problems* Aristotle discusses the question of how two motions can produce a circular motion, and points out that this mixed motion can only be the result of two motions not having a constant ratio. He had previously shown that the composition of two motions having a constant ratio results in a diagonal of the figure generated by them. These arguments must have stimulated the author to reflect on the apparent paradoxes of mixed motions, which were later discussed in Questions 23 and 24. Before discussing Question 23, Baldi points out that

[31] Baldi (1621, 128–129).

this offers a splendid consideration concerning mixed motions, which were well known to the ancient authors on mechanics, as were curves such as spirals, helixes, cissoids, conchoids, etc., which they used to find the two mean proportionals (the duplication of the cube) and the squaring of the circle. The long text of the question reads:

> why is it that in a rhombus, if the two extreme points move in two movements, they do not each pass through an equal straight line, but one passes through a much longer line than the other? In other words, why does the point that moves along the side pass through a distance less than the side? For one point goes through the diagonal, the other through the side which is longer, though the latter moves with one motion, and the other with two.[32]

How can the paradox be solved in which two points, which move with simple motions at equal speed, move through different distances? Aristotle concludes that one of the points moves with two motions, both of which are downward, whereas the other point moves with two motions, of which one is upward and the other downward; therefore the motion of the first point is faster and moves through a longer distance.

This solution seems not only to be true, but also marvellous and worthy of Aristotle. Baldi, however, shows that this is wrong and suggests another way of solving the paradox. In any parallelogram, including the rhombus, mixed motions, if they have the same proportion, are made along the diagonal. But the proportion between diagonals and sides is always changing, and therefore the proportions between the simple motions along the sides and the mixed motions along the diagonals will also always be changing. For instance, in the rhombus the mixed motions along the diagonals are not equal: the one along the greater diagonal is faster, and the one along the smaller diagonal is slower. Likewise, the simple motions of points along the sides are not equal to the motions along the diagonal.

Question 24 is one of the best known of the *Mechanical Problems.* Here it is asked: "why is it that a greater circle revolves along a line of the same length as a smaller circle when they are fixed around the same center?" When they revolve separately, then the lengths of the lines along which each of them revolves in turn are in the same ratio as their respective sizes. Since the geometrical figure used by Aristotle is somewhat obscure, Baldi proposes to demonstrate the same conclusion by using a clearer

[32] Baldi (1621, 140).

figure. Aristotle then explains the cause of such an amazing effect, after rejecting the opinion of those who think that the larger circle, when it is carried forward by the smaller circle, moves more slowly because it stops intermittently, whereas when the smaller circle is carried by the larger, it skips some space, so that the distances covered by the larger and by the smaller are the same. Before starting his demonstration, Aristotle assumes the following principles:

> the same and equal force moves one mass more slowly and another more rapidly; if a body, which has a natural movement of its own, moves together with a body which has no natural movement of its own, it will move more slowly than if it moved by itself; but it will move more quickly if it moves without the other.[33]

Suppose that there are two bodies, one light, which has a natural movement upward, and the other one heavy, which has a natural movement downward. If the light body were linked together with the heavy one, it would be more difficult for it to move upward and it would move more slowly than if it moved detached from the heavy body.

> Moreover, that which is moved not by its own movement, but by the movement of another body, must be moved just as far as the mover moves it. Therefore if the smaller circle is moved not by its own movement, but by the movement of the larger circle, it will cover a greater distance than if it moved by its own movement. Likewise, if the smaller circle revolves carrying the large one with it, the larger circle with its rotation will not cover a greater distance than that covered by the smaller circle.[34]

Aristotle says that those who think that each circle moves by itself when rotating around the same center are deceived. For when the smaller circle is carried by the larger one, the motion is made around the center of the larger circle; whereas if the larger circle is carried by the smaller, the motion is made around the center of the smaller. Aristotle's solution is considered by Baldi as absolutely certain and based on true causes.

[33] Baldi (1621, 148).
[34] Baldi (1621, 149).

3.11 *The Construction of Beds*: Question 25

In this question it is asked why beds are made with a length that is double the ends, and why the supporting ropes are not fixed diagonally? According to Aristotle, beds are probably made to those dimensions so that they may accommodate ordinary bodies: for the length is twice the width, the length being 4 cubits and the width 2 cubits. Baldi, however, remarks that in his time the proportion was 2 to 3, the length of the beds being 6 feet and the width 4 feet, so that a bed could accommodate two people. He also points out that the original text is rather obscure, both because its different readings in extant manuscripts are erroneous, and because Aristotle's argument is rather involute. Alessandro Piccolomini overcame this difficulty by using a text contained in a very ancient manuscript kept at the Marciana Library in Venice.[35] The ancient author gives three explanations for the reason why the supporting ropes are not fixed diagonally: 1) because in this way the timbers to which they are fixed would be less strained; 2) because the ropes would be less strained if the weight is put on the ropes stretched crosswise rather than diagonally; 3) because fewer ropes would be needed. Concerning the first reason, Baldi shows the different ways in which the timbers are strained according to whether the ropes are fixed perpendicularly or diagonally. As to the second reason, he points out that the ropes fixed diagonally are longer and therefore less resistant than those fixed perpendicularly. As the third reason Baldi calculates the length of the ropes needed when they are fixed diagonally: for a bed 6 feet long and 3 feet wide, the rope needed is about 40 feet and 2/3; this result is slightly different from that given by Piccolomini, which is 40 and 1/2.[36] Baldi is astonished that the ancients did not use the more simple perpendicular arrangement of ropes, which is more resistant and requires less rope, that is 32 feet, according to his own calculation.

3.12 *The Placement of Weights Carried on the Shoulders*: Questions 26–27, 29

In Questions 26 and 27, the problem of carrying weights on the shoulders of a single person is discussed, and in Question 29, the problem of a weight carried by two people. Why is it more difficult to carry a long timber on the shoulders at its ends than in the middle, though the weight is the same in both cases? In Question 26 Aristotle solves the problem by considering the

[35] Piccolomini (1547, 55r).
[36] Piccolomini (1547, 56v, 57v).

vibration at the end of the timber and the lifting of the weight. Baldi points out that in the text it is not explained why the vibration interferes with the carrying, and he gives his own explanation by referring to the concept of center of gravity and to the idea of rarefaction and condensation of the timber carried on the shoulders, recalling what he had said concerning the breaking and the bending of materials in Question 16.

As to the role played by weight, the ancient author had remarked that a timber is more easily carried on the shoulders in the middle because in this case each of the two ends assists in lifting the other and raises the other in an upward direction. Baldi is not satisfied with this explanation and resorts to the Archimedean law of lever as defined by Guidobaldo in Proposition 3 of the treatise of the lever in his *Mechanicorum liber*.[37] At the end of the Question, Baldi mentions similar problems, such as the difficulty of raising a rod by holding it at one end.

In Question 27 it is asked why it is that if the weight is extremely long, it is harder to raise it up onto the shoulders, even if it is carried in the middle, than if it were shorter. Baldi says that this question is similar to the previous one and can be criticized and explained in the same way.

The discussion of the way in which a weight is carried by two people in Question 29 is more interesting. It is asked why it is that when two people carry a weight between them by means of a timber placed at its ends on their shoulders, they feel a different pressure according to their distance from the weight; the closer the carrier is to the weight, the heavier it appears to be. For the author, the timber acts like a lever: the weight is the fulcrum, the carrier nearer to the weight is the thing that is moved, and the carrier more distant from the weight is the thing that moves. Therefore the more distant the moving carrier is from the weight, that is from the fulcrum, the greater the pressure is that is felt by the one moved at the shorter end of the timber. Baldi does not agree with this and referring to Piccolomini's *Paraphrasis* shows that there are two levers to be considered in one single timber.[38] He argues that when the weight is placed at the middle of the lever, the carriers feel the same pressure, since the ratio of the length of the lever to each of its two parts is the same. At the end, Baldi discusses various cases: when the two carriers are of different height, when the weight does not hang freely from the lever, but is fixed to it so that its center of gravity changes position; and when the two carriers are of the same height but move on an inclined plane. The last case, Baldi points out, is similar to that of the wheelbarrow, which could be regarded

[37] Guidobaldo del Monte (1577, 41r).
[38] Piccolomini (1547, 62r).

as a lever with the weight placed between the fulcrum and the moving power.

3.13 *Rising from a Sitting Position*: Question 30

Question 30 asks:

> why when men stand up, do they rise by making an acute angle between the shin-bone and the thigh-bone, and similarly between the trunk and the thigh-bone?

Aristotle answers that this is because equilibrium is a cause of rest and the right angle is an angle of rest and produces stability. When a man stands up his position is at right angles to the ground. When he is seated, his head and feet are not in a straight line, because the trunk is perpendicular to the thigh, as is the thigh to the lower leg. In this position he cannot rise. In order to rise he must bend the trunk and the lower leg so as to make an acute angle between them, and to bring his head immediately above his feet. Baldi rejects this solution to the problem, arguing that a man is unable to stand up from sitting, not because his position at right angles is a cause of stability, but because the center of gravity is outside the support of his feet and he is unable to lean against a stable point in the act of standing up. In order to stand up, it would be necessary to move the center of gravity so as to place it in one straight line, and this is exactly what happens by bending the trunk forward and the legs backward. In order to stand up, it is obvious that it is necessary to make acute angles, but this is not the cause of standing up, as Aristotle seems to think.

From his solution to the problem Baldi derives the solution to new questions: why the feet of men and of some animals who can walk in an upright position are not short and round, but rather long and extended in the lower part? Similarly, why are feet more extended toward the toes than toward the heel? Why those who walk on stilts keep upright by moving continually? All these questions Baldi answers by showing how, in order to keep in equilibrium, the center of gravity of both men and animals must fall inside that part of the body which makes it possible to stand up. The position of the center of gravity inside the supporting surface is a condition also for the equilibrium of objects made by man, such as vases, three-legged stools, etc. And this is the reason why the leaning towers in Pisa and in Bologna do not fall in spite of not being perpendicular to the ground.

3.14 *Problems Concerning Motion*: Questions 31–34

In Question 31 it is asked why it is easier to move that which is already moving than that which is stationary. Strictly speaking, this question is not mechanical since no machine is involved. Baldi gives the example of a sphere rolling on a plane by being pushed and points out that it is a physical problem. Baldi elaborates the solution given in *Mechanical Problems*: when a weight is moving in the opposite direction to the pusher, some of the power of the mover is lost; the same thing happens when the mover pushes a weight at rest. But when a body is already moving in the same direction as the pusher, it increases the force of the mover. This explanation, according to Baldi, offers a solution to the physical problem of why the speed of the natural motion of falling bodies increases continuously, and this constant push causes the acceleration of its motion.

Question 32 concerns the motion of projectiles and asks why thrown objects stop moving after a while. This, as well, is a physical problem. In *Mechanical Problems* various explanations are suggested, but Baldi accepts the solution given by Piccolomini in his *Paraphrasis*, which is based on the fact that the impressed force, by which the projectiles are moved, is not natural but accidental and violent, and as such does not last.[39]

Question 33 deals as well with the motion of projectiles and investigates why projectiles continue to move even after the thrower no longer has direct contact with the projectile. This is a central problem within the Aristotelian theory of violent motion. Once again Baldi's solution is in line with the explanation given by Piccolomini in his *Paraphrasis* of *Mechanical Problems* according to which the nature of the impressed motion is accidental and violent and eventually peters out. The last question concerning the motion of projectiles deals with a different aspect of the problem, that is, the proportion between the thrown body and the throwing force. Question 34 asks why neither small nor large bodies move very far when thrown, but must always bear a relation to the thrower. Baldi quotes the two explanations given in the Aristotelian work: it is either because an object thrown or pushed must always offer resistance to that which throws or pushes it; or because a moving body can only move as far as it can penetrate the depths of the air. Finally, Baldi deals briefly with three questions not strictly related to the main question: why does a body turn around when thrown so that its heavier part moves to the front? Why do pebbles skimmed across the surface of water rebound sev-

[39] Piccolomini (1547, 66v).

eral times? Why does a ball thrown against an horizontal plane rebound at equal angles?

3.15 *The Motion of Bodies in Eddying Water*: Question 35

The last question of *Mechanical Problems*, like the four preceding questions, concerns the motion of bodies, but in contrast connects the problem with the properties of the circle. This question asks why objects which are moving in eddying water all end their movement in the middle. Aristotle explains that the moving object is moving in two circles, one lesser and one greater, and that the greater circle, because it is moving more quickly, is turning the object around and driving it sideways into the smaller circle. Driven then from the second circle into the next inner circle and so on, the moving object ultimately reaches the middle and remains there at rest. In addition, the weight of the object overcomes the speed of the revolving circle so that it is left behind in each lesser circle in succession until it arrives at the center.

Baldi, however, does not accept Aristotle's explanation, as brilliant as it may be, and points out that whirlpools are not circles turning around the same center, but rather rotating movements along a spiral. In addition, the weight of the moving object could only cause its motion to slow down, but the movement toward the center must have a different cause.

3.16 *Appendix: The Problem of the Two Mean Proportionals*

At the end of Baldi's commentary to the *Mechanical Problems* there is an Appendix which does not seem related to the questions discussed in the Aristotelian text. It is a classical problem from ancient mathematics: finding two mean proportionals between two given straight lines. Baldi, after mentioning the solutions given by ancient mathematicians, suggests a mechanical procedure for finding a solution, claiming its originality. The demonstration of the validity of Baldi's solution is based on the ancient demonstration produced by Pappus for a procedure suggested by Nicomede.[40]

[40] Pappus of Alexandria (1588).

Chapter 4
Online Sources

The open-access repository *European Cultural Heritage Online (ECHO)* of the Max Planck Institute for the History of Science is continuously extending its collection of sources made freely accessible as text files in xml format and/ or as high-quality images via its web site *echo.mpiwg-berlin.mpg.de.* The following sources mentioned in the present publication and listed below are currently accessible in this way.

4.1 The First Edition of the Treatise of Baldi

Bernardino Baldi 1621

4.2 Ancient and Renaissance Sources Concerning Mechanics Used by Baldi

Niccolò Leonico Tomeo 1525 (see Thomaeus 1525)
Niccolò Tartaglia 1546
Federico Commandino 1565
Alessandro Piccolomini 1547 (1565 edition)
Jordanus Nemorarius 1565 (see Tartaglia 1565)
Federico Commandino 1575 (see Heron 1575)
Guidobaldo del Monte 1577
Guidobaldo del Monte 1581
Guidobaldo del Monte 1588
Pappus of Alexandria 1588 (1660 edition)

4.3 Other Works and Translations by Baldi

Bernardino Baldi 1589 (see Heron 1589)
Bernardino Baldi 1612a
Bernardino Baldi 1616 (bound together with Heron 1583)

4.4 Other Renaissance Sources

Vitruvius 1567
Cardano 1570
Guidobaldo del Monte 1615

Bibliography

Affò, I. (1783). *Vita di Monsignore Bernardino Baldi primo Abate di Guastalla.* Parma: Filippo Carmignani.

Archimedes (1558). *Archimedis opera non nulla a Federico Commandino Urbinate nuper in Latinum conversa, et commentariis illustrata.* Venezia: Paolo Manuzio.

Baldi, B. (1589). *Di Herone Alessandrino de gli automati, ouero machine se mouenti, libri due, tradotti dal greco da Bernardino Baldi Abbate di Guastalla.* Venezia: Girolamo Porro.

Baldi, B. (1612a). *De Verborum Vitruvianorum significatione. Sive perpetuus in M. Vitruvium Pollionem commentarius. Accedit vita Vitruvii, eodem auctore.* Augsburg: Ad insigne Pinus.

Baldi, B. (1612b). *Scamilli impares Vitruviani. A Bernardino Baldo Urbinate nova ratione explicati; refutatis priorum interpretum, Guilielmi Philandri, Danielis Barbari, Baptistae Bertani, sententiis.* Augsburg: Ad insigne Pinus (apud J.Praetorium).

Baldi, B. (1616). *Heronis Ctesibii belopoeeca, hoc est telifativa Bernardino Baldo Urbinate Guastallae Abbate illustratore et interprete, item Heronis vita eodem auctore.* Augsburg: David Franck.

Baldi, B. (1621). *In mechanica Aristotelis problemata exercitationes: adiecta succinta narratione de autoris vita et scriptis.* Mainz: Johann Albin Witwe.

Baldi, B. (1707). *Cronica de' matematici overo epitome dell'istoria de le vite loro opera di monsignor Bernardino Baldi da Urbino Abate di Guastalla.* Urbino: Angelo Antonio Monticelli.

Baldi, B. (1887). Vite inedite di matematici italiani scritte da Bernardino Baldi e pubblicate da Enrico Narducci. *Estratto da bullettino di bibliografia e storia delle scienze matematiche e fisiche 19.*

Baldi, B. (1998). *Le vite de' matematici. Edizione annotata e commentata della parte medievale e rinascimentale, ed. by Elio Nenci.* Milano: FrancoAngeli.

Baldi, B. (2010). *In mechanica Aristotelis problemata exercitationes, vol. 1: Testo latino riveduto e corretto con traduzione italiana a fronte, ed. by Elio Nenci.* Milano: FrancoAngeli.

Becchi, A. (2004). *Q. XVI. Leonardo, Galileo e il caso Baldi: Magonza, 26 marzo 1621.* Venezia: Marsilio.

Becchi, A. (2009). Uno e trino. Impronte stravaganti di un testimone postumo (1621). In F. P. Di Teodoro (Ed.), *Saggi di letteratura architettonica, da Vitruvio a Winckelmann, vol. 1*, pp. 19–35. Firenze: L.S. Olschki.

Cardano, G. (1570). *Opus novum de proportionibus numerorum, motuum, ponderum, sonorum, aliarumque rerum [...].* Basel: Heinrich Petri.

Cardano, G. (2004). *De subtilitate. Edizione critica libri I-VII, ed. by Elio Nenci.* Milano: FrancoAngeli.

Commandino, F. (1565). *Federici Commandini Urbinatis liber de centro gravitatis solidorum.* Bologna: Alessandro Benacci.

Commandino, F. (1575). *Heronis Alexandrini spiritalium liber. A Federico Commandino Urbinate liber ex Graeco in Latinum conversus.* Urbino: Domenico Frisolino.

Crescimbeni, G. M. (2001). *La vita di Bernardino Baldi Abate di Guastalla, ed. by Ilaria Filograsso.* Urbino: QuattroVenti.

Drake, S. and P. L. Rose (1971). The Pseudo-Aristotelian Questions of Mechanics in Renaissance Culture. *Studies in the Renaissance 18*, 65–104.

Guidobaldo del Monte (1577). *Guidi Ubaldi e Marchionibus Montis mechanicorum liber.* Pesaro: Girolamo Concordia.

Guidobaldo del Monte (1581). *Le mechaniche dell'illustriss. sig. Guido Ubaldo de' Marchesi del Monte: tradotte in volgare dal sig. Filippo Pigafetta.* Venezia: Francesco De Franceschi.

Guidobaldo del Monte (1588). *Guidi Ubaldi e Marchionibus Montis in duos Archimedis aequeponderantium libros paraphrasis scholiis illustrata.* Pesaro: Girolamo Concordia.

Guidobaldo del Monte (1609). *Guidi Ubaldi e Marchionibus Montis problematum astronomicorum libri septem.* Venezia: Bernardo Giunti, Giovanni Battista Ciotti e soci.

Guidobaldo del Monte (1615). *Guidi Ubaldi e Marchionibus Montis de cochlea libri quatuor.* Venezia: Evangelista Deuchino.

Jordanus Nemorarius (1565). *Jordani opusculum de ponderositate Nicolai Tartaleae studio correctum, novisque figuris auctum.* Venezia: Curzio Troiano Navò.

Leonico Tomeo, N. (1525). *Nicolai Leonici Thomaei opuscula nuper in lucem aedita quorum nomina proxima habentur pagella.* Venezia: Bernardino Vitali.

Leonico Tomeo, N. (1530). *Aristotelis Stagiritae parva quae vocant naturalia. De sensu et sensili. De memoria et reminiscentia. De somno et vigilia. De insomniis. De divinatione per somnia. De animalium motione. De animalium incessu. De extensione et brevitate vitae. De Iuventute et senectute, morte et vita, et de spiratione. Omnia in Latinum conversa, et antiquorum more explicata a Nicolao Leonico Thomaeo. Eiusdem opuscula nuper in lucem edita.* Paris: Simon de Colines, Louis Cyaneus.

Micheli, G. (1995). *Le origini del concetto di macchina.* Firenze: L.S. Olschki.

Pappus of Alexandria (1588). *Pappi Alexandrini mathematicae collectiones a Federico Commandino Urbinate in Latinum conversae, et commentariis illustratae.* Pesaro: Girolamo Concordia.

Piccolomini, A. (1547). *In mechanicas quaestiones Aristotelis, paraphrasis paulo quidem plenior. [...] Eiusdem commentarium de certitudine mathematicarum disciplinarum.* Roma: Antonio Blado.

Serrai, A. (2002). *Bernardino Baldi. La vita, le opere. La biblioteca.* Milano: Edizioni Sylvestre Bonnard.

Tartaglia, N. (1546). *Quesiti et inventioni diverse.* Venezia: Venturino Ruffinelli.

Valleriani, M. (2009). The Transformation of Aristotle's Mechanical Questions. A Bridge Between the Italian Renaissance Architects and Galileo's First New Science. *Annals of Science 66*, 183–208.

Vitruvius (1567). *De architectura libri decem cum commentariis Danielis Barbari*. Venezia: Francesco De Franceschi, Johann Crigher.

Part 2: Facsimile

BERNARDINI BALDI VRBINATIS

GVASTALLÆ AB-
BATIS

IN

MECHANICA ARISTOTE-
LIS PROBLEMATA

EXERCITATIONES:

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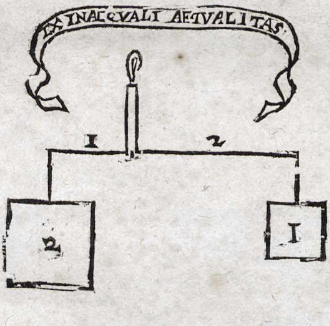

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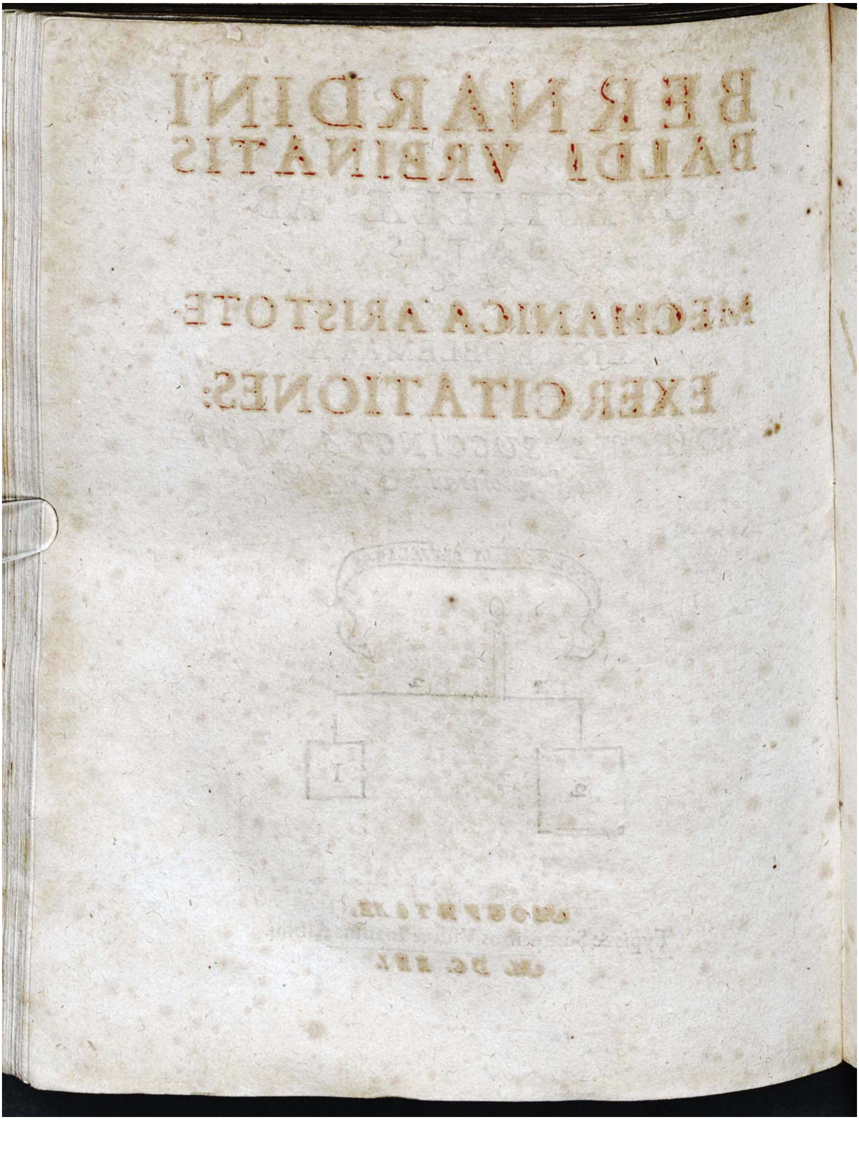

NOBILISSIMO AC GENE-
ROSO DOMINO

D. ADAMO PHILIP-PO BARONI A CRON-BERG, EQVITI, SACRÆ CÆSA-REÆ MAIESTATIS, ET SERENISSIMI

Principis Archiducis Alberti Camerario intimo &c.
Domino meo gratiosissimo.

OPportune sub hoc ipsum tempus, quo in Belgium ad Serenissimos Principes iter adornat Nobilissima & Generosa Dom. V.ra, prodit nostris formis in publicum editus Commentarius Bernardini Baldi Vrbinatis Guastallæ Abbatis in Aristotelis Mechanica. Is vir in omni scientiæ genere, at maxime in Mathematicis disciplinis fuit versatissimus, quod multa ab eo præclare scripta testantur opera, ex quibus paucula edita, reliqua vero speramus ſuo tempore in publicam lucem producenda. Cum vero nemini ſit obſcurum Nobiliſſimæ ac Generoſæ Dom. V.ræ id ſemper extitiſſe familiariſſimum, vt tum domeſticum otium, tum maxime peregrinationes, quibus totam pæne Europam ſumma cum laude circumſcripſit, tum variarum linguarum perfecto vſu, tum Mathematicarum diſciplinarum notitia & exercitio redderet iucũdiores, nulla me tenet dubitatio quin & Baldum Vrbinatem noſtris typis loquentem in hoc itinere, quod à Deo feliciſſimum Nobiliſſimæ ac Generoſæ Dom. V.ræ precor, in ſuum comitatum ac tutelam beneuolo animo ſit admiſſura. Id rogo humillime ſimulque precor, vt hanc meam typographiam plurimis iam retro annis de inclytæ familiæ Cronbergicæ tutela gloriantem, ſuo fauore proſequatur, viduæque afflictæ fortunis beneuole adſpiret. Sic Deus Nobiliſſ. & Generoſam Dom. V.ram illuſtret omnibus bonis, eamque R.mo & Ill.mo Principi ac Domino meo Clementiſſimo, D. Ioanni Suicardo Archiepiſcopo Moguntino Principi Electori ac per Germaniam Archican-

chican-

chicancellario &c. patruo ſuo optatiſſimo ſaluo florentique redhibeat ſaluum ſimiliter florentem ac incolumem. Moguntiæ è typographeio Viduæ Albinianæ, honori Nobiliſſimæ ac Generoſæ Dom. Veſtræ perpetuum dicato. Anno 1621. 26. Martij.

PRÆFATIO.

Diligenter legenti mihi quæstiones illas, in quibus ea quæ ad Mechanicam facultatem pertinent, explicantur, multa in mentem veniebant; & primum quidem eorum, quæ ibi disputantur, vtilitatem, subtilitatem, copiam admirabar: Tum ex animo dolebam, aureum hunc libellum propè negligi, & ab iis qui pulcherrimis hisce studiis dant operam, aßiduè præ manibus non haberi: Multas autem Auctori ipsi habendas referendasq́ esse gratias, qui tam egregiam, vtilem & probè instructam supellectilem Architectis, Mechanicis, & omnibus ferè Artificibus suppeditauerit. Aristotelis nomini ascribitur Commentarius, licet nonnulli, sitne Philosophi illius præclarißimi & acutißimi labor, an non, adfirmare subdubitauerint. Aristotelis tamen esse omnes ferè meliores consentiunt: Idque tum ex phrasi, & explicatione, quæ Aristotelem sapiunt, tum iudicio subtilitatis & rationum, quibus quæstiones ipsæ ingeniosissimè diluuntur. Videtur autem mihi, rem accuratius exploranti, satis verisimile (nullum enim habeo opinionis huius assertorem) sectionem esse hanc, & partem quandam eius operis nobilissimi, quod idem auctor De Problematibus edidit, & hanc, nescio quam ob causam; nisi fortè quod tractatio merè Physica non sit, à reliquo corpore distractam atque reuulsam. Id certè quod ad rem facit, probè nouimus, Diogenem Laërtium inter cætera Aristotelici ingenij monumenta Mechanica quoque adnumerasse. Quibus consideratis magnopere subit mirari, cur ij qui post Aristotelem floruêre atq; vixere, Mechanici, Archimedes, Athenæus, Heron, Pappus, & cæteri, nullam huius libelli fecerint commemorationem: & sanè debuerunt; neq; enim à vero est dissimile, ipsos per hunc aliquatenus profecisse. Verum enimuero cum ingenui illi fuerint homines, & nullatenus obtrectatores, credendum potius est, Commentariolum istud, eorum æuo, paucis cognitum, alicubi in Bibliothecis latuisse: etenim cætera quoq; Aristotelis scripta, post vetusta illa tempora, ante Alexandrum Aphrodisiensem, à multis fuisse ignorata

rata

rata non dubitamus. Habemus siquidem, Strabone teste, lib. 13. Aristotelis, & Theophrasti bibliothecam, post ipsius Theophrasti decessum, ad Neleum quendam Scepsium, Corisci filium, qui eius fuerat auditor, peruenisse; post hæc libros, blattis olim, & humore corruptos, Apelliconi Teio venditos, & ab eo Athenas translatos, tum Athenis captis in Syllæ potestatem deuenisse, eosque tandem à Sylla acceptos, Tyrannionem Grammaticum, vt potuit meliùs emendatos, promulgasse. Ex quibus colligimus, mirum non esse, Archimedi, Heroni, & alijs qui ante Syllam vixêre, fuisse incognitos. quicquid sit, illud certum est, Aristotelem eorum omnium qui de Mechanicis commentaria edidere, esse longè vetustissimum. Pappus enim Herone iunior, Athenæus Archimedi æqualis, vterq; enim sub Marcello, cui Athenæus suum de bellicis Machinis libellũ dedicauit. Archimedes verò circa CXL. Olympiadem floruit, quamobrem post Aristotelem Olympiadas XL. hoc est, annos ferè CLX. Isthæc autem considerantibus, facile est cognoscere facultatis huius nobilitatem, atq; dignitatem; quippe quod summus Philosophus non modo eam

pro-

probauerit, ſed etiam ſuis acutiſsimis lucubrationibus illuſtrauerit. Hanc porro tractationem ſubiecto quidem Phyſicam eſſe, demonſtrationibus verò Geometricam, ipſemet nos docuit Ariſtoteles, cuius etiam naturæ ſunt Perſpectiua, Specularia, Muſica, & cæteræ eiuſdem modi facultates, quas quidem ſubalternas Peripatetici appellant. Vitruuius Architecturæ membrum, vt ita dicam, & portionem quandam facit, ait enim Architecturæ partes eſſe tres, Ædificationem, Gnomonicam, Machinationem. Eſt autem Architecturâ quidem inferior, paret enim Architecto Mechanicus; attamen ſi cæteras artes ſpectes, Architectonica; hæc enim omnes ferè ſedentariæ, ſellulariæue, quas banauſas Græci appellant, ordine ſubijciuntur, & ſanè latiſsimos iſthæc habet fines; præcipuè autem circa eam verſatur cognitionem, eamque inter cæteras ferè principem, quam dixere Centrobaricam, quæ quidem ad Centri grauitatem, eiuſque ſpeculationem pertinet: qua in ſpecie inter veteres primum ſibi vindicauit locum Archimedes, mox Heron, deinde Pappus; inter neotericos autem Commandinus, qui librum de Centro grauitatis solidorum scripsit, & post eum G. Vbaldus è Marchion. Montis, qui non modò absolutissimum Mechanicorum librum cum maxima ingenij sui laude conscripsit, sed & Paraphrasin in librum Æqueponderantium Archimedis egregiè concinnauit Centrobaricam hanc, ignotam fuisse Aristoteli, satis patet. nunquam enim in Mechanicis demonstrationibus, quod tamen est potissimum, grauitatis centrum nominat, eiusue naturam atque vim speculatur. Diuiditur autem Mechanice tota, teste Herone apud Pappum libro octauo, in Rationalem, hoc est, Theoricam & Chirurgicam, id est, manu operatricem, quam Praxim aptè dicere valemus. Rationalis, speculationi & demõstrationibus, ex Geometricis, Arithmeticis & Physicis rationibus, dat operam; Chirurgica vero materiam tractat, & sese in varias artes diffundit, Ærariam, Lignariam, Sculptoriam, Pictoriam, Ædificatoriam, Machinariam & Thaumaturgicam, cæterasque eiusmodi. Machinatoriæ autem sunt partes Manganaria, qua ingentia trans-

transferuntur pondera, tum ipsa Poliorcetica, quæ bellicas Machinas ad vrbium expugnationes, quod vel ipso nomine profitetur, ædificat. Atqui hac de re plura scribere supersedemus, ne actum agamus: quisquis enim minutè magis hæc cognoscere desiderat, is Pappum adeat libro citato, & Guidum Vbaldum in Præfatione quam suo Mechanicorum Operi præposuit. Vt autem ad Aristotelis, de quo egimus, libellum reuertamur, pauci sunt qui ei ante nos stilum & operam commodauerint: Leonicenus Latinum fecit & figuris tum breuissimis, & parui sane ponderis, marginalibus adnotatiunculis, instruxit. Post hunc Alexander Picolomineus luculentissima Paraphrasi illustrauit. Modo, vt audio, Simon Sticinus Hollandensis quædam edidit, quæ ad nos minime peruenêre. Nos demum, omnium, tum scientia, & ingenio, tum ætate, postremi huic operi manum admouimus; Considerantes enim Aristotelem alijs principijs vsum, ac probatissimi post eum fecerint Mechanici, demonstrasse, morem huiusce facultatis studiosis gesturos nos fore arbitrati sumus, si easdem illas quæstiones

Mechanicis, hoc est, Archimedeis probationibus confirmaremus; dum per latißimos facultatis huius campos vagantes, alias quoque istis affines dubitationes introducentes solueremus. quicquid autẽ fecerimus profecerimusue, Lector optime, boni consule, & quia fax per manus traditur, tu interim de me accipe, vt alijs tradas.

DE VITA ET SCRI-PTIS BERNARDINI BALDI VRBINATIS

EX LITERIS FABRITII SCHAR-loncini ad Illuſtriſsimum & Reuerendiſsimum Dominum Lælium Ruinum Epiſcopum Bal-neoregienſem ex-Nuntium Apoſtolicum ad Poloniæ Regem &c.

NAtus eſt Bern. Baldus Vrbini nobilibus parẽtibus poſtridie Non. Iunij anno MDLIII. Genus traxit, quod me ſæpè ab eo memini audire, à familia Cantagallina, quæ inter Peruſinas illuſtris: hoc autem cognomen, Baldi accepto, vt in varietate temporum fit, Abauus reliquit, à teneris vnguiculis pietatẽ erga Deum præſetulit; nam vt mater eius narrabat, ſanctorum imagines & Altariola non cum lætitia ſolum, ſed cum veneratione anniculus intuebatur. Præceptoribus in adoleſcentia vſus fuit laudatiſſimis Io. And. Palatio, & Io. Antonio Turoneo, qui altero doctior, & Paulo Manutio maxime carus ob latinæ & græcæ linguæ peritiam propè ſingularem: ad illorum autem ſedulitatem tantum animi ardorem attulit, tantam ingenij ac iudicij vim, vt non tantum æqualis ſed omnium vicerit expectationem. Puer adhuc Arati apparitiones Italico carmine reddidit. Parens hac filij laude & gloria motus anno 1573. eum ad maiorem ingenij cultum capeſſendum Patauium miſit. Hîc in Emanuelis Margunij familiaritatem ſtatim venit, cui porro

 fuit

fuit in amoribus. Homeri Iliad. illo Doctore & interprete diligentius quam feciſſet antea, euoluit. priuato autem ſtudio Anacreonti, Pindaro, Æſchyli, Euripidi, Sophocli operam dedit, ſed præ cæteris Theocriti Bucolica triuit, ad quod ſcriptionis genus natura magis ferri videbatur: centenos græci alicuius poëtæ verſus memoriter tenebat, ſæpeque habebat in ore, in oratoribus græcis verſandis laborem ſe aliquem ſentire, in poëtis nullum. Scripſit Patauij libellum de Tormentis Bellicis, & eorum inuentoribus, & cum in Tranſalpinorum amicitias incidiſſet, ſibi ducebat dedecori ipſos ſua lingua loquentes non intelligere. quare incredibili celeritate Gallicam & Germanicam didicit. Peſtilentia ex eo Gymnaſio exactus in Patriam redijt, vbi quinquennium integrum Federico Cōmandino affixus omnes Matheſeos partes perdidicit, cui viro in delineandis figuris ad Euclidis, Pappi, & Heronis monumenta manum commodauit: ex eiuſdem obitu dolorem vix conſolabilem ſuſtinuit, ſuſceptoque eius vitam ſcribendi conſilio, ſubinde ad omnium Mathematicorum vitas conſcribendas animum adplicuit, quod & duodecim annorum ſpatio præſtitit feliciſſimè. cum vero Mathematicarum diſciplinarum amore torqueretur, amiſſo Commandino Præceptore, amicum nactus fuit præſtantiſſimum & ſymmyſtam Guidum Vbaldum è Marchionibus Montis, in cuius ſe conſuetudinem daret: quantum profeciſſet, oſtendunt ij commentarij quos anno 1582. in Ariſt. Mechanica ſcripſit. Vt poſtea à grauioribus ſtudijs ad amœniora animum abduceret, de re nautica poëma Italicè confecit. quo abſoluto Paradoxa multa Mathematica explicauit. Fama de Baldi virtutibus diſſipata Ferrandus Gonzaga Molfettæ Princeps & Guaſtallæ Dominus cœpit de illo in ſuam familiam aſciſcendo cogitare, vt qui iiſdem caperetur artibus, quibus excellere Baldus incipiebat:

piebat: Itaque opera Curtij Arditij honorifice fuit in aulam euocatus, dum vitam non aulicam viueret totus in litteras abditus precibus Vespasiani Gonzagæ Sablonetæ Ducis ad explanandos Vitruuij libros adactus fuit. quare tũc natus de Verborũ Vitruuianorum significatione commentarius; in quo minime mirandum si minuta quædam prosequutus fuit, quæ viro magno minus esse digna videantur: illi enim Principi morem gessit. scio dixisse aliquando Adrianum Romanum è Polonia reuersum, vbi Vitruuium Palatino cuidam explicauerat, si commentarium Baldi in Polonia adhibere potuissem, aurum quod mecum attuli emunxissem, quia satisfecissem muneri labore nullo. Cum Ferrando hero suo obuenisset necessitas Hispanias adeundi, illud iter sine Baldo facere se posse non putabat, non tam vt haberet, qui erudito eloquio viæ tædium leuaret, quam cui posset arcana committere, atque adeo à quo iuuaretur consilio. Vix viæ se dederant cum Baldus grauem in morbum delapsus itinere cogitur desistere: Mediolanum proinde diuertit, vbi à S. Carolo Borromæo & benignè exceptus, & tamdiu detentus donec valetudinem recuperaret. Guastallam postea se recepit, vbi cum absente Domino liberiori otio frueretur, libros sex de Aula eruditissimos methodo analytica conscripsit. alios non commemoro, quod cum otium erit, omnium syllabum dabo. Anno 1586. ipso nihil postulante eligitur Guastallæ Abbas, à quo tempore Iuri Can. Concilijs, & SS. Patribus totum se dedit. Hebreæ & Chaldææ linguarum discendarum triennium posuit. Anno 1593. nouæ Gnomonices libros quinque composuit. insequenti Chaldæam Onkeli paraphrasin in Pentateuchum vertit & commentarios adiunxit; quo exantlato labore in Iob ex Heb. fonte paraphrasin texuit, quam & scholijs illustrauit. Tabulam Etruscam Eugubinam interpretatus

fuit:

fuit: in ea autem diuinatione, vt aiebat, ſubciſiuas vnius menſis horas conſumpſit. De Firmamento & aquis egregie ſcripſit. Oeconomiam Tropologicam in S. Matthæum Card. Baronius, qui non alia Baldi vidit, vehementer probabat. Romæ dum viueret, fere neſciuit quid gereretur in Aulis: Arabicæ enim linguæ cum Io. Baptiſta Raimondo diligentiſſime ſtuduit, & arcana induſtria Slauonicæ, quam perfecte callebat. Ex Arabico vertit Hortum Geographicum Anonymi, quem ante ſexcentos annos floruiſſe arbitrabatur. Hunc vero extruſiſſet, vt alios Baldi libros, Marcus Velſerus IIvir Aug. ſi eo paulo longior huius lucis vſura contigiſſet. Compoſuit & Dictionarium Arabicum. atque cum beatiſſimam illam vbertatem ingenij aſſidue diffundi neceſſe eſſet, anno 1603. orbem vniuerſum deſcribere aggreſſus fuit; atque ita quidem, vt tam quæ ad Hiſtoriam, quam quæ ad Geographiam pertinerent complecteretur: Neque illuſtrare ſolum voluit quæ nouerunt antiqui, quemadmodum viſum Ortelio, ſed vel oppidula omnia & pagos, de quibus aliqua in poſtremis ſcriptoribus mentio. & profecto totum opus ad vmbilicum perduxit: non digeſſit tamen vniuerſum. quatuor aut ni fallor quinque tantum Tomi fuerunt ordine Alphabetico diſpoſiti: ſupereſſent ſeptem aut octo diſponendi, quantum ex chartarum & faſciculorum mole conijcere licet. Anno 1617. quarto Idus Octob. poſteaquam dies 40. vehementi deſtillatione vexatus fuiſſet, ſpiritum Deo reddidit Sacramentis Eccleſiæ omnibus rite munitus. Statura procerus fuit, facie oblonga & acribus oculis, colore ſubfuſco. Membrorum ei fuit decens habitudo, & compactum corpus. Diebus feſtis omnibus ſacrum faciebat, ieiunabat bis in hebdomada, eleemoſyniſque pauperes ſubleuabat. In ſtudijs ſic aſſiduus fuit, vt ſæpe & legeret & comederet. S. Auguſtini libros de Ciuitate Dei ter inter

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ter prandium euoluit. Statim à noctis meridie dum ei vires firmiores essent ad lucubrandum surgebat. à prandio Euclidem Arabice editum, vel libellum aliquem germanicum aut gallicum in manus sumebat. Suauitate morum & modestia, etiam si ceteræ dotes abfuissent, quemlibet ad amorem sui allicere potuisset. Sermo modicus ei fuit, itemque cultus. Nullos vnquam honores petijt, qui à Clem. 8. amplissimi promissi fuerant; nullum emolumentum quæsiuit suo censu contentus. facile parcendum esse dicebat, ijs maxime qui in re leui impegissent, quoniam si quos censemus optimos, nudos conspiceremus, nullum eorum non iudicaremus multis dignum verberibus. Bibliothecam habuit non locupletem, sed selectis instructã codicibus. Verum ire per singula longum esset. Satis mihi de incomparabili Baldi doctrina, & summa innocentia, ô rarum connubium, pauca dixisse, quæ forsitan ad imitandum nimis multa.

SYLLABVS LIBRORVM omnium B. Abb. Baldi.

ARati apparitiones è gr. in Ital. vertit.
De Tormentis Bellicis & eorum Inuentoribus lib.
Heronis automata vertit.
Vitas omnium Mathematicorum scripsit, & trib. in Tom. 2. 1. P^s. à Thalete ad Christum. 2. à Christo ad sua tempora.
Earumdem vitarum Epitomen Chronologicum confecit.
In Aristot. Mechan. Commentar.
De Re nautica Poëmation.
Paradoxorum Mathematicorum liber.
Descriptio Palatij Ducum Vrbinarum quod est Vrbini.
Poema cui titulus, Lamus.

Carmina pia, quæ inſcribuntur, Anni Corona.
De Verborum Vitruuianorum ſignificatione.
Carmina varia & eclogæ mixtæ.
Apologi centum, quos ſcripſit æmulatus Leonem Bapt. Albertum.
De Humanitate Dialogus qui inſcribitur Goſelinus.
Comparatio Vitæ Monaſticæ cum ſeculari.
De Aula libri ſex.
De felicitate Principis Dialogus.
De Dignitate Dial.
Carmina Romana.
Muſæi fabulam vertit.
De Italici carminis natura Dial. qui inſcribitur Taſſus.
De vniuerſali Diluuio poëmation.
Nouæ Gnomonices lib. quinque.
Hieremiæ Threnos vertit, & ex Heb. fonte annotat. adiecit.
Poemation inſcriptum, Deiphobe, quod ſcripſit æmulatus Lycophonem in Caſſandra.
Scala cœleſtis. i. Sermones pij & carmina.
Onkeli paraphraſin Chaldæam in Pentateuchum vertit & vberes commentarios adiecit.
In Iob Paraphraſis latina ex fonte Heb. additis Scholijs.
De ſcamillis imparibus Vitruuij.
De firmamento & aquis.
Quincti Calabri Paralipomena vertit.
Tabulæ Etruſcæ Eugubinæ Interpretatio.
Oeconomia Tropologica in S. Matthæum.
Vrbini encomium.
Horti geographici ex Arab. verſio.
Aduerſus Aulam Carmina.
Luciani de miſerijs Aulicorum verſio.
Oratio ad Romæ conſeruatores pro antiquitatum eius Vrbis cuſtodia.

Vni-

Vniuersi orbis geographica & Historica descriptio contexta ex septingentis & eo amplius scriptoribus.
Federici Vrbini Ducis Vita.
Guidi Vbaldi Vrbini Ducis Vita.
Epigrammaton & Odarum libri tres.
Aliorum Carminum liber.
Sententiarum moralium liber.
Dictionarium Arabicum.
Pro Procopio contra Flauium Blondum.
Horographium vniuersale.
Epigrammata alia.
Heronis lib. de Ballistis conuersio.
Exercitationes in Aristotelis Mechan.
Templi Ezechielis noua descriptio.
Antiquitatum Guastallensium liber.
Historiæ scribendæ leges.
Et alia quædam.

IN

IN MECHANICA ARISTOTELIS PROBLEMATA EXERCITATIONES.

Mechanices deſcriptio, natura, finis.

MECHANICE, facultas quædam eſt, quæ naturali materiâ, Geometricisq; demonſtrationibus vſa, ex centrobaricâ, & eorũ quæ ad vectem & libram rediguntur, ſpeculatione; humanæ conſulens neceſſitati, commoditatiq́ue, ſuapte vi, Naturam ipſam vel ſecundans, vel ſuperans, varia, eaq́ue mirabilia operatur. Hac diffinitione deſcriptionéue breuiter ea ferè omnia complexi ſumus, quæ fuſiſſimè ab Ariſtotele, Pappo, Guido Vbaldo, & alijs hac de re tradita fuêre.

Mechanices Obiectum.

Conſiderat autem Mechanicus Graue & Leue.

Graue duplex, Naturâ, Violentiâ.

Graue Naturâ dicitur, quod inſita propenſione in centrum mundi fertur. Graue autem Violentiâ, quod impreſſo extrinſecus pondere ab impellente pellitur.

Leue contrà, quòd Naturâ à centro fertur.

Cæterùm quicquid graue eſt, ſecundum punctum eſt, quod Grauitatis centrum dicitur, & hoc duplex, vt duplex eſt grauitas, Naturæ, Violentiæ.

Grauitatis centrum in triplici magnitudine considerari poteſt, lineari, planâ, ſolidâ.

De centro grauitatis linearum nemo ſcripſit, ſimpliciſſimi enim illud eſt contemplationis.

De centro grauitatis linearum egregiè tractauit Archimedes in libro Æqueponderantium, & de quadratura Parabole, tum in eo quem de his quæ vehuntur inſcripſit.

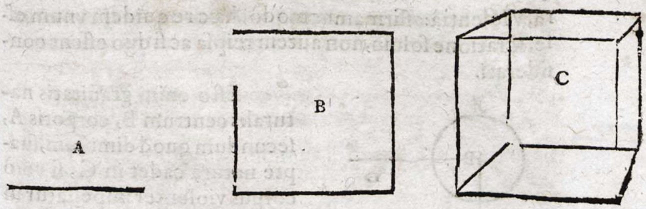
De centro grauitatis ſolidorum ipſemet olim ſcripſerat Archimedes, ſed ea quæ protulit, temporis iniuriâ deperdita, ſuâ diligentiâ reſtituit Iedericus Commandinus.

Eſſe autem & Leuitatis centrum in rerum natura, palam eſt. Punctum enim illud eſt, ſecundum quod leuia rectà à centro ſurſum feruntur. Huius autem non meminêre Mechanici, propterea quod aut nihil, aut parum ad eorum rem faciat.

Porro Grauitatis centrum ita definit Heron, & qui ab Herone Pappus 1. 8. Collectionum Mathematicarum.

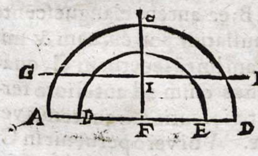
Centrum grauitatis vniuſcuiuſq; corporis eſt punctum quoddam intra poſitum, à quo ſi graue, mente appenſum concipiatur, dum fertur, quieſcit, & ſeruat eam quam in principio habuit poſitionem; neque in ipſa latione circumuertitur. Commandinus verò in lib. de centro grauitatis ſolidorum hoc pacto: Centrum grauitatis vniuſcuiuſque ſolidæ figuræ, eſt punctum illud intra poſitum, circa quod vndique partes æqualium momentorum adſiſtunt. Si enim per tale centrum ducatur planum, figuram quomodolibet ſecans, in partes æquè ponderantes eam diuidit. Nos verò quàm breuiſſimè dicimus: Centrū grauitatis, vniuſcuiuſq; magnitudinis punctum eſſe intra extraue magnitudinem poſitum, per quod ſi plano linea punctoue diuidatur, in partes ſecatur æqueponderantes.

 Dixi-



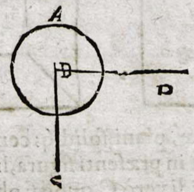
Diximus, Magnitudinis vt lineæ, planiꝗ́ſolidiq; centrum complecteremur. Erit igitur, vt in præſenti figura, lineæ quidem centrum A, plani B, ſolidi verò C. quod ſi obijciat quiſpiam, lineam & ſuperficiem nullam habere grauitatem; is ſciat, neq; corpora Mathematica grauitatem habere, Mechanicum verò funes, haſtas, vectes pro lineis ſumere; tabulas verò, & eiuſmodi plana ad ſuperficierum naturam referre.

Diximus inſuper, intra extraue. Aliquando enim grauitatis centrum extra molem corporis cuius corporis centrum eſt, cadit, vt in ſequenti figura.



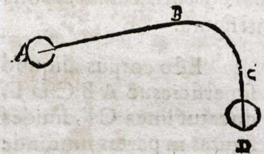
Eſto corpus aliquod ſuperficiesue A B C D E, ducatur linea C F, diuidēs figuras in partes hinc inde æqueponderantes A B C, E D C. Ducatur & G H. diuidens item in partes æqueponderantes G C H, & G A B, E D H. ſecent autem ſeipſas in I. erit igitur centrum I extra figuræ terminos & molem ipſam. Attamen licet hoc verum ſit, intra eſſe dici poteſt, quippe quod imaginario quodam, & vt ita dicam, virtuali ambitu A C D A contineatur.

Dicebamus, duplex eſſe grauitatis centrum, Naturâ, Violentiâ: affirmamus modò, hæc re quidem vnum eſſe, & ratione ſolum, non autem reipſa ac ſi duo eſſent conſiderari.



Eſto enim grauitatis naturalis centrum B, corporis A, ſecundum quod dimiſſum, ſuapte naturâ cadet in C, ſi verò corpus violenter impellatur in D, aliud acquiret centrum grauitatis ex violentia ſecundum quam fertur, motum, in D, idē autem ſunt re, nempe vnum B, duo autem ſi violentia & natura ſeorſum conſiderentur.

Hæc centra, duo motus ſequuntur, rectus vterque, Naturalis videlicet, & Violentus. Tertius ex his mixtus, & is quidem non rectus, ſed curuus.



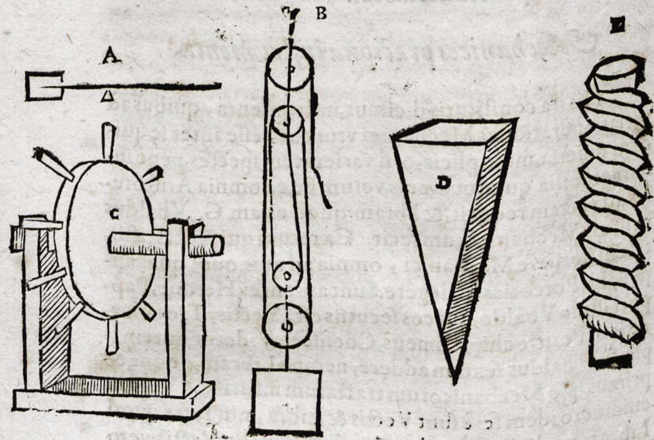
Proijciatur enim violenter corpus graue A ſuperante igitur violentia, rectà feretur in B; ea autem elangueſcente paullatim per curuam & mixtam lineā ſecetur in C, quatenus enim ad anteriora fertur, violentia eſt; quatenus verò ad inferiores partes, naturæ. Vbi verò peruenit in C, violentiâ ceſſante, naturâ verò manente, rectà deorſum fertur D C D.

Cæterùm hæc centra, hique motus, naturalis nempe, & violentus diuerſimode ſe habent adinuicem. Si enim graue corpus externâ vi adhibita, centrum mundi verſus impellatur, adiuuabunt ſe inuicem Natura, Violentia. Si autem contra, altera alteri reſiſtet, in motibus autem

autem ad latus, eo magis pugnabunt, quo magis ab inferioribus ad superiora fiet motus.

Mechanices præcipua instrumenta.

His ita constitutis dicimus, instrumenta, quibus ad varias operationes Mechanici vtuntur, esse inter se quidem diuersa, multiplicia, & si varietatem spectes, penè innumerabilia, quod quamuis verum sit, ea omnia Aristoteles ad vectem reducit, & libram: quod etiam G. Vbaldus in libris Mechanicorum fecit. Cæterum qui post Aristotelem floruere Mechanici, omnia ad quinque, quas appellant, Potentias, redegêre. Sunt autem ex Herone, Pappo, Guido Vbaldo, qui eos secutus est, Vectis, Trochlea, Axis in Peritrochio, Cuneus, Cochlea. Videtur autem ipse G. Vbaldus sextam addere, nempe Libram, de qua & primus ipse Mechanicorum tractatum instituit. Verum enimuero idem ferè sunt Vectis & Libra, nisi forte quod Libra tunc dicitur, cum brachia sunt æqualia. Vectis vero quomodocunque ea se habeant; quinque harum Potentiarũ imagines ita ob oculos ponimus. Vectis A. Trochlea B, Axis in Peritrochio C. Cuneus D. Cochlea vero E.



Porro, Cuneum ad libram reducere conatur Aristoteles, quod facit & G. Vbaldus, qui eò refert & Cochleam, quippe quod nihil aliud sit Cochlea, quàm Cuneus Cylindro inuolutus. Nos autem duas tantùm Potentias ad vectem reduci posse arbitramur, Trochleam nempe, & Axem in Peritrochio. Nequaquam autem Cuneum & Cochleam. quod latiùs quidem ostendemus, cùm de Cuneo erit nobis sermo peculiaris.

De Vecte & Libra secundum Aristotelem.

Aristoteles in ipso Mechanicorum ingressu ita scribit, Mirum videri ab exigua virtute magnum pondus moueri,

ueri,addito nimirum ponderi pondere,ſiquidem & vectis eſt pondus. Duplex ergo illi admiratio, ſcilicet quòd exigua potentia moueat ingens pondus, idque etiam addito vectis ipſius pondere, fiat. Hoc ſecundum adieciſſe videtur, amplificationis alicuius gratiâ. Etenim quatenus ad rem pertinet, ſi mouendis ponderibus vectis ipſius pondus compares, nullius ferè eſſe momenti proculdubio affirmaueris. Sed & illud quoque notandum, aliquando vectis pondus mouenti auxilium ferre, quod fit vbi fulcimento inter potentiam mouentem, & pondus ipſum collocato, vectis pars quæ à fulcimento ad potentiam eſt, premitur. Tunc enim, vt dicebamus, vectis pondere ſuo potentiam adiuuat. Contra verò accidit, cum pondus ipſum inter fulcimentum eſt & potentiam vel potentia ipſa inter fulcimentum & pondus. tunc enim vectis vnâ cum pondere attollitur. quæ licet vera ſint, non tamen inde ſequitur, vectis pondus, quicquam quod curandum ſit, in operatione efficere, aut impedire.

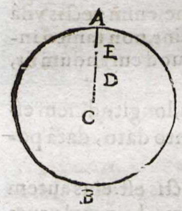
Porrò vectem ita finire poſſumus, longitudinem eſſe quandam inflexibilem, quæ fulcimento dato, datâ potentiâ datum pondus mouetur.

Ipſa quoque Libra, vt diximus, vectis eſt: eius autem naturæ, vt ſemper fulcimentum medium obtineat locum inter pondus & pondus. Statera autem merus eſt vectis, ſi ſparſum pro fulcimento; appendiculum verò currens pro potentia mouente deputaueris.

De Circulo eiusque natura Ariſtotelis doctrina examinata.

Ariſtoteles, quicquid mirum in Mechanicis operatur, id totum admirabili circuli naturæ eſſe tribuendum arbitratur. Ait autem, abſurdum nullatenus eſſe, ſi ex re mirabili mirandum quippiam oriatur. In circulo autem qua-

quatuor inueniri qualitates admiratione dignas. Primā, quod ex contrarijs constituatur, mouente videlicet & moto. Secundam, quòd contraria in eius circumferentia inueniantur, quippe quæ cum vnica linea sit, concaua simul est & conuexa. Tertiam, quod contrarijs feratur motionibus, antrorsum nimirum, retrorsum, sursum, atque deorsum. Quartam, quod vnicâ existente semidiametro, nullum in ea punctum sumi possit, æqualis alteri, in latione, velocitatis. Sit enim circulus A B, cuius centrum C, semidiameter A C, sumatur autem in ea punctum D, itemque punctum E. Erit itaque in ipsa circulatione D tardius E, ipsum verò E tardius A, & ita citius id feretur semper, quod remotius à mouente termino accipitur.



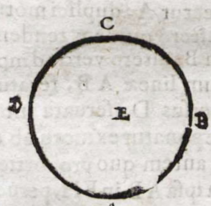
Hæc ex illo, quibus ne vltro assensum præbeamus non vnica de causa cohibemur. Dicimus igitur, videri nobis, circulum non ex contrarijs cōstitui, puta ex manente & moto, sed ex moto simpliciter. Nulla est enim semidiametri pars, quæ non moueatur. Punctum autem, quod stat, semidiametri pars nulla est. Et sanè cur moto semidiametro fiat circulus, non ideo accidit, quod alterū extremum stet, alterum verò moueatur: sed ideo quòd semidiameter perpetuò eandem seruet longitudinem. Ellipsis sanè centrum habet, sed ab eo ad circumferentiam quatuor tantùm semidiametri quomodolibet sumpti ducuntur æquales. Si quis igitur semidiametrum daret proportione crescentem & decrescentem, stante altero extremorum Ellipsis describeretur. Præterea & spiralis linea, quæ mixta est, altero semidiametri extremo manente, altero vero moto producitur. Legem itaque circulo

præ-

præſcribit, non quidem quòd hæc extremitas ſtet, illa verò moueatur, ſed quod ſua circulatione ſemper ſemidiameter eandem ſeruet longitudinem, quod vel ex ipſa circuli definitione colligitur.

Ad ſecundum miraculum, ſcilicet, quòd in circulo circumferentia, quæ vacua linea eſt, concaua ſimul ſit, & conuexa. Diceret quiſpiam id, ſi modò mirabile eſt non circulari tantum, ſed cuilibet curuæ lineæ primo competere, etenim & Ellipſis & Hyperbole, & Parabole, & ſpira, tum Cyſſois, Conchois, & infinitæ aliæ irregulares concauæ ſimul ſunt & conuexæ. Sed & hæc in ſuperficiebus quoque deſiderantur.

Ad tertium, quod contrarijs feratur lationibus, antrorſum, retrorſum, ſurſum & deorſum. Dicimus, facilè ſolui. Nullus enim, re bene perſpectâ, affirmauerit circulum contrarijs lationibus moueri.

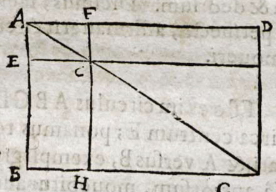


Eſto enim circulus A B C D, circa centrum E; ponamus rotari, & A verſus B, exempli gratiâ, antrorſum, mouebitur autẽ & B verſus C, & C verſus D, tum D verſus A. Non puto quenquã dicturum, circulum hunc antrorſum eodem tempore, & retrorſum ferri nec ſurſum aut deorſum, ſi enim quiſpiam per eius circuli circumferentiam ambularet, is certè centrum ipſum ſemper ad dexteram haberet, vel ad ſiniſtram, ſi ad dexteram, antrorſum ibit, ſi ad ſiniſtram, retrorſum. Sed nec ſurſum vel deorſum, eſt manifeſtum. Nihil autem prohibet eundem motum vario reſpectu contrarium dici poſſe, id tamen profectò fieri nequaquam poteſt, nempe A moueri verſus B, hoc eſt, antrorsum,& eandem eodem tempore versus B, id est, retrorsum; repugnat enim naturæ.

De quarto circuli miraculo, ibi erit nobis sermo, vbi ea perpenderimus primò, quæ Philosophus de Circuli productione disserens in medium profert. Sunt autem eiusmodi:

Circulum quidem duplici notione produci, Naturali videlicet altera, & altera quæ est præter naturam, & ideo circularem lineam in ter mixtas computari.

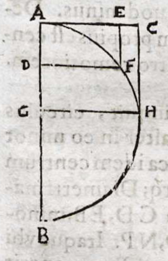
Motus mixtus ait, vel proportione seruata fit, aut non; Si proportione seruatâ, rectam lineam; ea verò non seruata, circularem lineam produci.



Esto enim rectangulum A B C D, cuius latera in datâ sint proportione, A D cum A B. Moueatur A, duplici motu, Altero quidem tendens in B, altero verò ad motum lineæ A B, feratur versus D, seruata interim laterum proportione. Itaque ponatur ex motu ab A versus B, peruenisse in E, ex motu autem quo proportionaliter fertur cum linea A B, facta ipsa A B, in F H, peruenisse in G, & E G connectatur. Erit igitur Parallelogrammum A E G F, Parallelogrammo A B C D proportionale simile, & circa eandem diametrum A G C. Semper igitur punctum A si duabus lationibus feratur, laterum proportione seruata, lineam producet rectam, diametrum nempe A G C. Et hoc sanè nullam habet dubitationem, ex ijs quæ docet Euclides 1. 6. prop. 24.

His ita demonstratis hac vti videtur Philosophus argu-

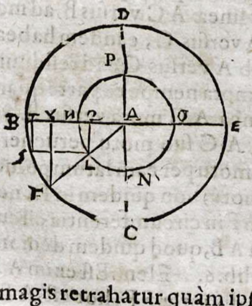
argumentatione: Si mixtus motus proportione ſemotâ, rectam producit, ſi nunquam ſemota, efficiet circulum; ſi enim modo ſeruaretur, modo non, partim recta partim non recta produceretur. Ingenioſa quidem argumentatio, ni vitium contineret. non enim mixtus motus, qui nunquam ſeruatâ proportione fit, ſemper circulum producit, ſed & Ellipſim poteſt, & quamlibet aliam lineam, cuius nulla pars ſit recta. Hanc difficultatem vidit Picolomineus in ſua Paraphraſi, & eam ſoluere conatus eſt, ſed quàm bene, aliorum eſto iudicium. Cæterùm falſum eſt, aſſerere circulum ex mixto motu nunquam ſeruatâ proportione produci. ſeruat enim aſſiduè mixtus motus quo producitur (ſi eum mixto motu producere velimus) aliquam proportionem, ſed non eandem.



Eſto enim recta A B, cui ad rectos angulos A C. Moueatur autem A, verſus C per lineam A C, & eodem tempore linea A C, verſus B, ita tamen, vt ſemper ipſi A B, ſit perpendicularis. feratur autem eâ lege, vt quam proportionem habet motus lineæ A C verſus B, ad motum puncti A verſus C, eandem habeat ipſe motus ab A verſus C, ad reſiduum lineæ A B, demptâ nempe ea parte quam peragrauit linea A C mota verſus B. Sit autem, cum A C ſuo motu peruenerit in D, punctum A, ſimiliter ſuo motu per eam latum peruenisse in E. erit ergo ex mixto motu, non quidem in D, nec in E, ſed in F, eritque punctum F in circumferentia circuli, cuius eſt diameter ipſa linea A B, quod quidem demonſtratur ex conuerſa propoſ. 13. lib. 6. Elem. Eſt enim A E hoc eſt D F media proportionalis inter E F, hoc eſt, A D, & D B. Iterum ſi fiat motus A C in G H, ad motum H per lineam A C, vsque in C, vt se habet proportio A G ad G H & G H ad G B, erit ex motu mixto A in H, nempe in eiusdem circuli circumferentia A F H B. ex quibus habemus, circulum ex mixto motu fieri posse proportionibus quidem mediarum seruatis, sed nunquam ijsdem.

Vera hæc proculdubio sunt; nihilominus, veluti ad rectam producendam mixtus motus non est necessarius, licet mixto motu produci possit, ita neque ad circularem, & ideo verum non esse quod asserebat Philosophus, circulum ex mixto motu proportione nunquam seruatâ necessariò produci.

Conatur post hæc Aristoteles rationem afferre, cur circuli partes, quò propiores centro fuerint, eo sint tardiores. Ait autem; si duobus ab eadem potentia latis hoc quidem plus repellatur, illud verò minus, æquum est tardiùs id moueri quod plus repellitur, eo quod minus. Detrahi autem plus lineam, cuius extremum propius est centro illa quæ suum habet terminum à centro remotiorem.



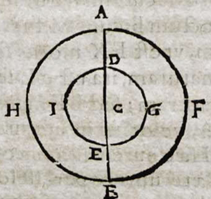
Esto, inquit, circulus B C D E & alter in eo minor M N O P circa idem centrum A. Ducanturq; Diametri maioris quidem C D, E B, minoris verò M O, N P. Itaque vbi A B circulata eò peruenerit vnde est gressa, ipsa quoque A M eo vnde moueri cœperat, perueniet. Tardiùs autem fertur A M, quam A D, propterea quòd A M à centro magis retrahatur quàm ipsa A B. Ducatur igitur A L F & à puncto L, ipsi A B perpendicularis L q, cadens in minori cirri circulo, & rursus ab eodem L ipsi AB, parallela ducatur L S, Ab S verò eidem perpendicularis S T, & ab F item F X. Sunt ergo q L, S T, quidem æquales, nempe illæ, per quas, secundum naturam, mouentur puncta B M. Motu verò retractionis ad centrum, hoc est, præter naturam, plus motum est M quàm B. Maior enim est M q, ipsa B T, quod, ceu notum, supposuit Aristoteles. nos autem infrà demonstrabimus. Si igitur fiat vt motus præter naturam ad motum præter naturam, ita motus secũdum naturam, ad motum secundum naturam, punctum B; cum M fuerit in L, non erit in S, sed in F. tunc enim, vt est F X motus secundùm naturam ad X B, præter naturam, ita est q L secundum naturam ad q M præter naturam; sed B F maior est M L, ergo proportione seruatâ, velociùs mouetur B quàm M circa idem centrum A. Hæc autem summa est eorum quæ præfert Aristoteles. Cæterùm nos parallelogrammum, quod in figura eius habetur prætermisimus, quippe quod nihil ad eam quæ affertur, demonstrationem faciat.

Modò quod pollicebamur, nempe minorem esse BT, quàm q M, ita demonstramus. quoniã S T. ex prop. 13. l. 6. media proportionalis est inter B T & T E, erit quadratum T S æquale parallelogrãmo seu rectangulo B T, T E, item, quoniam q L media proportionalis est inter M q, & q O. erit quadratum q L æquale rectangulo M q, q O, æqualia ergo sunt rectangula B T E, M q O, itaque reciproca latera habent proportionalia. quare, vt T E, ad q O, ita M q ad T B, sed T E maior est ipsa q O, quippe quòd pars sit q O ipsius T E, maior ergo & M q ipsa T B, quod ostendendum fuerat.

Cæterùm subtilia & ingeniosa isthæc esse non negamus, & longè faciliori & explicatiori modo veritas hæc demonstrari potest, reiectis nempe illis, secundùm, & præ-

 ter

ter naturam motibus, qui quidẽ in simplici circulo necessario non cadunt: caderent autem fortasse, si de circulo res esset à põderibus circumlatis ex stabili centro descripto; qua de re agit G. Vbaldus in Mechanicis tractatu de libra. tunc enim dici potest, pondus quod aliâs rectà ad mundi centrum tenderet, à circuli centro in circulatione retrahi, sed hæc ad circuli naturam, quatenus circulus est, nequaquam spectant.



Esto igitur circumferentia AFBH, cuius centrum C, diameter ACB, semidiameter AC. sumatur in AC punctum quodlibet, D, & centro C, spatio CD, describatur circumferentia DGEI. Dico punctum A velocius moueri puncto D eâdem circulatione rotato. etenim vt diameter ad diametrum, & semidiameter ad semidiametrum, ita circumferentia ad circumferentiam: igitur vt AC ad CD, ita circumferentia AFHB ad circumferentiam DGEI. At mota linea CA circa centrum C mouetur simul & CD, eodem igitur tempore rotationem complent puncta AD, maius ergo spatium eodem tempore metitur A, ipsa D, quare velocior. Ita igitur se habet velocitas ad velocitatem, vt circumferentia ad circumferentiam, & diameter ad diametrum, quare id quod mouetur in puncto à centro remotiori, velocius illo mouetur quod ab eo distat minus, quod fuerat demonstrandum.

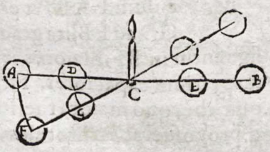
QVÆ-

QVÆSTIONES MECHANICÆ.

QVÆSTIO I.

Cur maiores libræ exactiores sint minoribus?

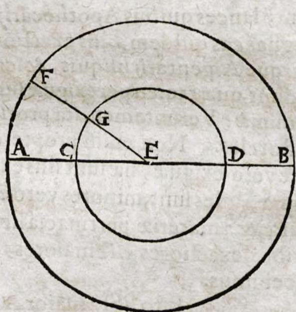
PRioribus, ceu fundamentis quibusdam iactis, opportunè ad quæstiones proponendas, easque diluendas se confert Aristoteles. Porro in proposita quæstione videtur prima fronte caussam quæri de re quæ non est: etenim quis affirmauerit vnquam, lances quibus Apothecarij & Macellarij vtuntur, magnas eas quidem, illis exactiores esse quibus Gemmarij, atque Argentarij siliquis, & scrupulis minutissima appendunt, quæ tamen perexiguæ sunt, & si illis comparentur minimæ? Veruntamen, ita prorsus res habet, vt asserit Aristoteles. Non enim propterea quòd illæ magnæ sint, hæ verò exiguæ, hæ sunt illis exactiores; sed quoniam magnæ, rudes sunt, minores verò exquisita diligentia elaboratæ, & à materiæ pertinacia liberiores. Cæteris ergo paribus, exactiores esse maiores, ex Philosophi mente, ita docebimus.



Esto libra maior AB, cuius fulcimentum C. Minor verò libra DE, circa idem fulcimẽtum C, vnà cum maiori, imaginatione, conuersa. Apponatur quoduis pondus maiori libræ in A, declinetq; exempli gratiâ in F, eritque minor libra in G, in eadem enim linea sunt CGF. Vtraq; igitur ex eodem cen-

centro C portionem circuli deſcribet GD, AF, eritque ACF ſector circuli, cuius diameter AB, ſed DCG ſector circuli, cuius diameter DE. Itaque vt diameter ad diametrum, ita portio ad portionem: maior autem diameter AB diametro DE: maior ergo portio AF, portione DG. quod autem maius eſt, minùs obtutum fallit, exquiſitius itaque tractum ex maiori AB quàm ex ipſa minori DE cognoſcemus, quod fuerat oſtendendum.

Cæterùm hac eadem de cauſſa, Aſtronomica inſtrumenta, puta Aſtrolabia, Armillæ, & alia eiuſmodi, quo ampliora eò exquiſitiora, & certiora probantur.



Eſto enim Aſtrolabium magnum, cuius diameter AB, paruum autem CD, circa idem centrum E. Ducatur à centro recta EF tangens maiorem circulum in F, minorẽ verò ſecãs in G, vt igitur GD ad totum circulum GCD, ita FB. ad totum circulum FAB, vt ergò GD ad FB, ita gradus ſignati in GD, ad eos qui ſignantur in BF, maiores ergo ſunt qui in FB, & minutarum partium capaciores. Hinc itaque apparet, inſtrumẽta quælibet quò maiora fuerint, eò eſſe & exquiſitiora, quod propoſuerat Ariſtoteles, in hac quæſtione de Libra.

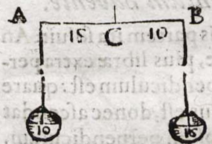
Quod autem addit de fraudibus Purpurariorum, inquiens; quamobrem machinantur ij qui purpuram vendunt, vt pẽdendo defraudent, dum ad medium, ſpartum,

non

non ponentes;tum plumbum in alterutram libræ partem infundentes;aut ligni quod ad radicem vergebat, in eam quam deferri volunt partem constituentes, aut si nodum habuerit, ligni enim grauior ea est pars, in qua est radix, nodus verò radix quædam est. Hinc quæri posset:

Vtrum libræ quæ ponderibus vacuæ æquilibrant, omni prorsus careant fraude?

Videri cuipiam posset, libras, quæ ponderibus vacuæ, æquilibrant, omni prorsus fraude carére, veruntamen ita non est, quod diligentiùs (res enim magni momenti est) disquiremus.



Esto enim libra AB, ita diuisa in C, vt AC sit partium 15, CB verò earundem siti 10. apponatur parti A lanx ponderans 10, parti vero B lanx ponderans 15. ex permutata igitur proportione libra suspensa in C, ęquè ponderabit; si autem apponatur lanci B sacoma vnciarum 6, & in lance A constituatur purpura, quæ ita se habeat ad vncias 6, vt 10 ad 15, iterum æqueponderabit, sed vt 10 ad 15, ita 4 ad 6. Purpurarius ergo fraudulentus, ponens in lance A vncias purpuræ 4, facto æquilibrio petet pretium vnciarum 6, & ita emptorem decipiet, quod sanè innuerat, non autem demonstrauerat Aristoteles. Hæc autem faciliora fient ex ijs, quæ in sequentibus quæstionibus, vbi de vecte agetur, explicabuntur.

Detegitur autem fraus, si alternatim sacoma in ponderando, modo huic, modò illi lanci apponatur. Si enim in lance A constituatur sacoma, in B verò purpura non fit æquilibrium.

QVÆSTIO II.

Cur, si sursum libræ fulcimentum sit, apposito ad alteram partem pondere, descendat libra, & eo amoto, iterum ascendat, & ad æquilibrium reuertatur Si verò deorsum fulcimentum fuerit, depressa ad æquilibrium non reuertatur?

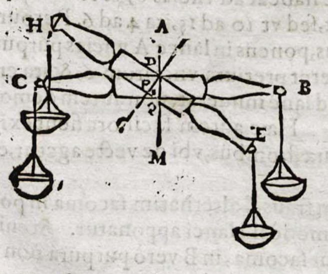
BImembrem proponit Philosophus quæstionem, quam trimembrem debuit, triplici siquidem loco fulcimentum aptari potest, superiori, medio, inferiori. Nos de omnibus verba faciemus.

Prima Quæstionis pars.

De Libra sursum fulcimentum habente.

Aristoteles primam quæstionis partem ita soluit: An quia sursum parte quidem existente, plus libræ extra perpendiculum sit? Spartum enim perpendiculum est: quare necesse est deorsum ferri id quod plus est, donec ascendat qua bifariam libram diuidit ad ipsum perpendiculum, cum onus incumbat ad libræ partem sursus raptam.

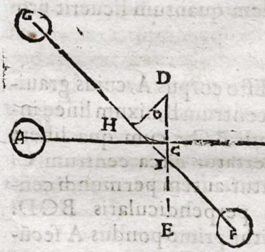
Sit libra recta (hoc est, in æquilibrio constituta) B C, spartum autem A D, fulcimentum autem D, desuper: sparto autem deorsum proiecto ad M perpendicularis erit vbi A D M. Si igitur in ipso B ponatur onus, erit B quidem vbi E, C autem vbi H, quamobrem ea quæ bifariam librã



secat, primo quidem erit D M, ipsius perpendiculi; incũbente autẽ onere, erit D G. quare libræ ipsius E H, quod extra

extra perpendiculum, eſt A M, vbi eſt q P maius eſt dimidio. Si igitur amoueatur onus ab E, neceſſe eſt deorſum ferri H, minus eſt enim E: ſiquidem igitur habuerit ſpartum ſurſum, propter hoc aſcendit libra.

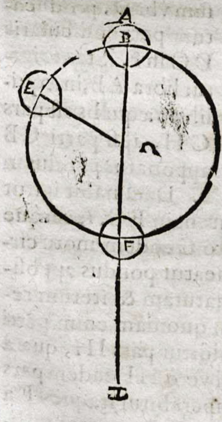
Peſſimè omnes ſchema hoc lineârunt, ita vt difficillimum ſit auctoris inde ſenſum aſſequi. Nos autem clarius rem ob oculos ponimus. Id ergo ſibi vult Ariſtoteles, propterea quòd pars iugi H D G maior eſt parte E D q, eam eleuatam neceſſe eſt deſcendere, & iterum à perpendiculari A D M bifariam diuiſam ad æquilibrium reuerti. Poſſumus nos idem ſimpliciori figura demonſtrare.



Eſto libra A B, bifariam diuiſa in C, fulcimentũ verò ſurſum vbi D, producatur perpendicularis D C in E. Stante igitur libra A B, in æquilibrio æqualis eſt pars C H, ipſi parti C B apponatur pondus in B. Declinabit igitur libra mota circa centrũ D, fiat autem in F G, ſecetque perpendicularem in I. Punctum vero C eodem motu circa idem centrum D erit in H. amoueatur pondus appoſitum: Dico libram à ſitu F G declinaturam & iterum reuerſuram in ſitum priſtinum A C B. quoniam enim parti G H, quæ æqualis eſt parti H F, additur pars I H, quæ à perpendiculari eſt vſque ad H, ipſi verò H F eadem pars detrahitur, erit I F minor G I. Superabitur itaque I F à G I, deſcenderque F I, aſcendet verò I F, donec iterum libra in partes æquales, vt antea, diuidatur in C, fiatque æquilibrium.

Hæc Philosophi demonstratio est vera illa quidem, sed non ex Mechanicis principijs, hoc est, ex centri grauitatis speculatione; nos igitur clariùs rem exponemus, his quæ sequuntur consideratis.

Si pondus circa stabile centrum conuertatur, dimissum non stabit, nisi secundum grauitatis centrum fuerit in perpendiculari, quæ per centrum, circa quod conuertitur, ad mundi centrum cadit. Stabit autem in ea perpendiculari in duobus punctis, altero à centro mundi remotissimo; altero verò eidem quantum licuerit proximo.

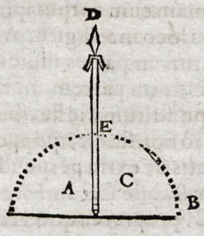


Esto corpus A, cuius grauitatis centrum B, nixum lineę inflexibili B C, cum qua liberè conuertatur circa centrum C. Ducatur autem per mundi centrum perpendicularis B C D. Sit igitur primò pondus A secũdum gracilis B centrum, in perpendiculari ipsa supra centrum C, puta in B. Moueatur & descẽdat in E. Post hæc verò in F, hoc est iterum in ipsa perpendiculari infra centrum C. Describet ergo circulum ex centro C, nempe B E F secantem perpendicularem in duobus punctis oppositis B F, dico, pondus liberè dimissum

missum in duobus tantum punctis suapte naturâ permansurum, BF, in B, primò, quoniam cum corpus ipsum A à perpendiculari, quæ superficiei loco intelligitur ABCD per centrum grauitatis diuidatur, in partes diuiditur æqueponderantes, quare in neutram partem inclinabit. Stabit igitur erectum, lineæ ipsi fultum, inflexibili BC, quæ nititur puncto C. In E verò non stabit, quippe quod eo situ centrum ipsum grauitatis sit extra perpendicularem, & ideo extra fulcimentum stabile C. In F verò iterum stabit, pendens à centro C, propterea quòd & ibi ab eadem perpendiculari diuidatur per grauitatis centrum in partes æqueponderantes. Est igitur respectu B, ipsum punctum C, fulcimentum deorsum, respectu verò F, fulcimentum sursum. At quia linea DF, CB, à centro mundi, quod est extra circulum, BEF, circulum ipsum per centrum C secat, erit pars eius DF quidem breuissima, ipsa verò DB longissima, ex propos. 8. lib. 3. Elem. Pondus igitur A conuersum seu liberè motum circa centrum C, in duobus tantum locis perpendicularis lineæ stabit remotissimo altero, vt est B, altero verò eidem quamproximo, vt est F.

Hoc idem egregiè demonstrauit G. Vbald. in suis Mechanicis, Tractatu de Libra prop. 1.

Ad hæc autem dubitare quis posset, cur experientiâ docente, pondera quæ infra fulcimentum habent, vt lancea sarissaue ad planum horizontis perpendiculariter erecta, licet eo casu grauitatis centrum in ipsa perpendiculari constituatur, non stet quidem, sed altrinsecus cadat?

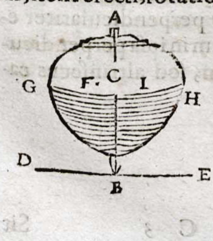


Sit enim horizontis planum A B, cui in puncto C perpendiculariter erecta statuatur sarissa D C, cuius grauitatis centrum E, in ipsa perpendiculari. Stabit ergo, ex præmissis, & certè stare debuit, staretque, ni vitium obstaret materiæ; non stat autem, quia difficillimum est grauitatis centrum, suapte naturâ indiuisibile, ita ad amussim sistere, vt in neutram partem à perpendiculari declinet. Hæc igitur ex ijs speculationibus est, quæ ad praxim, materiæ vitio impediente, aut vix aut nunquam rediguntur.

Hinc autem ea quæstio soluitur, Cur ij qui sarissam erectam digito summo sustinere conantur, non stent quidem, sed digiti motu, sarissæ motum sequantur.

Id certè agit, qui nutantis sarissæ, digito, motum sequitur; vt in ipso motu digitum assiduè centro grauitatis sarissæ supponat, vnde fit vt nunquam extra fulcimentum permanens, nunquam cadat.

Similis huic alia quoque dubitatio soluitur: Nempe, Cur turbines, quibus pueri ludunt, dum quidem rotantur, stent erecti, rotatione vero cessante, cadant.

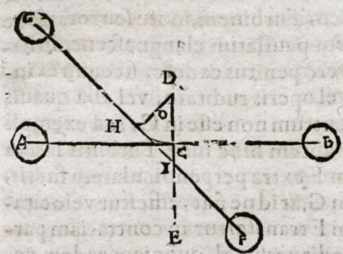


Esto enim Turbo A B, cuius grauitatis centrum C, planum horizontis D E, linea Horizonti perpendicularis A B C, transiens per centrum grauitatis C, sit autem fulcimentum in B. Itaq; cum centrum grauitatis C sit in ipsa perpendiculari, stabit ex demonstratis,

ſtratis,at ex vitio materiæ non ſtabit. Modò, vt aſſolet, rapido motu rotetur. Dico, Turbinem, motu ſeu rotatione durante ſtare. ea autem paullatim elangueſcente in caſum vergere; ceſſante verò penitus cadere. fit enim ex inæqualitate materiæ, vel operis ruditate, vel aliâ quauis ex cauſſa, grauitatis centrum non eſſe in C, ſed exempli gratiâ vbi F, notentur autem hinc inde Turbinis latera notis G H. Vtique cum F extra perpendicularem fuerit, cadet Turbo ad partem G; at id ne fiat, efficitur velocitate motus, quo centrum F transfertur in contrariam partem, vbi I. non autem cadit verſus H, quoniam eadem velocitate iterum transfertur in F, quamobrem cum huiuscemodi centri aſſidua circa perpendicularem fiat translatio, ad nullam partem Turbo cadere poteſt; elangueſcente verò motu rotans, paullatim incipit inclinari, donec eo penitus ceſſante, ad eam partem cadit, ad quam à perpendiculari grauitatis centrum vergit. Deſcribit autem in rotatione grauitatis centrum, quod in medio non eſt paruum circulum, per cuius centrum ipſa perpendicularis pertingit.

Modò redeuntes ad libram, cuius fulcimentum eſt ſurſum, alio principio, nempe Mechanico, cur depreſſa ad æqualitatem reuertatur, demonſtrabimus.

Sic



Sit igitur, vt ſuperiùs, libra A B, cuius centrum grauitatis C, fulcimentum verò ſurſum in D libræ quidem in C perpendiculariter coniunctum. Perpendicularis verò quæ per fulcimentum, & grauitatis cētrum tranſiens ad mundi centrum tendit D L E. ſtante igitur librâ in ſua æqualitate, erit centrum grauitatis C in ipſa perpendiculari infra quidem fulcimentum D. Loco verò, mundi centro quàm proximo. Pondus poſthæc apponatur in B, Declinabit autem pars C B, in H F, eleuatâ interim parte A C, in G H. Mota igitur libra tota, circa fulcimentum D mouebitur circa idem centrum, & grauitatis centrum C, deſcribens portionem circuli C H, fietq; C in H, & quoniam H, hoc eſt C, extra perpendicularem fit, amoto pondere, ex lance B, cuius preſſione libra declinauerat, centrum grauitatis per eandem circuli portionem H C, ad perpendicularem deſcendet, donec iterum in ea quieſcat, quo caſu libra A B ad æquilibrium reuertetur: quod fuerat demonſtrandum.

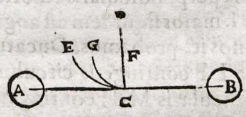
His ita declaratis, oſtendemus, (quod nullus ante nos animaduertit) harum librarum, quæ fulcimentum habent ſurſum, eam eſſe naturam, vt non à quouis pondere appoſito moueantur, vel penitus declinent.

Iiſdem enim ſtantibus, addatur quoduis pondus lanci B; Itaque ſi tale fuerit quod ſuperet reſiſtentiam, quam illi

illi facit centrum grauitatis contra naturam elatum in H mouebitur quædam libra. Sin autem tam parui momenti ſit, vt eam reſiſtentiam non vincat, ſtante circa locum infimum centro C, non mouebitur aut ſaltem parum, ipſa libra.

Hinc colligimus fieri poſſe, libras illas, quæ non " quouis, quantumuis paruo pondere declinant, eas fulci- " mentum habere ſurſum.

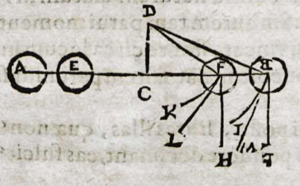
His addimus, cæteris paribus, reſiſtentiam eò eſſe maiorem, quo minus grauitatis centrum diſtat à fulcimento ſurſum, circa quod ipſa libra aduertitur.



Eſto libra A B, cuius grauitatis centrum C, & primò quidem eius fulcimentum ſurſum ſit vbi D, itaque ſi appoſito pondere declinauerit libra ad partes B, punctum C, dum aſcendet deſcribet portionem circuli C E. fulciatur iterum ſurſum puncto F, & iterum declinet ad partes B, & iterum punctum C, dum aſcendet, circuli portionem deſcribet C G. Eſt autem minor angulus contactus A C E, angulo A C G, magis ergo ſurſum, hoc eſt, ad naturam ſui feretur C, per C G, ex centro F, quàm per C E, ex centro D, quod fuerat demonſtrandum.

Hæc autem reſiſtentia ex eodem fulcimento & eodem pondere eo faciliùs ſuperabitur, quo longius brachium libræ fuerit.

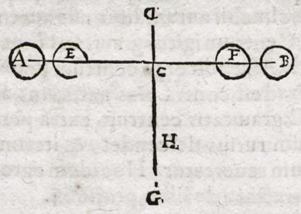
Eſto enim iterum libra A B, cuius fulcimentum D, centrum grauitatis C, ſit & alia libra, cuius brachia breuiora E F, idem habens centrum C, & eidem puncto ſuſpenſa D. Dico igitur, eodem pondere appoſito, faciliùs



declinaturam libram ad partesB, quàm ſi idem apponeretur in F. Demittatur enim à puncto B horizonti perpendicularis B G, & ab F item perpendicularis F H, Tum iuncta D B, centro D, eodem vero ſpatio D B, circuli portio deſcribatur B I, item iuncta D F eodem centro D, ſpatio D F, portio circuli deſcribatur F K. eſt autem maior D B ipſa D F ex propoſ. 21. lib. 1. Elem. quare maioris circuli portio eſt B I quàm F K. Obliquior autem, hoc eſt, à perpendiculari remotior eſt motus per F K quàm per B I. maior ſiquidem eſt angulus K F H angulo I B G. quod nos ita probamus. Ducatur perpendicularis ipſi D F linea L F contingens circulum F K in F, item ipſi D B, perpendicularis M B, contingens circulum B I in B, & quia angulus contingentiæ maioris circuli minor eſt angulo contingentiæ minoris, erit K F L maior I B M, Recti autem ſunt D F L, D B M, minor ergo D F K reſidua ipſo D B I reſiduo. Maior autem D F C ex iam citata propoſ. quã D B C, erit igitur reſiduum C F K, multo minus reſiduo F B I. ſed recti ſunt C F H, F B G, ex quibus ſi detrahantur C F K, F B I, erit reſiduum K F H, maius reſiduo I B G, plus ergo retrahitur à perpendiculari pondus deſcendens per F K quàm per B I, minus igitur præualebit reſiſtentiæ in C pondus appenſum in F, quàm ſi appendatur in B. quod fuerat demonſtrandum.

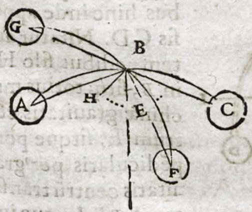
Poſſumus & idem quoque aliter oſtendere.

Sint enim ſeorſum duæ libræ, maior A B, minor E F, quàm commune grauitatis centrum C, fulcimentum verò ſurſum D. Producatur perpendicularis D C, in G & fiat C G æqualis C B, C H verò æqualis C F. Sunt igitur duo vectes



vectes D G, D H, quorum quidem commune fulcimentum D, pondus verò C, potentiæ vbi H G. Sunt autem hi vectes eius naturæ, in quibus pōdus est inter fulcimentum & potentiam, itaque vt se habet D C, ad D G, ita potentia in G ad pondus in C, item vt D G ad D H ita potentia in H ad idem pondus C, sed minor est propositio D C, ad D G quàm D C ad D H. minor ergo potentia requiritur in G, hoc est, in B, quàm in H, hoc est in F. Data igitur ponderis æqualitate faciliùs superabitur resistentia C in B, quàm in F: quod ostendendum fuerat.

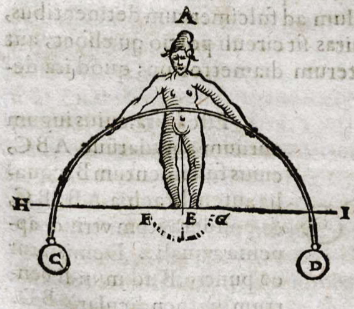
Ad huius libræ naturam illæ quoque rediguntur, quarum iugum non rectum quidem, sed curuum, vel ex rectis sursum in angulum ad fulcimentum detinentibus, nec refert vtrum curuitas sit circuli portio quælibet, aut ellipsis secundum alterum diametrorum; quod ita demonstramus.



Esto libra, cuius iugum curuum angulatūue A B C, cuius fulcimentum B, æqualia autem brachia A B, B C, & pondera item vtrinq; appensa æqualia. Demittatur ex puncto B ad mundi centrum perpendicularis B D. Stante igitur libra A B C in æquilibrio, erit eius grauitatis

tatis centrum in ipſa perpendiculari B D, puta in F. Apponatur pondus in C, declinabit autem libra, ſit autem iuxta poſitionem F B G. Centrum igitur grauitatis E per portionem E H, erit in H. Aſcendit ergo centrum grauitatis in H, hoc eſt, ſurſum, id eſt, contra eius naturam; amoto igitur pondere ex C, grauitatis centrum extra perpendicularem conſtitutum rurſus deſcendet, & iterum libra A B C ad æquilibrium reuertetur. Hoc idem egregiè oſtendit G. Vbald. in tractatu de libra, propoſ. 4.

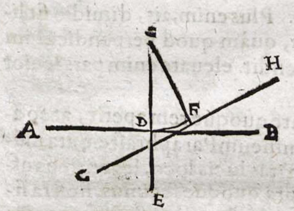
Hinc ratio pendet earum imaguncularum, quas ex contuſa papyro ligneaue leui materia compingunt, perque manus earum ambas, ferreum filum trajicientes, vtrinque plumbea appendunt pondera æqualia, ea quidẽ lege, vt centrum grauitatis infra pedes imagunculæ ſtatuatur. Tunc enim extenſo filo imponentes ceu funambulos per illud, vltrò citroq; decurrere faciunt, imaguncula interim erecta & in neutram partem cadente, quod vt figurâ clarius fiat;



Eſto imaguncula A B, per cuius manus traijciatur filum ferreum curuum cũ æqualibus ponderibus hinc inde appẽſis C D. Nitatur autem pedibus filo H I in *B*, ſitq; totius machinæ grauitatis cẽtrum E, ſitque perpẽdicularis per grauitatis centrũ tranſiens A *B* E. Itaque inclinata imaguncula, & conuerſa circa punctum *B*, ſi declinet

clinet ad partes I, centrum grauitatis eleuabitur in F. Si verò ad partes H eleuabitur in G. quare cum F G loca sint remotiora à mundi centro, quàm sit E, non ſtabit grauitatis centrum in punctis F G, ſed ad infimum locum reuertetur, hoc eſt, in ipſa perpendiculari in E, & imaguncula ad perpendiculum ipſi H B E filo, hoc eſt, ipſi horizonti reuertetur.

Hinc etiam Arietum, Teſtudinumque demolitoriarum Machinarum vis pendet, nempe ex ratione librarum, quæ fulcimentum habent ſurſum.



Eſto enim Aries A B funi appenſus C D, cuius grauitatis centrum D, perpendicularis verò quæ ad mundi centrum ipſa C D E. Stante igitur in æquilibrio machina, centrum grauitatis erit in ipſa perpendiculari. Applicetur alicubi potentia retropellens, eleuabitur igitur centrum grauitatis per circuli portionem D F, cuius ſemidiameter eſt C D, fietque iuxta poſitionem C F. Aries verò in G F H. Dimiſſa itaque Machina centrum F vtpote graue, non ſtabit, ſed ſuapte naturâ reuertetur in D. Quadruplici autem de cauſſa motus Arietis violentiſſimus eſt ex vi naturalis ponderis, quo deorſum fertur, tum velocitate naturalis motus in deſcendendo auctæ, tum ex vi potentiæ impellentis, & naturalem motum adiuuantis, tum ex velocitate ex motu violento deorſum & antrorſum impellente acquiſitâ. Id etiam addimus, eo validiores fore ictus, quò grauior fuerit Machina, & maius ſpatium, quo retrotra-

 hitur,

hitur, grauitate ipsa & spatio tum virium vnione operationem mirum in modum adiuuantibus.

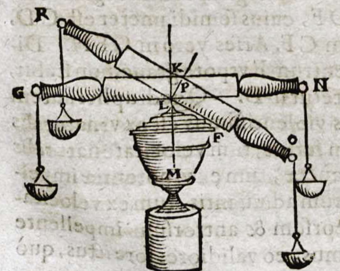
Hæc nos de Libra sursum fulcimentum habente, dicta voluimus, nunc de ea, cuius fulcimentum deorsum est, verba faciemus.

Altera quæstionis pars:

De Libra cuius fulcimentum deorsum est.

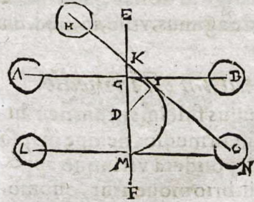
Si deorsum fuerit, inquit Aristoteles, id quod substat, contrarium facit illi quæ sursum habet, nempe ad æquilibrium non reuertitur. Plus enim, ait, dimidio fit libræ, quæ deorsum est pars, quàm quod perpendiculum secet, quapropter non ascendit. eleuata enim pars leuior est.

Hæc ille, qui schemate quoque rem aperit, atq; apud interpretes, & Picolomineum Paraphrastem, ita mendosè lineato, vt inde obscuritas lucis loco, legentibus offundatur. Nos, quod & suprà quoque fecimus, nostra figurâ, sole ipso clariorem, ex Aristotelis ipsius mente rem totam efficiemus.



Sit libra recta, (hoc est, in æquilibrio constituta) vbi N G. Perpendiculum autem (id est, perpendicularis quæ ad mundi centrũ) K L M. Bifariam igitur secatur N G. imposito posthæc onere in ipso N, erit quidem N, vbi O. ipsum autem G vbi R. K L autem vbi L P. quare

quare maius est K O, quam L R, ipsa parte P K L. Amoto igitur onere necesse est manere. Incumbit enim onus excessus medietatis eius, vbi est F. Sensus est igitur, idcirco partem iugi K L O inclinatam, ad æquilibrium non reuerti, propterea quòd maior sit ipsa K L O pars quæ trahit, ipsa R K L, quæ trahitur & eleuatur.



Potest hoc idem longè simpliciori themate demonstrari. Esto enim libra A B, cuius centrum C, fulcimentum vero deorsum D, Perpendicularis per centrum & fulcimentum transiens E F. Apponatur pondus in B, declinabitq; puta ad G H, centrum verò C, ex stabili fulcimento D, circuli portionem describet C I, libra autem secabit E F perpendicularem in K. Æquales autem sunt I G, I H, at ex parte H I desumpta est K I, additaque ipsi I G, maior est ergo tota K G, totâ K H. Non igitur K H habet K G, sed libra, nisi impedita fuerit, cum centro C descendente per I in M, ad ipsam perpendicularem delata, ad inferiorem partem, mutatis vicibus quiescet, facto nempe fulcimento sursum, fietq; horizonti æquedistans iuxta positionem L M N.

Demonstratio quidẽ est hæc, sed non ex proprijs principijs Mechanicis, nẽpe ex ratione cẽtri grauitatis petitâ. Iisdem enim stantibus, cũ centrum grauitatis C fiat extra perpendicularem, descendens ad I, nunquam reuertetur in C, ascenderet enim; sed si liberè circa centrum D conuerteretur, descendens vt dictum est per circulum C I M pondus B, fieret in L, A vero in N adepta positione L M N.

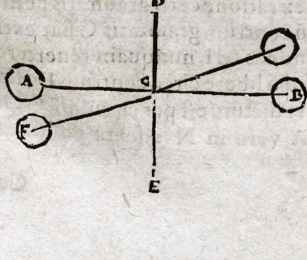
Cur

Cur autem huius libræ, quæ aliâs inutilis est, meminerit Philosophus, ea videtur caussa, quòd inde vectis virtutem eliciat, vt suo loco videbimus. Id autem valde mirum, hominem acutissimum nihil prorsus de ea libra egisse, quæ fulcimentum nec sursum habet, nec deorsum, sed in ipso exquisitè medio, ita vt centrum grauitatis in ipsomet fulcimento consistat. Nos igitur de hac quod operæ pretium fuerit, & ad rem, qua de agimus, vtile, in medium proferemus.

De libra cuius fulcimentum est in medio.

Dicimus itaque, libram, cuius fulcimentum nec sursum est, nec deorsum, sed prorsus in medio, nempe in ipso grauitatis centro, vbi brachia & pondera vtrinque apposita fuerint æqualia, si ab æquilibrio mouentur, quomodocunque posita, stare nec ab eo, quem adepta est, situ dimoueri.

Quæstionem hanc perperam tractârunt recentiores quidam, Hieron. Cardanus, Nicolaus Tartalea, & alij nonnulli, qui Iordani Nemoracij assertiones sunt secuti, quorum demonstrationes vel paralogismos potiùs egregiè confutauit in libr. Mechanicor. Tractatu de libra prop. 4. Guid. Vbald. ad cuius probatissima scripta Lectorem ablegamus. fusissimè enim ibi hac de re & absolutissimè agit. Nos autem quidem paucis ea, quæ ad hanc cognitionem pertinent, explicabimus.



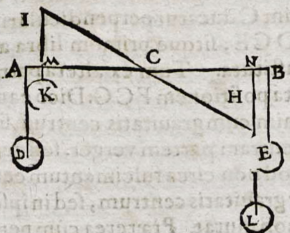
Esto enim libra A B, cuius brachia æqualia, & centrum grauitatis in C, brachijs verò A C, C B æqualibus, æqualia pondera hinc inde apponãtur. Tum fulci-

fulcimento in medio, hoc est, vbi grauitatis centrum C applicato per centrum ipsum C ducatur perpendicularis, quæ ad mundi centrum, D C E, sitque primum libra æquedistans horizonti, constituta. Tum ex altera parte pressa moueatur & fiat iuxta positionem F C G. Dico eam dimissam permanere, etenim cum grauitatis centrum sit in ipsa perpendiculari, in neutram partem verget, sed nec vergere potest, quippe quod non circa fulcimentum ceu centrum motus, moueatur grauitatis centrum, sed in ipso sit fulcimento; situm ergo non mutat. Præterea cùm perpendicularis D C E per grauitatis centrum ducatur, corpus ipsum ex ponderibus & libra constans ab ea in partes ęqueponderantes secatur, & ideo ex centri grauitatis diffinitione, quam protulit Pappus, corpus ipsum centro grauitatis appensum, dum fertur quiescit, & seruat eam, quam à principio habuit positioné. Et sanè si partes quomodolibet librâ per grauitatis centrum diuisâ, sunt æqueponderantes nec trahent inuicem, nec trahentur, stabit ergo libra, & quam adepta fuerat positionem, eam seruabit. Id tamen non negamus, difficile esse libras eiuscemodi ex materia fabricare, quippe quod non omnia quæ vera sunt, & euidentissimis demonstrationibus patent, commodè ad praxim, ex artis & materiæ imperfectione, reducuntur.

Cæterùm harum librarum ea est virtus, vt vel minimo pondere altrinsecus apposito, declinet; quod illis quæ centrum sursum habent, non euenire, demonstrauimus.

Circa hæc posset cuipiam oriri Dubium, num chordulæ, quibus lances appenduntur, variationem aliquam circa ea quæ demonstrata sunt, inducere valeant.

Dicimus nullam inde fieri: Esto enim libra A B, cuius centrum & fulcimentum C, ab cuius extremitate A dependeat, funiculus A D, ab alia verò *B*, funiculus *B* E,



quibus appensæ sint æqualis ponderis lances D E. Moueatur libra, fiatque in I C H, funiculi verò in lancibus in I K, H L. secet autem funiculus I K libram A B, in M, L H verò producatur & eandem secet in N. quoniam igitur I C, æqualis est C H, parallelæ autem K I, L N æquales erũt alterni anguli M I C, N H C, sed & anguli ad verticem I C H, B C H æquales sunt, quare triangulum I M C, æquale triangulo H N C, & latera lateribus, quæ æqualibus angulis subtenduntur. Æqualis est igitur linea M C lineæ N C. Itaque si pondera lancesue, K L mente concipiantur appensæ in punctis M N, ex brachiorum & ponderum æqualitate æneponderabunt. quod fuerat demonstrandum.

QVÆSTIO III.

Cur exiguæ vires (quod etiam à principio dixerat) vecte magna mouent pondera, vectes insuper onus accipientes, cum facilius sit, minorem mouere grauitatem, minor est autem sine vecte?

ARistoteles ita quæstionem proponit, vt eam Rhetorico quodam fuco admirabiliorem faciat. Soluit autem hoc pacto, inquiẽs, fieri posse eam esse caussam, quod vectis sit libra, eius nempe generis quod fulcimentum habet deorsum, atque idcirco in ipsa pressione in partes inæquales vectem diuidi.

Figu-

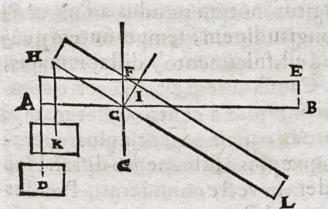


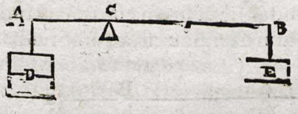
Figura quam exhibet, vix ferè quid ſibi velit explicat. Nos ad eius mẽtem aliam proponemus eamq; longè clariorem.

Eſto vectis A *B*, cuius fulcimentum deorſum in C, pondus D, potentia ex vecte, pondus ſuſtinens E. Perpendicularis per fulcimentum F C G. Itaque quoniam potentia in E non ſuperat pondus D, nec ab eo ſuperatur, ſtat vectis cum potentia Horizonti æquidiſtans, hoc eſt, in æquilibrio, vectis autem in puncto C diuiditur in partes æqueponderantes. Modo præualeat potentia ponderi, & vectem deprimat, fiat autem in L C H, erit igitur *B*, in L, A in H, D in K, & C F, quæ vectem in partes æque ponderantes diuidebat, in C I. Iam igitur non æqueponderant partes, ſiquidem pars vectis F C I, aufertur parti H C I, & adiungitur parti I C L, quæ ideo fit ponderoſior, vnde & potentia ad ponderis eleuationem adiuuatur. Eadem igitur vtitur hic demonſtratione, quam in explicando effectu libræ, cuius fulcimentum deorſum eſt, adhibuerat. Nec alia de cauſſa, vt ſuprà notauimus, videtur eius libræ in ſuperiori quæſtione, conſiderationem introduxiſſe. Et ſanè verum eſt quod concludit, Veruntamen minimi eſt momenti ad tantam vim parua illa adiectio, quæ parti vectis depreſſæ in ipſa depreſſione adiungitur. Aliunde igitur tantæ rei cauſſa eſt petenda, quod & nos deinceps faciemus. Videtur autem ipſe quoque Ariſtoteles non ſibi prorſus in aſſignata ratione ſatisfeciſſe, & ideo ſubiungit: quoniam ab æquali pondere celerius mouetur maior earum quæ à centro ſunt: duo verò pondera, quod mouet &

quod mouetur. quod igitur motum pondus ad mouens longitudo patitur ad longitudinem, semper autem quã-tum ab hypomochlio (id eſt, fulcimento) diſtabit magis, tanto facilius mouebit. Cauſſa autem eſt, quæ retro commemorata eſt, quoniam quæ plus à centro diſtat maiorẽ deſcribit circulum. quare ab eadem potentia plus ſuperabitur id quod mouetur, quæ plus à fulcimento diſtat. Hęc ille, qui aſſerit duo pondera in vecte conſiderari, Pondus nempe motum, & mouentem Potentiam (hanc enim põderis habere vim atq; rationem certum eſt) Vires autem potentiam acquirere ex brachij longitudine, & ex inde conſequenti velocitate, quo enim brachia longiora, eo in extremitate velociora, atque idcirco ita ſe habere motum pondus ad potentiam mouentem, vt brachij longitudo ad brachij longitudinem: brachia autem vocamus, partes illas vectis, quæ à fulcimento ad vtranque vectis extremitatem pertingunt, & ideo quantum à fulcimento potentia diſtabit magis, eo faciliùs pondus mouebit.

Vera vtique & exploratiſſima hæc aſſertio eſt. Veruntamen, cauſſam huiuſce mirabilis effectus, eſſe velocitatem, quæ brachij longitudinem conſequitur, non affirmamus. quæ enim velocitas in re ſtante? Stant autem vectis, & libra dum manent in æquilibrio, & nihilo ſecius parua potentia ingens ſuſtinet pondus.

Dicet ad hæc quiſpiam, velocitatem in longiori brachio ſi non actu, ſaltem potentiâ eſſe maiorem. At quæſo quid in re quæ eſt actu, momenti habet potentia? actu enim ſuſtinet, ſuſtinens. Conſequitur, (id vtique fatemur) neceſſariò velocitas maior motu brachij maioris; non tamen cauſſa eſt cur vis loco vbi velocitas maior fit, appoſita magis moueat. Sanè ex velocitate, dum mouentur, põdus acquirere corpora, tum proiecta, tum cadentia certum eſt, quod etiam in quæſtione 19. cum Philoſopho cõſideſiderabimus. Sed hoc ex velocitate & motu fit, quæ ſunt actu. At brachia in ipſo æquilibrio ſuſtinent actu quidem, ſed non mouentur. Cæterùm videtur Ariſtoteles id ſubodoraſſe, quod poſtea Archimedes, Mechanicorum princeps, in propoſ. 6. primi Æqueponderantium explicitè protulit & probauit: nempe in æquilibrio ita eſſe pondus ad pondus, vt brachium ad brachium, ratione permutata.

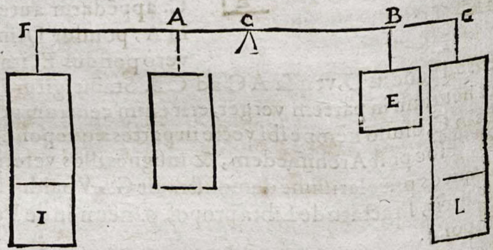


Eſto enim vectis A B, quomodolibet fulcimento diuiſus in C. appēdatur autem in A, pondus D, in B verò pondus E, ita ſe habens ad pondus D, vt ipſa A C ad C B. Stabit igitur vectis, & neutram in partem verget, erit enim centrum grauitatis in C, diuiſo nempe ibi vecte in partes æqueponderantes. Hoc poſt Archimedem, & inſignes illos veteres Mechanicos præclariſſimè demonſtrauit G. Vbaldus in Mechanicis, Tractatu de Libra propoſ. 6. necnon de Vecte propoſ. 4.

Cæterùm vt aliquid interim, quod noſtrum ſit, afferamus, liceat nobis egregios illos viros interrogare, quænam mirabilis eius effectionis ſit cauſſa? Dicent permutatam proportionem. Teneo, at nondum acquieſco: petam enim, Cur ea rationis permutatio mirabilem illum effectum pariat. Hoc quod illi non docent, puto nos, ignorantiæ ſomno ſepultos, ſomniaſſe.

Æqualitatem ſtatus eſſe cauſſam, nemo, vt puto, inficiabitur. res eſt enim per ſe clara. Eſto ſiquidem linea quæpiam A B, applicetur extremitati A potentia quædam quæ lineam ad ſe trahat ad partes nempe A, Tum in B quædam alia potentia ipſi quæ in A potentię, æqualis, quæ lineam trahat ſimili modo ad partes B. Datâ igitur harum potentiarum æqualitate, linea A B, nec ad partes A, nec ad partes B transferetur, ſed prorſus immobilis ſtabit.

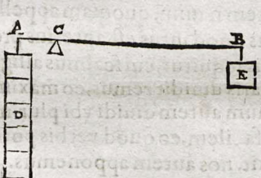
His ita conſtitutis, Dico vecte quomodolibet diuiſo, ponderibuſque vtrinque appoſitis, permutatâ proportione ſibi inuicem reſpondentibus, rem eſſe redactam ad æqualitatem, & inde ſtatum fieri, hoc eſt, æquilibrium.



Eſto enim vectis A B, quomodolibet diuiſus in C, & ipſi quidem C fulcimentum ſupponatur. Appendantur quoque vtrinque pondera ex ratione brachiorum A C, C B, ſibi inuicem permutatim reſpondentia, ſintq; D E. Dico vectem ex æqualitate, in neutram partem inclinaturũ, ſed permanſurum in æquilibrio. quoniam enim Pódus D idem poteſt quod brachium C B, addatur in directum ipſi A C, recta A F æqualis ipſi C B, item quoniam Pondus E id poteſt quod brachium A C, rectæ C B addatur in directum B G, ipſi A C æqualis. Igitur cum partes C A, A F totius F C, æquales ſint partibus C B, B G, totius C G, erit totum F C, toti C G æquale. Diuiſus itaque

que erit vectis F G in partes æquales F C, C G in puncto fulcimenti C. Et quoniam æquale in æquale non agit, stabit vectis & in neutram partem inclinabit. Rursum quoniam ad partem F C, duæ sunt brachiorum potentiæ F A, H C, appendantur puncto F, duo pondera H, I, ipsis D E æqualia, item puncto G, alia duo pondera ijsdem D E æqualia K L, iterum æqueponderabit, quippe quod æqualibus brachijs F C C G æqualia appensa sint pondera H I K L. Cur igitur seruata permutatim brachiorum & ponderum proportione fiat æquilibrium, ex his quæ demonstrauimus, clarè patet.

Sed forte dicet quispiam, si brachia, pondera sunt, vel ponderibus æquipollentia, sustinenti duplicabitur pondus.



Esto enim vectis A B, ita diuisus in C, vt pars maior C B minori A C sit in proportione quintupla. Appendatur autem in A pondus D, quintuplũ ponderi E appenso in B. Si igitur brachio A C, quod est vnum, addatur pondus D, quod est quinque, fient sex, item si brachio C B, quod est quinque, addatur pondus E, quod est vnum, fient sex. Fulcimentum igitur sustinebit duodecim, quod est absurdum ex ijs quæ clarè demonstrauit G. Vbald. in Mechan. tractatu de Libra propos. 5. His respondemus, brachia quidem operari non pondere, sed potentiâ, quæ vis quædam est, non autem pondus. Etsi & illud verum sit, dato vecte ponderoso, fulcimentum tum ponderum appensorum, tum vectis ipsius pondus sustinere.

Iacta huiuscemodi, quam diximus, æqualitate, sequitur

quitur necessariò, centrum grauitatis ipsius vectis cum appensis ponderibus, ac si vnum idemque esset corpus cadere in perpendiculari quæ per centrum ipsum & fulcimentum transiens ad mundi centrum pertingit.

QVÆSTIO IV.

Quærit hic Aristoteles, cur ij qui in nauis medio sunt remiges maximè nauem moueant?

AIt, ideo fortasse fieri, quòd remus vectis sit, fulcimentum verò scalmus, stat enim. Pondus autem mare ipsum, quod à remo propellitur, mouens verò ipsum remigem, semper autem plus mouere ponderis qui mouet, quo magis distat à fulcimento. Ita enim maiorem fieri quæ ex centro; Scalmum verò centrum esse. Cæterùm in medio nauis plurimum remi intus esse. Ibi enim nauem esse latissimam. Moueri autem nauim, quoniam appellẽte mari remo, extremũ illius quod intus est anterius promouetur, cuius motum nauis sequitur, cui scalmus alligatur. Vbi autem plurimum maris diuidit remus, eo maximè necesse esse propelli. Plurimum autem diuidi vbi plurima pars remi à scalmo est. Rem facilem, eo quod verbis potuerit, schemate non declarauit, nos autem apponemus.

Esto enim nauis A B, mare C D, remorum alter, qui ad proram E F, cuius scalmus G, alter verò in medio nauis, H I, circa scalmum K. Ait igitur, remos esse vectes, scalmos verò fulcimenta, pondus quod remo, ceu vecte, mouetur mare ipsum. Itaque quoniam nauis lata est in medio vbi Scalmus K maior pars K H intra nauim est, minor verò K I, extra. Contra autem remi ad proram, nempe E F pars minor E G intra

intra nauim, pars verò maior GF extra nauim est. Pondus autem eò faciliùs mouetur, quo maior est vectis pars, quæ à fulcimento est ad mouentem potentiam.

Acutè sanè Philosophus. Ego autem si per modestiam liceret, dicerem, non quidem esse fulcimentum scalmũ, sed mare ipsum, pondus vero nauim, ad locum scalmi, nẽpe inter mouentem potentiam, & fulcimentum positum, etenim & eo pacto possumus vti vecte, quod obseruat & demonstrat G. Vbaldus tractatu de vecte propos. 2. Erunt igitur in descripta figura puncta F I, quæ in mari sunt, fulcimenta, quibus remorum extrema in ipsa impulsione nituntur, pondera verò seu pondus pluribus vectibus & potentijs impulsum nauis ipsa, quæ scalmis est annexa. Resistente igitur mari, cedente autem impulsionibus scalmo, nauis eo transfertur, quo scalmi ab ipsa potentia mouente in anteriorem partem pelluntur. quoniam autem vt F G ad F E ita potentia mouens in E ad pondus motum in G. item vt I K ad I H ita potentia mouens in H ad pondus motum in K, maior autem est proportio F G ad F E quàm proportio I K ad I H. Maiori indiget potentia vt pellatur pondus in G quàm pondus in K.

Hæc certè vti diximus ita se habent. Philosophi autem ratio tunc procederet, si stante naui immobili, vt fit vbi à Remoræ occulta vi aut ab alio impedimento retinetur, remiges in ipso remigandi actu mare pulsarent, Tunc enim verè scalmus fieret fulcimentum, mare autem pondus, remex verò ipse mouens.

Addimus, falsum videri quod asserit Aristoteles, nempe illos qui in media naui sunt, remiges, maximè nauim mouere; facilius, melius dixisset. Si enim maximè, quod ait, denotat maximo spatio, & velocius prorsus falsum, etenim tardius mouent & minori spatio, quod nos ita demonstramus.

F Esto

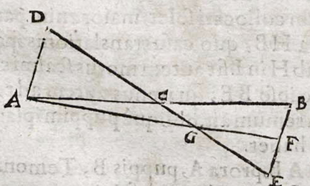
Eſto enim Remus AB qui mari fulcitur in B, Scalmus remi qui ad prorã puppimue C, qui in media naui D, maior autem remi pars eſt à ſcalmo D ad A quam ipſius G ad A, Pellantur remi & ſtante ceu centro B A, in E. eodem igitur tempore C erit in F, & D in G, ſed maius eſt ſpatium C F ſpatio D G. Ergo vnica impulſione, plus mouit ſcalmum, hoc eſt, nauim, potentia ad puppim proramue remigans, quàm ea quæ operatur in media naui vt ſentire videbatur (ſi modo is eſt eius ſenſus) Ariſtoteles. Neceſſarium igitur eſt, quod ait, maximè intelligendum, faciliùs, Veritatem hanc cognoſcentes Triremium præfecti robuſtiores quidem remiges ad proram & puppim, inualidiores verò circa mediam triremem collocant.

QVÆSTIO V.

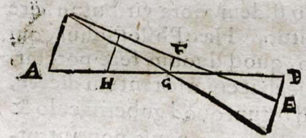
Dubitatur, Cur paruum exiſtens gubernaculum, & in extremo nauigio tantas habeat vires, vt ab exiguo temone, & ab hominis vnius viribus alioqui modicè vtentis magnæ nauigiorum moueantur moles?

AN, inquit, quoniam gubernaculum vectis eſt, onus autem mare, Gubernator vero mouens eſt? Non autem ſecundùm latitudinem veluti remus, mare accipit gubernaculum; non enim in ante nauigium mouet, ſed ipſum commotum mare accipiens inclinat obliquè. quoniam enim pondus eſt mare contrario innixum modo nauem inclinat. fulcimentum enim in contrarium verſatur, mare verò interius, & illud exterius. illud autem ſequitur nauis quæ illi eſt alligata. & remus quidem ſecundum latitudinem onus propellens & ab eodem repulſus in rectum

ctum propellit, Gubernaculum verò, vt obliquum iacet hinc inde in obliquum motionem facit. in extremo autē, non in medio iacet, quoniam mouenti facillimum est motum mouere: prima enim pars celerrimè fertur, & quoniam, quemadmodum in ijs quæ feruntur in fine deficit latio, sic ipsius continui in finem, imbecillima est latio. Imbecillima autem ad expellendum est facilis. Propter hæc igitur in puppi gubernaculum ponitur, nec minus, quoniam parua ibi motione facta, multo maior fit in vltimo, quia æqualis angulus semper maiorem adspectat, tātoque magis, quanto maiores fuerint illæ, quæ continent. Ex ijs etiam manifestum est, quam ob caussam magis in contrarium procedit nauigium, quam remi ipsius palmula, eadem enim magnitudo ijsdem mota viribus in aëre plus quàm in aqua progreditur. Hæc Philosophus, qui haudquaquam ex more suo, quod duobus ferè poterat, sexcentis verbis exposuit. Licebat enim id tantum dicere, Gubernaculum (ita vocat id totum quod gubernaculo & temone constat) esse ceu remum, quo nauis non antrorsum, sed obliquè & ad latus mouetur. quamobrem omnia ferè quæ de Temone dicenda fuerant, de remo loquens proponit. Ait autem:



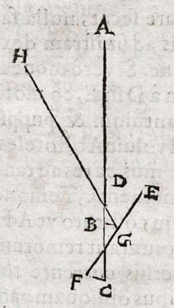
Sit remus A B, scalmus vero C, remi in nauigio principiū A, palmula autem quæ in mari B. Si igitur A, vbi D translatum est, non erit B vbi E. æqualis enim B E ipsi A D, æquale igitur translatum erit, sed erat minus. erit igitur vbi F, minor enim B F, ipsa A D, quare ipso G F ipsa D G. Hæc demonſtratio licet vera videatur, rei tamen, de qua eſt ſermo, minimè aptatur. Si enim aptaretur in ipſius remi motu, cum palmula eſſet in F, ſcalmus fieret in G, excurreret ergo vel ſcalmus per remum, vel remus per ſcalmū, facta nempe eiuſmodi translatione de C in G, & ſic intra nauim modo eſſet pars remi D C, modò verò G D, quod tamen non fieri ipsâ experientiâ docemur. Illud quoque falſum eſt, nauim ipſam tantùm moueri in aëre, quantum eſt ſpatium A D, hoc eſt, remi extremum quod eſt in naui, ſiquidem ſcalmi motu, non autem manubrij remi, nauis agatur. Aliter igitur res ſe habet, & forte hoc pacto.



Sit remus A B, cuius manubrium A, palmula B, ſcalmus C. Pellatur antrorſus A, fiatq; in D, tunc ſi æqualiter mouerentur manubrium & palmula, ipſa palmula fieret in G, at minus mouetur: fiet ergo in E. ipſe verò ſcalmus C translatus erit in F, motaq; erit nauis à C in F, non autem ab A in D. Poſuit autem Ariſtoteles ſcalmum ad medium remi, ſed non ad medium collocari ſolet, maior enim pars in mare propendet puta H B, quo caſu translationis ſpatium fit maius, nempe ab H in I. fit autem motus ſcalmi ex centris qui ſunt in ſpatio ipſo B E, quatenus autem ad temonem pertinet, quem remum ait, obliquè puppim ipſam propellentem, ita ſe res habet.

Eſto nauis carina A B, prora A, puppis B, Temonis ala B C, gubernaculum B D, cardo verò fulcimentumue B; facta itaque impulſione obliquâ gubernaculi à D in E, minor fiet motus in mari à C in F, eritque temo vbi E G F,

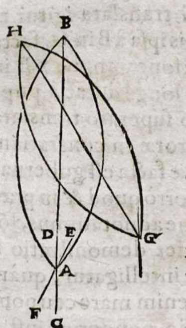
cardo



cardo verò vbi G, translata igitur erit eo motu, puppis ipsa à B in G. facta itaque paruâ motione puppis ex B in G, prora ipsa quæ longè distat à puppi B maiori spatio superato translata erit in H facta proræ in contrariam partem ab ea quæ facta est gubernaculi motione. Porrò quod & in præcedente quæstione adnotauimus, lōgè meliùs procedet demonstratio si fulcimentū mare intelligatur, quàm scalmus, neque enim mare ceu pondus, sed scalmus ipse Temonis ue cardo, ponderum instar transferuntur.

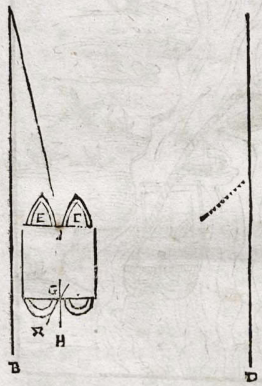
Cæterùm in hac speculatione liceat nobis aliquantulum à Philosopho dissentire. Certè si breuitas Temonis, è puppi eminentis, respectu longitudinis totius nauis consideretur, & parua motio, quæ temone gubernaculoue moto fit, nullius ferè momenti erit ad eam quæ in prora fit translationem. aliter ergo se rem habere non dubitamus, & quæstionis solutionem aliunde petendam. Naui non currente nullum ferè, aut qui vix curandus sit ex gubernaculi conuersione nauis ad dextram sinistramue motum fieri. at eâ currente maximum, experientiâ docemur. Obliqui igitur motus qui validè in puppi fit, caussa est non quidem ex conuersione temonis percussio maris, sed mare ipsum, cuius fluctus naui currente obliquam temonis alam ad eam partem quæ mari obuertitur, impellentes temonem cum puppi ad contrariam partem validissimè transferunt.

Esto nauis carina A B, prora B, puppis A, Temo A C, gubernaculum A D; Itaque currente naui, Temone interim & gubernaculo in eadem carinæ linea existentibus,



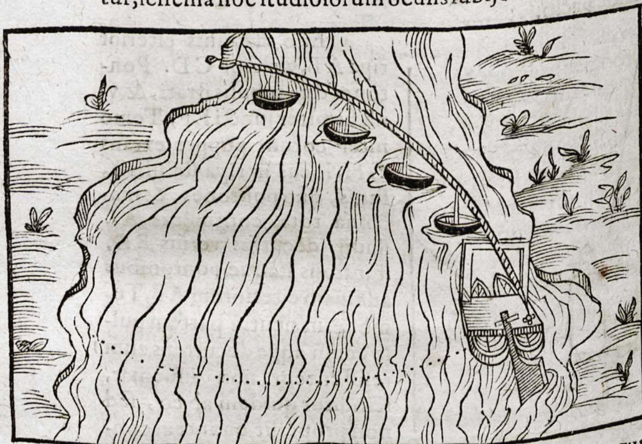
Temo quidem mare ſecat, nullâ factâ in puppi, nauis ad ſiniſtram dextramue translatione. Si verò moueatur gubernaculum à D in E, eo moto mouebitur aliquantulum & puppis ad partes E, quod voluit Ariſtoteles. Sed minimi, vt diximus, ea res ad tantum effectum eſt momenti. Temone autem in obliquum cõſtituto vt A F, naui interim, ventorum aut remorum vi pulſa proram verſus currente temonis latus à fluctibus obliquam partem alamue in ipſo curſu ferientibus, in contrariam partem transfertur, ad eám nempe, ad quam ipſum gubernaculum vergit. facta igitur nauis ceu circa centrum centraue quæ in carina inter puppim proramue conſiderantur A, fertur in G, prora verò in H. ex quibus manifeſtè apparet, duo ad nauis ex temone in puppi conuerſione motionem eſſe neceſſaria; Temonis nempe obliquationem, & nauis curſum, quorũ ſi alterum ſine altero adhibeatur, nullam fieri quæ alicuius momenti ſit, nauis conuerſionem. Illud quoque notamus, carinam in nauis conuerſione vectis inſtar ſe habere, cuius pars mota ad puppim, & mouens potentia eſt; fulcimentum verò circa proram, potentia autem mouens mare ipſum, temonem in nauis curſu oblique feriens. Vnde colligimus naues, quo longiores ſunt in mouente ad Temonem adhibita maiori facilitate ad dextram ſiniſtramue propelli: quod ſanè ipſemet conſiderauit Ariſtoteles, qui idcirco inquit, in extremo, non autem in medio temonem poni eo quod mouenti facilimum ſit ab extremo motum mouere.

Ex hac noſtrâ ſpeculatione ratio habetur eius machinachinationis, quâ in magnis fluminibus, ceu Pado, Abdua & similibus, Portitores, equos, currus, viatoresq; ipsos, è ripa in ripam transferunt. Pulcherrima enim res est, & nobis perspectissima, qui Guastallâ residentiæ olim nostræ oppido ad Padum, Mantuam pergentes sæpissimè ad Castrum Burgi Iusis ea qua diximus machinatione latissimum eiusdem Padi aluum transiecimus. Habet autem se hoc pacto.



Esto fluminis citerior ripa A B, vlterior C D. Pontones duo tabulis strati, & vnâ firmiter juncti E F, Temo inter eorum puppes extans G H, locus in ripa stabilis A, funis, quo pontones, & machina tota continetur A I. fluuij decursus versus B D, stantibus itaque pontonibus ad ripam citeriorem A B, Temone in neutrã partem pulso, cum aqua decurrens eum resistentem non inueniat, scinditur quidem ab eo, sed non propellit, eo autem conuerso & in G K constituto, ala eius G K ab aqua defluente propulsa machinam secum trahit versus ripam C D, factâ motione circa centrum seu stabilem locum A, otiosis interim portitoribus, donec per circuli portionem M L deuenerit ad vlteriorem ripam in L. Vnde iterum temone in contrariam partem conuerso, aquâ similiter temonem propellente, per eandem circuli portionem ad ripam citeriorem reuertitur, à qua paullo antè discesserat. Ex quibus apparet, motus caussam non esse

esse solam eam, quæ ab ala temonis fit, aquæ percussioné, vt senserat Aristoteles, sed currentis aquæ temonis alam ferientis impulsionem: nihil autem referre, vtrum stante naui aqua currat, vel eâ currente aqua stet, vt in mari fit, idem enim vtroque modo temo patitur. Vt autem machinæ huius & totius negotij species facilius animo concipiatur, schema hoc studiosorum oculis subijciemus.

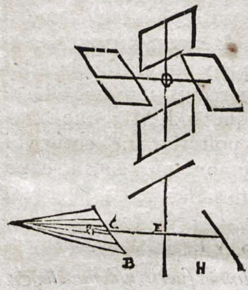


Lembi nauiculæue ideo appositæ sunt, vt oblongum funem sustineant; id etenim nî fieret, aquæ immersus aquam scindens machinæ motum impediret, ideo etiam apponuntur, ne funis madens celeriter maceretur & putrescat.

Huic speculationi affinis est ea, velorum eorum, quæ obliquè ventum excipientia frumentarijs molis dant motum, item verticillorum ex papyro, quibus contra ventum currentes per lusum pueri vtuntur. vnicum enim

enim horum omnium principium & eadem ratio.

Diximus enim, Temonem currente naui, lateraliter conuersum obuios fluctus excipientem puppim ipsam obliquè in alteram partem transferre. Porrò ea vela, de quibus loquimur, ventorum flatibus obliquè opposita eandem ob caussam circulariter agitantur, quod vt figurâ euidentius fiat,

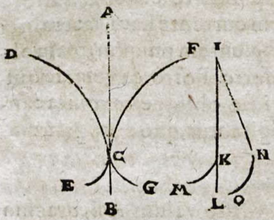


Esto velum AB, brachio CE obliquè affixum ita vt angulus ACE maior sit angulo BCE, ventus obliquè velum feriens FG. Itaq; quoniam ventus in velum obliquum incidit, elabitur velum, & circa centrum E vnà cum brachio circumuertitur, in cuius locum succedit velum HI, ex qua assidua velorum successione, brachiorum & axis cui adhærent, rotatio fit perpetua. Sed enim de Temone agentes non est interim cur de caudis auium piscium que taceamus. instar enim temonum sunt à Natura ipsa opportunis animalium partibus, postremis videlicet, appositi, quanquam nec solum Temonis vsum præstent, vt videbimus.

Esto piscis AB, cuius caput A, cauda verò CB. Hac igitur neutram in partem reflexâ, piscis pinnarum motu rectâ in anteriorem partem progreditur. Si autem necesse ei fuerit ad dextram sinistramque conuerti non poterit, nisi cauda ipsa iuuetur. Omnis enim motus progressiuus quiete indiget, nec absq; stabili fulcimento progredi

 potest,

poteſt,quod in libris de animalium inceſſu docet ipſemet Philoſophus. Sit igitur, piſcem conuerti velle,& fieri capite in D, deflectet illico caudam in E,eaq; aquam ceu ſtabile quippiam feriēs eique quodammodo fultus, reliquum corpus C A reflectet in D, ſi autem conuerti velit in F,caudam deflectet in G,& eadem ratione flectetur in F. Sed & Temonis quoque vſum præſtat natatilibus & volatilibus cauda. Sit enim rectus piſcis,hoc eſt, rectâ pergens I K L, caudam obliquet in K M itaque ex aquæ in ipſo motu colliſione,eius poſteriora pellentur vbi I N O. Hæc itaque nos de Temone,quatenus ad hanc quæſtionem pertinet,conſideraſſe ſit ſatis.

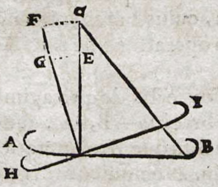


Qvæstio VI.

Dubitatur, Cur quanto Antenna ſublimior fuerit, iiſdem velis, & vento eodem celeriùs ferantur nauigia?

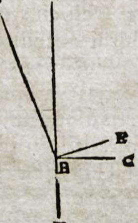
SOluit Philoſophus,inquiens : *An quia malus quidem ſit vectis,fulcimentum verò mali ſedes,in qua collocatur,pondus autem quod moueri debet, ipſum nauigium: mouens verò is,qui vela tendit ſpiritus ? Si igitur quanto remotior fuerit fulcimentum facilius eadem potentia, & citiùs idem mouet pondus, altiùs certè ſublatâ antennâ, velum à mali ſede,quę fulcimentum eſt remotius faciens, id efficiet.* Hæc ille. quæ ſic figurâ explicamus.

Eſto



Eſto nauis A B, malus C D, mali ſedes D, locus antennæ ſublimior C, depreſſior E: itaque quoniam C D vectis eſt, quo mouens remotior fuerit à fulcimento D, eo citiùs & violentiùs pellet, velocius ergo nauis mouebitur antenna in C, quàm in E, conſtituta.

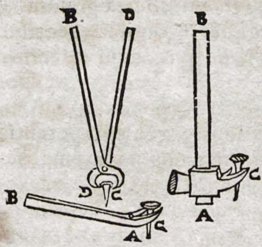
Plauſibilia ſunt hæc, at certè per veritatem ipſam, non vera. Rogo, Si fulcimentum dum vectis mouetur, cẽtrum eſt, centrum vtique motus erit D. ſpirante igitur validè vento inclinabitur malus, fietq; vbi F G D, quæ quidem inclinatio violentius fiet, vento pellente in F q uàm in G, vtpote puncto à fulcimento remotiore. Impulſo malo, duo neceſſariò cõſequontur, vel enim ad ipſam ſedem D. frangetur vel puppis ipſa circa D punctum conuerſa, vt mali ſequatur motum eleuabitur. Prora verò ſubmergetur facta naui in H D I. Quod ſi quiſpiam funem ad mali ſummitatem annexam ad ipſam puppim alligauerit in B, impedietur ſanè mali inclinatio ad partes F, & ideo nulla vis prorſus fiet in D ex vectis ratione. Attamen nihilo ſecius, quo ſublimior fuerit antenna, eo faciliùs à ſpirante vento puppis eleuabitur. quatenus igitur malus vectis eſt, hoc tantum quod dicimus operatur. Quod ſi contrà obiectum fuerit, experientiam docere, quo ſublimior antenna fuerit, eo citiùs nauigium, ſpiritu flante moueri. Reſponſio facilis, nempe, mirum non eſſe, ſi mali pars ſublimior validius à vento feriatur. Videmus enim, & turres quo ſublimiores fuerint, eo magis à ventorum impetuoſis flatibus infeſtari, quod ſanè ad vectis longitudinem referre, eſſet ridiculum. Cæterùm quod ad puppis faciliorem eleuationem ex mali ipſius altitudine pertinet, ad vectis contemplationem reducimus. est enim quædam vectium species ab alijs non considerata, cuius brachia in angulum desinunt, vt ipse angulus in operatione sit fulcimentum.



Esto enim vectis, de quo agimus, A B C, cuius brachia A B, B C. iuncta ad angulum B, sitque B in operatione fulcimentum. Nec quicquam refert quatenus ad vsum pertinet, vtrum angulus ipse rectus sit, acutus vel obtusus. sit autem modò rectus. Ponatur igitur pondus aliquod in C, tum potentia quædam applicetur in A, quę ipsam vectis extremitatem A propellat in D. erit igitur A B in D B & angulo seruato B C in B E. Pondus igitur cum parte vectis B C eleuabitur in E. In hoc autem vectis genere attenditur proportio quam habet A B ad B C. Si enim potentia quæ applicatur in A ita se habet ad pondus in C vt C B, ipsi B A, fiet æquilibrium. Si maior autem fuerit proportio potentiæ in A, ad pondus in C, ea quam habet A B ad B C, superatâ ponderis resistentiâ fiet motus. Res autem haud aliter se habet, ac si producta in F, fieret B F æqualis B C. Tunc enim vectis ad rectitudinem, seruatâ proportione, redigeretur, & ita potentia in A, fulcimento B operaretur in F, vt operabatur in C.

Ad huius vectis naturam referuntur fabrorum mallei, quibus clauos reuellunt, forcipes item quæ tenaci morsu clauorum capita vmbellasue apprendentes, violenter è tabulis extrahunt. In malleo itaque subtili, vt in figura videre est, A B vectis est pars quæ à fulcimento ad potentiam; ac verò quæ à fulcimento ad pondus, ponderi

siqui-



ſiquidem æquiparatur reſiſtentia quę fit in C. Idem obſeruamus in forcipe, in quo duo quidem brachia AD, CB, quatenus ad apprenſionem pertinet, fulcimentum habent in ipſo cētro ſeu vertebra, & ideo quo longiores fuerint, eo tenaciùs apprehendunt & retinent. quatenus autem ad extractionem facit, pro vnico forceps totus habetur vecte, cuius quidē pars à potentia ad fulcimentum AB. quæ verò à fulcimēto ad hoc eſt clauum ipſum qui reuellitur AC. Violentiſſimè autem extrahunt forcipes, propterea quod maxima ſit proportio longitudinis brachij BA, ad eam quæ eſt ab A ad C.

His igitur hoc pacto examinatis, ad nauim & malum reuertentes, dicimus, tunc facillimam fieri puppis eleuationem, proræ verò demerſionem, cum maxima fuerit proportio, quam habet altitudo mali, ad eam nauis partē quæ à malo ad ipſam puppis extremitatem pertingit. Quamobrem prudentes nauium fabri, vt huic difficultati occurrant, malum non in medio quidem nauis, ſed in tertia ferè parte longitudinis quæ à prora eſt, puppim verſus conſtituunt.

Eſto enim nauis AB; cuius malus CD: prora A: puppis B; vēto igitur velum impellente, malū ad partem contrariam vergit, puta in FD. At quoniā carcheſium funi ad puppim vnitur in B, nauim, hoc eſt, ipſam puppim trahat ne-

 ceſſe

cesse est. non potest autem; quoniam suburræ grauitas & onera, quæ naui imposita inter D. & *B*. grauitatis centrum circa punctum E constituunt, quod quidem vi ventorum inclinante malo ab E, in G eleuaretur, quo igitur minor fuerit proportio C D ad D E & maius pondus ipsum cuius grauitatis centrum in E minus præualebit potentia pellens in C ad eleuationem partis nauigij, quæ à mali sede ad puppim intercedit. An igitur malus sit vectis, pes verò fulcimentum, pondus autem quod vecte mouetur, ipsũ nauigium, vt placuit Aristoteli, & qua item ratione malus in nauim vt vectis operetur, ex ijs quę dicta sunt, facilè patet.

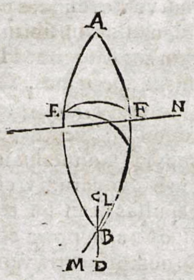
QVÆSTIO VII.

Quæritur, Cur quando ex puppi nauigare voluerint, non flante ex puppi vento, veli quidem partem, quæ ad gubernatorem vergit, constringunt; illam verò quæ proram versus est, pedem facientes, relaxant?

MIrabilis huius effectionis caussam explicat Aristoteles. inquit enim, An quia retrahere quidem multo existente vento gubernaculum non potest, pauco autem potest, quem constringunt? propellit igitur quidem ipse ventus, in puppim verò illum constituit gubernaculum retrahens, & mare compellens: simul & nautæ ipsi cum vento contendunt; in contrariam enim se reclinant partem. Hæc ille.

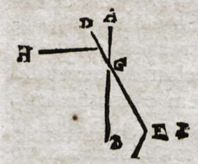
Cuius sensum breuitate subobscurum, mirâ facilitate explicat Picolomineus. Nos autem vt rem lucidiorem faciamus, schema, quod nec ipse fecit, nec Philosophus, proponemus.

Esto nauis A *B*, cuius prora A, puppis verò D, gubernaculum C *B*, temonis ala *B* D, veli sinus E F, velum vero ita cõnstitutum, vt directè ex puppi flantem ventum excipiat.



piat. Hoc vbi euenerit, nauigium rectâ è puppi mouetur in proram; Si autem ventus lateraliter ſpirat, puta à parte G verſus H & nihilo ſecius nauigium ac ſi ventus ex puppi eſſet antrorſum propellere volunt, velum quidem obliquant partem eius infimam, pedem nempe, quæ eſt in F contrahentes, Cornu verò antennæ vbi E, proram verſus laxantes ventumq; ipſum obliquè excipientes id efficiũt, vt ventus minus violenter feriat, & minori ſui parte velũ impleat, & quoniam ventus velum pellit in partem contrariam, nempe in H, ipſi vt vento reſiſtant conuerſo gubernaculo ex C in L, & temone *B* D, in *B* M compellunt proram ad partem à qua ventus ipſe ſpirat. Sit igitur inter ventum & temonem pugna, illo proram in dextram, hoc verò eandem in ſiniſtram pellente, itaq; cum neuter præualeat, neceſſario nauis mediam viam, quæ inter vtramq; eſt, ſuo curſu tenet. Nautæ autem ideo in partem nauis A E *B*, quæ verſus ventum eſt, ſe conferunt, vt vento æquilibrium faciant, ne ſcilicet naui in cõtrariam partem pellente ſpiritu, eam demergat. Cæterùm quod nec Ariſtoteles nec Picolomineus animaduerterunt, velum obliquè conſtitutum à vento in anteriora impellitur eandem ob cauſſam, quam retulimus, vbi de temone & velis, quibus farinariæ molæ cõuertuntur, verba faceremus. Quod autem addit Picolomineus rem ad vectem reduci poſſe, non eſt cur ſub ſilentio prætereamus. Ventus, inquit, ponderis gubernaculum mouentis vicem obtinet; centrum verò (fulcimentum intelligit) in medio nauis eſt, quod tamen

men ad proram vergit, vt faciliùs ipsi vento resistere possit. Tunc enim in rectum mouebitur nauis, cum sibi inuicem æquatæ vires, quasi libramentum constituerint. Hæc ille, cuius sensum figurâ propositâ facilè aperiemus.



Esto carina A B, cuius prora A, puppis B, temo B C, ventus verò obliquè feriens H. Conuersus itaque temo vt in B C vndarum vi currente naui repulsus sit in E F tendens versus I, quo casu prora condens uertitur in D, nempe contra ventũ qui spirat ex H. fit autem conuersio circa punctum G, quod fulcimenti locum obtinet. Vẽtus verò ad contrariam partẽ proram impellit, repugnans Temonis violentiæ contra ipsam proram dirigentis. Est igitur A B, seu D E carina, instar vectis, cuius fulcimentum G, vis mouens mare quo temo E F repellitur, pondus verò, ventus premens in D; quo igitur remotior erit temo à fulcimento G, D autem vbi pondus ei vicinius, eo magis temo venti vim superabit. Hæc Picolominei ratio, quam explicauimus, sanè ingeniosa est, verum enimuero, quoniam fulcimentum sui naturâ stare debet, hic verò nullã habeat stabilitatem, difficultatem patitur.

QVÆSTIO VIII.

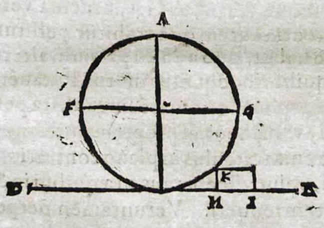
Quæritur, Cur ex figuris omnibus rotundæ faciliùs moueantur?

TRifariam, inquit Aristoteles, circulum rotari contingit; Aut secundum absidem cẽtro simul moto, quemadmodum plaustri vertitur rota; aut circa manens centrum, veluti trochleæ puteorum, stante centro: Aut in pauimento manente centro, sicuti figuli rota conuertitur.

Caussam

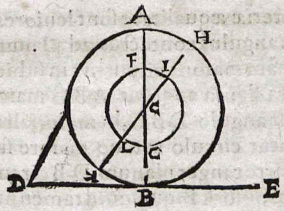
Caussam verò explicans, ait, celerrima eiusmodi corpora esse, eo quod paruâ sui parte planum contingunt, vti circulus secundum punctum, item quoniam non offensant: Non offensandi vero esse caussam, quod semotum à terra habeant angulum. Item propterea quod corpus, cui fiunt obuiam, secundum pusillum tangunt. Rectilineo autem aliter euenire, quippe quod rectitudine suâ, multum plani contingat. Ad hæc, quo nutat pondus eo mouentem mouere.

Hæc ferè Philosophus, cuius rationes ad eum solummodo circularem motum faciunt, qui fit secundum absidem, vt in carrorum rotis vsu venit, nec aptantur rotis figulorum trochleisque, cuiusmodi sunt illæ, quæ supra puteos appenduntur. Nos igitur, ad Aristotelis mentem, primam rotationis speciem, quæ est secundum absidem, examinabimus.



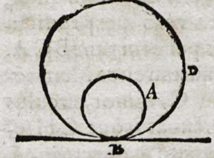
Esto rota sphæraue A B, cuius centrum C; Horizontis planum DE; contactus circuli in plano B. perpẽdicularis horizonti à puncto cõtactus B ipsa BCA, transiens per centrũ C, partes rotæ circa perpendicularem AFB, AGB, angulus contactus GBE. Primo itaque id constat, circulum in puncto planum, seu lineam contingere. At quoniam, vt Mechanici, de circulis rotisque seu sphæris agimus materialibus, rectè Philosophus non in puncto planum præcisè tangere dixit, sed secundum partem sui minimam. Angulum porro, quem à terra semotum dicit, ipse angulus est contingentię. eleua-

tur enim ex *B* in G. Si autem corpus quodpiam in plano
fuerit, puta HI in puncto illud tanget ci culus ei occur-
rens, exempli gratiâ in K. Hæc igitur accidunt circulari
figuræ. In lateratis autem ſecus fit, quippe quæ nec in pũ-
cto ſeu ſecundum paruam ſui partem, planum tangunt,
nec ſemotum vt circulus à plano habent angulum, nec
i npingentes offendiculum in puncto tangunt. Cæterùm
potiſſimam facilitatis motus in rotatione quæ fit ſecun-
dum abſidem, eſſe cauſſam dixit, nempe quò nutat pon-
dus eò à mouente impelli ac moueri. Primò igitu circu-
laris ſphæricaue figura in æquilibrio ſtat; æquales enim
ſunt partes quæ circa perpendicularem: ceu ſunt A F *B*,
A G *B*. ſi enim impulſus fiat ex parte F, pars oppoſita nuta-
bit, & propendet in pa tem G, & ſuo nutu motuq; ſecum
trahet partem A F *B*, fietque progreſſus. Si enim ducatur
F C G diameter, ipſi horizonti æqu diſt ans, erit veluti li-
bra, cuius pondera vtrinque A F *B*, A G *B*, brachia verò
æqualia C F, C G. Potentia autem quâ trahitur pellitur-
ue ad inſtar ponderis ſe habet, quo addito partium alteri,
factoque receſſu ab æquilibrio, ſequetur motus. Putauêre
quidam, vt refert Philoſophus, circularẽ lineam, ita per-
peti motu verſatum iri, vt manentia, propter contrarium
nixum, manent, neque enim circulus in plano contrarium
nixum habet, cum ſit, veluti dicebamus, in æquilibrio &
facilis in vtramuis partem moueri. Veruntamen perpe-
tuum eſſe non poſſe horum corporum motum, ea eſt cauſ-
ſa, quod violentum accidat naturæ, & ideo non durabile.
Ad hæc, addit Philoſophus, Maiores circulos ad minores
nutum habere quẽdam; & nutum maioris ad minoris nu-
tum, ſe habere vt angulos ad angulos, & diametrũ ad dia-
metrum. Angulos autem hîc ſectores ipſos vocat; oportet
enim circulos tum maiores tum minores circa idem cen-
trum eſſe conſtitutos. Hæc autem non abſimili ab eo
quod ſuprà poſuimus ſchemate explicantur.
Eſto

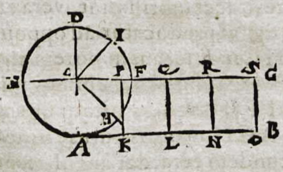


Esto enim circulus A B circa centrum C, Horizontis planum D E, tangens circulum in B, linea verò perpendicularis per centrum B C A. Sit autem circa idem cētrum C, minor circulus F G, ducaturque C H secus minorem circulum in I, tangens verò maiorem in H, constituensque cum A C linea angulum A C H, duos angulos, ex Aristotelis mente comprehendentem, hoc est, duos sectores A C H, F C I. quoniam igitur sector seu angulus A C H, suo spatio superat angulum seu sectorem F C I, facilè ex nutu quem maior supra minorem habet, maior ipse minorem mouet. Videtur autem tacitè Philosophus hæc ad vectis naturam referre, cuius altera extremitatum in centro sit, altera verò in abside, & ita se habere nutum maioris supra minorem, vt vectis ad vectem, hoc est, semidiameter ad semidiametrum, seu sector ad sectorem, quos quidem sectores, vt vidimus, angulos appellat. Hæc autem quæ de nutu refert, licet subtilia sint, vera esse non videntur. Si enim in figura producatur ad oppositam partem semidiameter H C in K secans minorem circulum in L, duos alios sectores angulosue habebimus, nēpe K C B, L C G, ipsis A C H F C I æquales. Itaq; quantum adiuuat motum anguli A C H maioris nutus, in descendendo ad partes B, tantundem retardat anguli item maioris K C B, contra nutus (vt ita appellem) in ascendēdo ad partes A. & sanè quatenus ad rei naturam pertinet & ad ipsum æquilibrium, non differunt maiores circuli à minoribus, nec sunt maiores minoribus mobiliores, imo ex aliqua ratione minores videntur fore ad motum faciliores,

liores, tum quia data materiæ æqualitate sunt leuiores, tum etiam quod maior est angulus contactus ad planum circumferentiç minoris quàm maioris circuli, vt in subiecta figura angulus A B C maior est angulo D B C, in materiali igitur circulo rotaue maiore sui parte tanget planum D B circulus, ipso A B. quicquid tamen sit, mobiliores sunt maiores circuli non quidem ex natura circuli, quæ tam in maioribus quàm in ipsis minoribus est par, sed alijs de caussis, quas suo loco examinabimus.



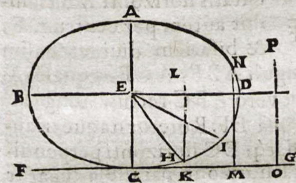
Cæterùm vt aliquid de motu qui secundum absidem fit, ex nostro penu promamus, Dicimus, Circulos, rotasue, quæ hoc pacto mouentur, vel per horizontis planum moueri, vel per accliue, aut decliue. Si autem per horizontis planum, ideo facilem esse motum, quòd nunquam, cæteris paribus, centrum grauitatis ipsius corporis à centro mundi, in ipsa rotatione, fiat remotius.



Esto enim planum horizontis A B, cui circulus insistat A D, circa centrum C, diuisus per centrũ ipsum à perpendiculari A C D; Ducatur autem per centrum C recta linea horizonti æquidistans, E C F G: dum diuidatur circulus vtcunque in partes A H, H F, F I, I D, & C I, C H iungantur. Posthæc intelligatur circulum secundum absidem moueri ad partes G, erit igitur aliquando punctum H, tangens horizontis planum, tangat autem in K, tum F in L, I

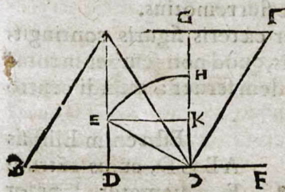
L,I in N. D verò in O. Ducanturque K P, L Q, N R, O S ipsi A C parallelæ horizonti autem perpendiculares. Centrum ergo circuli, quod idem & grauitatis est centrũ, feretur per rectam C P Q R S, sunt enim K P, L Q, N R, O S ipsi A C semidiametro æquales, nũquam igitur centrum ipsum C in circuli rotatione ab horizontis plano eleuabitur, nec à mundi centro fiet remotius.

Hoc autem longè aliter cæteris figuris contingit, quarum motus ideo inæqualis, quòd non semper in rotatione centrum grauitatis eandem seruet à mundi centro distantiam.



Estò enim Ellipsis A B C D, cuius cẽtrum E, diameter longior B E D, breuior A E C, Horizontis planum F C G. locus contactus C perpendicularis à contactu per centrum ipsa C E A diuidens Ellipsim in partes æquales, & æqueponderantes A B C, A D C. Sumantur in quadrante C D, pũcta H I, tum E H, H I iungantur, erit autem E H longior ipsa E C, tum E I, ipsa E H & E D, ipsa E I. Rotetur ellipsis secundum absidem, fiet igitur punctum H in K, & à puncto K horizonti perpendicularis erigatur K L, quæ fiat æqualis E H. Post hæc punctum I erit in M, & ab M perpendicularis, æqualis E I. rursus D fiat in O, & ipsi E D, æqualis perpendicularis O P. Mota igitur ellipsi à C in K, haud ita difficilis erit motus, quippe quod haud multum E H superet E C, at difficilior erit translatio in M, difficillima verò in O. Valde enim à situ E, vbi attollitur grauitatis centrum, ascendens nempe vbi P. Videmus igitur ex his eandem potentiam

tiam in mouendo ellipſim, haud pariter ſe habere, vt in mouendo circulum. ibi enim centrum grauitatis fertur per æquidiſtantem horizonti, hic verò modò attollitur, modò deprimitur, quod ſanè moleſtiam & difficultatem facit. Sed idem alijs figuris contingere, & maximè lateratis, ita docebimus.



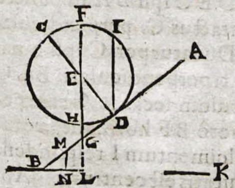
Eſto enim triangulum æquilaterum ABC, cuius grauitatis centrum E horizontis planum BD. Demittatur à vertice A perpendicularis horizonti AF tranſibit autem per centrum E, & bifariam diuidet baſim BC in F. Sunt autem trianguli ABF, ACF, æquales & æqueponderantes. angulus verò AFC rectus. Iungatur EC, erit igitur maior EC, ipſa EF. Rotetur itaque triangulum circa punctum C, fiatq; EC horizonti perpendicularis, ſitque CH, & per E horizonti parallela ducatur EK, moto igitur triangulo, centrum grauitatis E translatum erit in H, ſed KC æqualis eſt EF, minor autem ipſa CH, eleuatur ergo centrum grauitatis ab E in H, nempe ſupra K, totum ſpatium KH. ex qua eleuatione fit in motu difficultas. Idem prorſus eadem demonſtratione oſtenderetur fieri in quadrato & alijs lateratis figuris. Cur igitur in plano horizontis facillimè circularia, difficile autē laterata & quæ inæquales habent ſemidiametros, moueantur, ex dictis clarè patet.

Ad hanc quæſtionem illud quoque facit, cur per decliue planum grauiora corpora, & rotunda maximè, magno impetu dimiſſa, delabantur.

Eſto enim rota ſphæraue aut Cylindrus CD, cuius centrum E, tangens decliue planum AB in D, quæritur

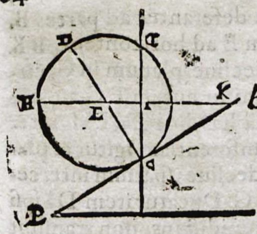
cur

tur dimiſſa hæc magno impetu deferantur ad partes B, Ducatur per grauitatis centrum E ad horizontem BK perpendicularis FEL ſecans decliue planum in G, circumferentiam verò in H. opponitur autem EG angulo recto EDG, maior ergo EG ipſa ED, hoc eſt, EH, inter circumferentiam igitur & planum decliue, ſpatium intercedit HG. Ducatur item DI ipſi FG æquidiſtans. non tranſibit igitur per centrum E. minor erit igitur diametro CD, quare circulum in partes inæquales ſecabit, & non per grauitatis centrum, quod idem cum magnitudinis ſeu figuræ centro ſupponitur.



Dimiſſa igitur rota, contingit quidem planum decliue in puncto D. At centrum grauitatis premit ſecundam per lineam perpendicularem FG, non ſuſtentatur autem in H, quippe quod inter planum & circumferentiã intercedat ſpatium HG, nec H locum habeat cui innitatur, corpus autem ita per lineam DI eſt diuiſum, vt longè maior ſit pars IFCHD ipſa DI, & centrum in ea parte cadat quæ non fulcitur. itaque ſuopte nutu, cum extra fulcimentum ſit D & perpendicularem DI ad inferiores partes rapidè rotans delabitur. Ducatur autem perpendicularis GL, parallela MN, & quoniam BN breuior eſt BL, erit MN ipſa GL breuior. Eſt igitur punctum M mundi centro propius quàm D & G, quare eò non impedita rota ipſa ſuo nutu feretur, nec ſtabit donec infimum locũ vbi quieſcat naniſcatur. Poſſumus etiam Rota ſphæraue in plano decliui collocata, datam potentiam inuenire, quæ extremitati diametri ad eam partem qua vergit applicata ipſam rotam ſphæramue impediat ne delabatur.

Eſto



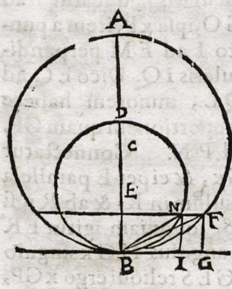
Esto planum inclinatum A B, cui Rota sphæraue insistat tangatq; illud in C. Rota verò ipsa sphæraue D C, cuius centrum E, diameter verò D E C ipsi B A ad punctũ contactus C, perpendicularis. Ducatur per C ipsi horizonti perpendicularis F C G circulum secãs in G tum per E ipsi C G perpendicularis, ipsi verò B F horizonti æquidistans H E I ceu vectis, cuius fulcimentum I respondens ipsi C, pondus verò in E, vbi grauitatis est centrum. Applicata igitur potentia in H erit pondus inter fulcimentum & potentiam, quare vt I E ad I H ita potentia sustinens in H ad pondus in E, quod demonstrandum fuerat.

Quippiam simile ostendit Pappus 1.8. prop. 9. alijs tamen suppositis & consideratis. Dico præterea, ijsdem stantibus angulum E C I æqualem esse angulo inclinationis C B F. Producatur H I concurrens cum ipsa A B in K, concurret autem propterea, quod C I K rectus sit, I C A minor recto, & quoniam H K parallela est horizonti B F alterni anguli I K C, C B F, æquales erunt. Similes autem sunt E C I, E C K, trianguli, estque E C I angulus æqualis angulo E K C, hoc est, ipsi C B F. vnde sequitur, quo minor fuerit inclinationis angulus, eo facilius rotam sphæramue in plano inclinato sustineri. quo enim minor fuerit angulus E C I, eo minus latus E I & minor proportio E I ad I H, & ideo minor potentia sustinens requiratur in H. Cæterùm accliue & decliue planum nihil differunt nisi respectu.

His ita consideratis, admonet nos locus, vt pulcherrimam dubitationem diluamus. Quæritur, Cur maiores

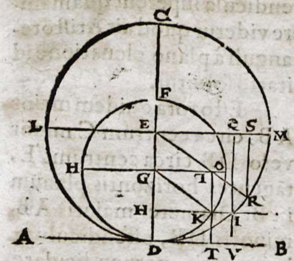
rotæ

rotę impingentes, facilius offendicula superent quàm minores. Neque enim satisfacere videtur quod ait Aristoteles, ex contactu in puncto eo anguli à plano eleuatione id fieri, alijs ergo principijs dubitatio soluitur.



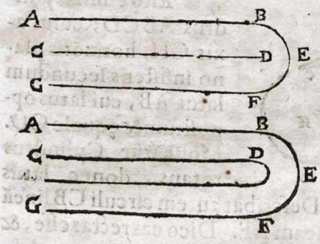
Esto rota quidem maior A B, circa centrum C minor vero D B circa centrum E, tāgentes horizontis planum in B. Diameter maioris A B, minoris D B, offendiculum horizonti perpendiculare F G. Ducatur per F horizonti parallela F K secans minoris rotæ peripheriam in H, diametrum verò A B in K, & à puncto H ad planū horizontis perpendicularis demittatur H I: erit autem H I æqualis ipsi offendiculo F G, & iungantur B H, B F. Itaq; quoniam B H ab extremo B cadit in triangulum K F B, erit K H B angulus maior angulo K F B. Parallelæ autem sunt K F, B G, pares ergo anguli K H B, H B G, pares item K F B, F B G, Maior ergo H B I, ipso F B C. At minoris rotæ grauitatis centrum mouetur secundum lineam B H, maius verò secundum literam B F, difficilius ergo mouebitur, & superabit offendiculum minor rota, quàm maior: quod fuerat demonstrandum.

Possumus idem ostendere magis mechanicè, hoc est, rem ad vectem reducendo. Esto horizontis planum A B, rota maior C D planum tangens in D. rotæ verò maioris centrum E. Rota verò minor F D, tangens itidem planum in D. rotæ autem centrum G, offendiculi verò rectitudo D H. Ducatur per H ipsi A B horizonti æquidistans H I secans minorem circulum in K, maiorem verò



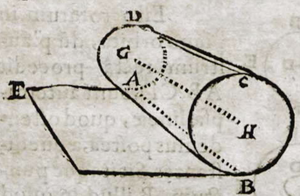
in I. Ducantur etiam diametri maioris quidem L E M, minoris N G O, Tum à puncto K perpendicularis ducatur ad G O, ipsa K P, item à puncto I ad E M perpendicularis I Q. Dico E Q ad Q L, minorem habere proportionem quam G P, ad P N. Connectatur G K, & ei per E parallela ducatur E R, secans maiorem circulum in R, & ab R ipsi E M perpendicularis ducatur R S. quoniam igitur E R parallela est ipsi G K, erit G E R angulus H G K angulo æqualis. Recti autem sunt H G P, G E S reliqui ergo K G P, R E S ad inuicem sunt æquales. Sed & E S R, G P K recti sunt, quare E R S G K P anguli æquales sunt, & trianguli G P K E S R, per pr. diff. l. 6. similes. Vt ergo G K hoc est G N ad G P, ita E R hoc est E L ad E S. Componendo igitur vt N P ad P G, ita L S ad S E. quamobrem si fulcimentum esset in S, pondus in E, potẽtia in L, idem fieret ac fiat fulcimento in P, pondere in G, potentia verò in N constituta. & id quidem si eiusdem ponderis vtraque rota supponatur. Rursus quoniam vt D K ad totum circulum D F, ita D R ad totum D C. Minor est autem proportio D I ad totum circulum D C, ergo minor est D I ipsa D R. Maior ergo M I ipsa M R, maior ergo Q I ipsa S R, propius ergo centro E est Q ipso puncto S, minor est igitur proportio E G ad L Q quàm E S ad S L. Minor ergo potentia requiritur in L ad sustinendum pondus E ex fulcimento Q hoc est I, quàm requiratur in N ad sustinendum pondus G ex fulcimento P, hoc est K. Minor ergo potentia requiritur ad ad transferendam maiorem rotam C D vltra offendiculum IV, hoc eſt, D H, quàm requiratur ad transferendam minorem vltra offendiculum K T, hoc eſt H D, quod fuerat oſtendendum.

Ad hæc, quæri poteſt, quo pacto plauſtrorum rotæ in ipſa plauſtri conuerſione ſe habeant, nempe quæ ſit linea illa curua, quam in conuerſione deſcribunt.



Eſto rotarum in plano orbita, dū plauſtrum rectâ procedit A B, C D, Sunt autem ipſæ lineæ, quod oſtendemus poſtea, æquediſtantes. Sit itaque punctum B illud in quod rota quæ per A B fertur, eò delata planum tangit, D verò alterius rotæ atque plani contactus. Igitur dum plauſtri fit conuerſio, punctum D conuerſionis fit centrum. Stat enim interim rota & circa lineam conuertitur, quæ à puncto contactus D per rotæ centrum ducta horizontis plano eſt perpendicularis. ea autem ſtante, rota quæ in B circa centrum D ſemicirculū pertranſit DEF, vbi autem rota B, peruenerit in F, plauſtro iam in oppoſitam partem conuerſo, rota quæ eſt in D per lineam DC, quæ verò in F per rectam F G mouetur, plauſtrique fit regreſſus. Et quoniam vel D in ipſa conuerſione ſtat omnino nec quicquam progreditur, vt in prima figura, vel non ſtat vt in ſecunda, quo caſu portionem parui circuli deſcribit, ipſi maiori circulo & exteriori concentricam. Vnde colligimus, Plauſtrorum conuerſiones flexioneſque ſemper circa centrum, & concentricorum circulorum portiones fieri. Hinc etiam diſcimus, cur veteres, vt ex antiquis cognoscimus vestigijs, circos in quibus cursus quadrigarum fiebant ea forma quæ apparet, efformauerint. Hoc etiam theorema probamus.

Cylindros, quorum bases axi sunt perpendiculares, dum in æquato plano conuoluuntur, rectâ incedere & per parallelas, quarum distantia axis seu latoris longitudine præfinitur.



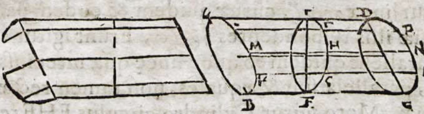
Esto enim Cylindrus ABCD, cuius axis GH, horizõtis plano insistens secundum latus AB, cui latus oppositum & ęquale CD. Moueatur Cylindrus rotans, donec latus CD, in plano sit vbi EF. Describat autem circuli CB lineã BF. Circulo verò AD lineam AE. Dico eas rectas esse, & parallelas. Si enim superficies basium DA, CB, extendantur ita vt horizontis planum secent, illud secabunt iuxta lineas AE BF, recta ergo est vtraque. Sed & parallelas esse ad inuicem ita ostendimus. quoniam semicirculus AD, æqualis est semicirculo BC, erit linea AE, æqualis lineæ BF, sed & AB, æqualis est ipsi DC, quare & ipsi EF. Opposita igitur quadrilateri figura ABFE latera æqualia sunt, quare EF æquedistat ipsi AB, tum AE ipsi BF, quod fuerat demonstrandum.

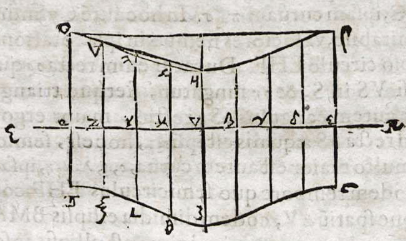
Probabimus etiam si cylindri bases axi perpendiculares non fuerint, & ideo ellipses in ipsa rotatione per planum, parallelas quidem describere, sed non rectas.

Esto enim Cylindrus ABCD, cuius bases ellipses inuicẽ æquedistãtes, quarum axes longiores AB, CD, Communis autem sectio cylindri & plani ad axem & horizontem planum perpendicularis EHF. Diuidatur autem semicir-

culus

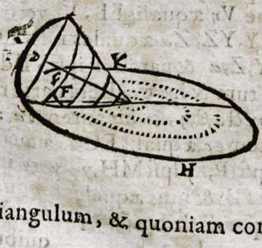
culus EHF in partes æquales quatuor FI, IH, HG, GE.





Tum per diuisionum puncta lateri parallelę, rectæ ducantur KGL, MHN, OIP, quæ quidem cũ bases AMB, DNC parallelæ sint, erunt inuicem æquales, cumque circumferentia EHF æquales, eosque rectos angulos cõstituent, Ducatur post hæc seorsum recta QR, & eidem perpendicularis ST eam secans in V. applicetur autem rectæ ST æqualis Cylindri lateri BC, ipsa $\eta\zeta$. ita tamen vt punctum E congruat puncto V, sitque Vη æqualis EB, Vζ verò æqualis EC. Tum fiant VX, XY, YZ, Zα æquales ipsis EG, GH, HI, IF, & per puncta X, Y, Z, α, & paralleli ipsi ST ducantur $o\alpha\pi$, νzξ, $\lambda\gamma\mu$, κxθ, tum & his ex altera parte respondentes parallelæ per puncta $\beta,\gamma,\delta,\varepsilon$. Sit autem $o\alpha$, æqualis AF, $\alpha\varpi$ æqualis FD, item $\varepsilon\varrho$, æqualis EC, $\varepsilon\sigma$ æqualis EB, sed & νz ęqualis OI, zξ ipsi IP, λy ipsi MH, yμ verò ipsi HN, tũ κx ipsi KG. & xθ, ipsi GL & ipsis æquales & ęqualiter positæ ad partes R, aliæ parallelæ aptẽtur per $\beta,\gamma,\delta,\varepsilon$, quibus ita diſpoſitis per puncta $o, \nu, \lambda, \kappa, \eta$, item per $\pi, \xi, \mu, \theta, \zeta$. ducantur lineæ $o\eta$, $\pi\zeta$, curuæ quidem & eodem pacto aliæ curuæ illis reſpondentes $\eta\varrho$, $\zeta\sigma$, Erunt igitur o, η, ϱ, π, ζ, σ, parallelæ quidem eo quod lineę quæ inter ipſas ducuntur, parallelæ ſint & æquales, non tamen rectæ illæ, ſed curuæ. Moto igitur Cylindro circulus EHF rectam deſcribet $\alpha\varepsilon$, ellipſis verò AMB, curuam $o\eta\rho$, ellipſis autem DNC, ipſam curuam $\pi\zeta\sigma$. In hoc autē Cylindri motu illud mirabile, velociores nempe, in ipſa rotatione eſſe ellipſes ipſo circulo EHF. Ducatur enim recta $o\varrho$ quæ occurrat ipſi VS in S, & $o\eta$ iungatur, fietque triangulum $o\eta$S. eſt autem angulus oSη rectus, maior ergo $o\eta$ ipſa oS, ſed recta oS æqualis eſt ipſi $\alpha\nu$, hoc eſt, ſemicirculo FHE. multo maior eſt autem curua, $o, \nu, \lambda, \kappa, \eta$, ipſa recta $o\eta$, ſed eodem tempore quo ſemicirculus EHF conficit in rotatione ſpatiū αV, eodem dimidia ellipſis BMA metitur curuam $o\nu\lambda\kappa\eta$. velocior igitur eſt ellipſis ipſo circulo.

Hæc quoque ſpeculatio ad motum qui ſecundum abſidem fit, manifeſtè pertinet. Coni, quorum baſes circuli ſunt, ſi in plano ſecundum latus rotentur, baſi circulum deſcribunt, cuius centrum immobile coni ipſius eſt vertex, ſemidiameter verò ipſum latus.



Eſto conus ABC cuius vertex C baſis AB, axis DC, baſis verò centrum D, latus quo planum tangit BC, ſecatur itaque Conus per latus BC & axem DE à plano horizonti perpendiculari, cuius & coni communis ſectio eſt ABC triangulum, & quoniam coni grauitatis centrum eſt in axe

axe ipſo,conus in partes æquepõderantes ſecatur AEBC, AFBC, ſtat ergo conus ſibimet æquilibris. Si autem à potentia quadam moueatur,puta ab A verſus F, trahitur ſemicirculus BEA,à ſemicirculo AFB,& ita fit rotatio. Itaque ſi imaginemur,infinitos vſque ad verticem parallelos baſi circulos,eorum ſemicirculi in ipſo motu & trahent & trahentur;at cum ad verticem circuli deſinant,nec ibi ſemicirculi ſint qui trahant & trahantur, motus rotationis prorſus ceſſat & vertex ipſe immobilis fit rotationis centrum. Quoniam igitur lateris BC, punctum C ſtat,B verò circa ipſum mouetur, in ipſo motu circulus deſcribitur BHIK, cuius ſemidiameter BC, & eodem pacto alij circuli in cono, qui baſi HEBF ſunt æquediſtantes, circulos in plano circa idem centrum deſcribent, vt facile videre eſt in obiecto ſchemate. Huic ſimilem demonſtrationem affert Heron in libello Automatum, quem nos Tyrones adhuc vernacule è Græco translatum, Venetijs prælo ſubiecimus.

Porrò ſi conus rotundus pro baſi ellipſim habeat, ſectionem videlicet per planum axi non perpendiculare, in ipſa rotatione,ſtante vertice, ellipſis baſis, ellipſim deſcribit in plano, cuius maior diameter à puncto quod coni vertex eſt,ita diuiditur,vt diametri pars maior æqualis ſit lateri maximo;minor verò æqualis lateri minimo. Sed hæc ad aliam pertinent ſpeculationem.

His itaque de motu rotundorum,qui circa abſidem fit,conſideratis,reliquum eſſet de motu trochlearum,qui circa centrum fit,opportunè agere, ſed cùm in ſequenti quæſtione de hoc ſermonem faciat Philoſophus, ad ea quæ ibi diſputabuntur, lectorem ablegamus.

Modò de tertia motus ſpecie nobis erit ſermo; in qua quidem ſpecie nonnulla perpendemus,quæ omiſit Ariſtoteles. Agitur autem hìc de rotundorum corporum motu,

motu, qui fit çirca axem horizonti perpendicularem, axis altera extremitate in eodem horizontis plano manente, vti videre eſt in ipſis figulorum rotis.

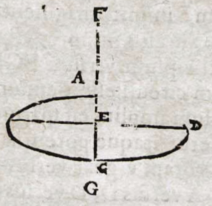
Hanc motus ſpeciem in extrema quæſtionis parte cum duabus alijs ſpeciebus comparans ait, eam quæ in obliquo fit motionem (ita enim hanc, de qua agimus, appellat) ipſam impellere mouentem, hoc eſt, nullum ex ſe ad motum propenſionem habere, nutumue, & omnia illi eſſe à motore, ſecundum verò eam motionem, quæ ſupra diametrum eſt, ſe ipſum mouere circulum. Dixerat enim, ea referens quæ ſuperiùs circa principium de circulo verba faciens, examinauerat, circulum ex duabus fieri lationibus, altera præter, altera verò ſecundum naturam, & ideo hanc ſemper nutum habere, & ceu continuo motam ab eo moueri qui mouet. Videtur autem clarè profiteri, ideo difficiliorem eſſe huius tertiæ ſpeciei motum, eo quòd nutu careat proprio & tantum ab alieno, vt ita dicam, motore, moueatur.

Veruntamen motum hunc facilitate alijs illis duobus nequaquam cedere, facilè ex ſequentibus oſtendemus.

Primo, quia pondus totum rotati corporis, ex grauitatis centro quod in ipſo axe eſt à plano cui nititur, ſuſtinetur: minima quidem ſui parte axe ipſo tangente planũ vnde fit, nullam ferè dum rotatur corpus, circa centrum vbi nititur, frictionem partium fieri. Præterea grauitatis centrum ſemper ſtat, nec minimum quidem in ipſa rotatione attollitur, quod ſanè cum naturæ ſit repugnans, difficultatem facit. Ad hæc circa axem ita libratur rota, vt quantumuis exigua potentia alteri parti applicetur, altera illico ſuperata moueatur. Licet enim propriè ea tantũ corpora æquilibrare dicantur, quæ ob ponderis hinc inde æqua-

æqualitatem horizonti fiunt æquidiſtantes, nihilominus & hic aliquam eſſe æquilibrij ſimilitudinem patebit.

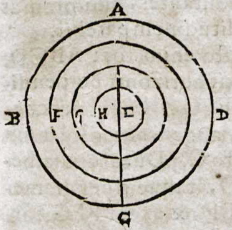
Eſto enim rota ABCD, cuius axis horizonti perpendicularis FEG tranſiens per centrum E, tangens autem planum in puncto G. Ducatur diameter BED, Itaque ſi per diametrum BED, & axem FEG corpus diuidatur, eo quòd centrũ grauitatis in axe inueniatur, corpus ipſum in duas partes tũ mole tum põdere æquales ſecabitur, nempe BAD, BCD. Nulla igitur adhibita vi extranea ſtabit corpus in quodã, vt diximus, æquilibrio. At alteri partium potentiâ quauis licet exigua appoſitâ, puta in C, præualebit pars BCD, & partem BAD vel impellet vel rapiet, alterâ interim eius motui obſequente. Potentia igitur quæ in C, nullam rem quæ impediat inueniens, velociſſimè rotam mouet, quod eo faciliùs velociusq́ue fit, quo magis rota eſt in motu, eius verò diameter maior & potentia mouens à centro remotior, & ſanè motus facilitatẽ inde cognoſcimus, quòd ipſo impulſore ab impulſu ceſſante, diutiſſimè rota impreſſum motum ſeruet, nec niſi poſt longam rotationem omnino quieſcat.



Cæterùm quia ſicco, vt aiunt, pede Ariſtoteles quæ ad hunc motum pertinẽt pertranſijt, nos quædam quæ ad hanc rem faciunt, diligentiùs expendemus.

Quærimus igitur primò; Cur ea quæ hoc pacto rotãtur, in ipſa rotatione locum non mutent, niſi extrinſeca aliqua id fiat ex cauſſa.

Eſto enim rota aut aliud quippiam rotundum ceu Turbines ſunt, quibus pueri ludunt, quod circa axem horizonti



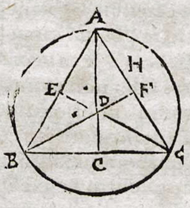
rizonti perpendicularem moueatur, ABCD, cuius centrum E, Diameter AEC. Modò circa centrum E infiniti imaginentur circuli, alij alijs minores vſque ad centrũ ipſum, vti ſunt FGH; ibi enim circuli eſſe deſinunt, vbi nullum amplius eſt ſpatium. Applicetur itaque potentia in B, quæ rotam vigeat verſus A. eodem igitur tempore & inſimul A verſus D, D verſus C, & C verſus B mouebitur. quantum enim ſemicirculorum à parte CBA tranſit vltra diametrum AEC, tantundem ſemicirculorum, qui ſunt ad partem ADC, tranſibit ad partes CBA. At vbi deſierit motus, ibi deſinit rotatio; vbi autem deſinit ſpatium, deſinit motus, ſed vbi deſinunt circuli, deſinit ſpatium, quare in centro cum non ſint circuli, nec ſpatium ibi deſinit motus. nulla enim adeſt ratio, cur ipſum corpus alio à loco in quo eſt, ex rotatione transferatur. Stat ergo rotans, quod fuerat demonſtrandum. Eſt autem hæc demonſtratio ei ſimilis, quam ſuprà retulimus de coni in plano circa verticem rotatione, quam ab Herone in Automatis excogitatam diximus.

Addimus in hoc rotationis genere corpus in ipſo motu fieri leuius, idque eo magis, quo rotatio velocior. Cauſſa eſt, quod lateralis motus eum motum aliqualiter impedit, qui ex naturali grauitate fit ad centrum, idcirco experientiâ docemur, leuiſſimos eſſe turbines, quibus pueri ludunt, ſi manus teneantur palmâ, dum citiſſima rotatione mouentur.

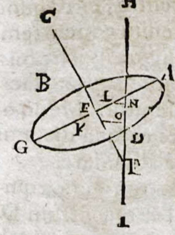
Ad hæc alia proponitur, & ſoluitur quæſtio, Cur rotunda corpora huic motionis generi ſint aptiora.

Exploratiſſimum eſt, corporum, quæ ita mouentur, par-

partes eo esse velociores, quo magis à centro, circa quod mouentur, fuerint remotiores. maius enim eodem tempore spatium pertranseunt. quo igitur figura ijs partibus, quæ longius à centro absunt, abundauerit magis, eo facilius, & velocius in circulum rotata mouebitur. Modò ostendemus, circularem cæteras omnes ea qua diximus partium à centro remotissimarum copiâ abundare.



Esto triangulum puta æquilaterum ABC circa centrum D. Ducantur Catheti per centrum ab oppositis angulis ad opposita latera ADG, BDF, CDE, erunt autem lateribus perpendiculares. quoniã igitur latera AD, DB, DC, rectis angulis subtenduntur, maiora erũt lateribus DE, DF, DG. tres igitur lineæ in hoc triangulo sunt longissimæ DA, DB, DC. tres verò breuissimæ DE, DG, DF, quamobrem rotato super centrum D triangulo, tres tantum partes eius ABC velocissimæ erunt, tres verò tardissimæ E, G, F. Minus igitur apta est motui huic triangularis figura, quam quadrata, in qua partes à centro remotissimè, & ideo velocissimè sunt quatuor. Itaq; quo magis laterata figura angulis abundabit, eo magis erit ad hunc, & cæteros omnes circulares motus aptior. At circulus infinitas, vt ita dicam, partes à centro remotissimas habet, itaque nulla figura est circulari, in ipsa rotatione, commodior atque velocior. Alia quoque de caussa id fit, quod dum circularis figura mouetur, nullis eminentibus angulis aërem verberet circũstãtem, ex qua verberatione motus impeditus sit tardior. Quæri etiam potest, Num axe inclinato, rotæ motus aliqualiter impediatur? Nos negatiuam partem amplectimur.



Esto enim rota ABCD, cuius centrum E axis inclinatus, circa quem conuertitur EGF. Duobus autẽ punctis fulcitur GF. Sit autem tum grauius tum figuræ centrum E, Perpendicularis vero per inferius fulcimentum transiens HFI. Conuersa igitur rota, grauitatis centrum stabit nec à suo situ sursum deorsumue mouebitur. Est autem axis FEG, ceu vectis in quo pondus in E, potentiæ sustinentes GF; non enim hic vt in axe perpendiculari pondus totum ab inferiori fulcimento sustinetur. quo igitur minor erit proportio FE ad FG, eo minori indigebit potentiâ is qui pondus sustinet in G. Et hæc sanè ita se habent, grauitatis centro in axe ipso constituto, si enim extra fuerit motus impeditur & motore cessante citò quiescit. Esto enim grauitatis centrum in K. Dum igitur circa axem fit motus, centrum circulatum aliquando erit in L; Secet autem rotæ diameter AC perpendicularem HI in M, Porrò à punctis LK ad ipsam perpẽdicularem ducantur ad rectos angulos lineæ LN, KO. Maior est autem MK ipsa ML, maior ergo MO, ipsa MN. magis igitur à mundi centro distat punctum N puncto O. Centrum ergo grauitatis K si liberè dimittatur, requiescet in K & contra naturam transferetur in L. Cessante igitur violentiâ & præualente naturâ citò rota suâ sponte quiescet, quod fuerat ostendendum.

QVÆSTIO IX.

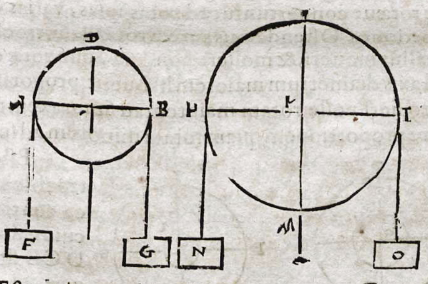
Quæritur, Cur ea quæ per maiores circulos tolluntur, & trahuntur faciliùs, & celeriùs moueri contingat, veluti maioribus trochleis, & scytalis similiter?

RESpondet ad hæc Philosophus, forte id euenire, quoniam

niam quanto maior fuerit illa quæ à centro est, in æquali tempore maius mouetur spatium. quamobrem æquali existente onere idem faciet. Ita enim dixerat de librarū natura,& differentijs agens, maiores minoribus exactiores esse. Circulos verò libras,in quibus centrum spartum, semidiametri hinc inde æqualia brachia.

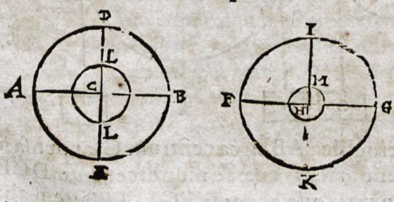
Quod vltimo loco affirmauit, trochleas esse instar librarum,verum est. Quod autem dixit, faciliùs & celerius mouere maiores libras ijs quæ minores sunt,si simpliciter intelligatur,falsum,quippe quod facilitas motus, in tractorijs machinis velocitati sit contraria, quod demonstrauit Guid. Vbald. in tractatu de Trochlea in 2. Corollario propositione vltima.

Ad id autem quod dixit, quo maiores fuerint trochleæ,eo faciliùs mouere,non est, vt dicebamus, simpliciter verum,quod facilè ostendemus.



Esto enim trochlea AB circa centrum C, appensa in puncto D, perpendicularis quæ ad mundi centrum DCE, pondera æqualia vtrinque appensa FG. Esto item alia Trochlea,eaq; maior HI, circa centrum K appensa in L, perpendicularis, quæ ad mundi centrum LKM, æqualia pondera vtrinque appensa N,O. Dico maiorem HI ipsa minori DE facilius pondera non mouere, eo quòd sit maior, illa verò difficiliùs, propterea quòd sit minor. Etenim, quoniam vtraque trochlea per centrum grauitatis à perpendiculari diuiditur, erunt partes DAE, DBE, æquepõderantes. Eadem ratione ipsæ quoque LHM, LIM æquè ponderabunt. Itaque si quantumuis pusilla pondera addas, vtriq; earum ad alteram partem tolletur æquilibriũ, nec minus requiritur pondus vt recedat ab æquilibrio Trochlea minor, quàm maior. Vnico autem verbo concludi potest disputatio, tã in minori quàm in maiori, brachia siquidem bifariam diuiduntur, ergo in vtrisq; eadem brachiorum proportio, & eadem ponderum ratio.

Exploratissima sunt hæc. Veruntamen cùm res ipsa doceat, verum esse quod scribit Aristoteles, huius effectus caussa aliunde à nobis, nempe à mechanicis principijs, est mutuanda. Dico igitur, Axium, circa quos trochleæ rotæue conuertuntur ad rotas ipsas, varias habere proportiones. Ostendemus autem rotã illam, trochleamue faciliùs moueri, & mouere pondera, quo rotæ diameter ad axis diametrum maiorem habuerit proportionem, & ideo fieri posse rotam maiorem ad suum axem minorẽ habere proportionem quam rotam minorem ad suum.

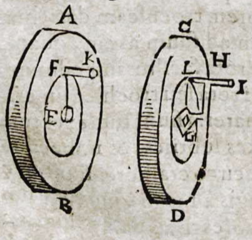


Esto enim trochlea AB circa centrum C, cuius diameter DCE sit in ipsa quæ ad mundi centrum perpẽdiculari: sit autem appensa in D. Alia similiter ei æqualis sit trochlea FG circa centrum H, cuius diameter IHK, conueniens cum

cum perpendiculari quæ ad mundi centrum. appendatur autem in I. Habeant autem & axes, circa quos conuertantur. Hi si æquales fuerint, proportione non mutatâ idem operabuntur. Modò ponantur inæquales, sitque axis rotę AB, crassior axe rotæ FG, sitque crassioris quidem semidiameter CL, subtilioris autem HM. Dico per trochleam FG facilius attolli pondera æqualia quàm per AB, licet altera trochlearum alteri sit æqualis. Quoniam enim mechanica corpora sine materia & pondere non sunt, onera appēsa & trochlearum ipsarum grauitas ex superiori parte prement axes, vbi puncta L, M, quæ res, secutâ inuicem corporum solidorum fricatione, motum ipsum trochlearum difficiliorem & asperiorem facit. Succedit igitur impedimentum loco ponderis. Duos igitur habemus vectes DC, IH, quorum fulcimenta contra ipsa C, H. Pondera verò inter fulcimenta & potentias in L, M. Intelligantur autem potentiæ applicatæ punctis DI. Igitur ex natura eiusmodi vectis, in quo pondus inter fulcimentum est & potentiam erit vt CL, ad CD, ita potentia in D ad pōdus, hoc est, resistentiam fricationis, quæ fit in L. Sed maior est proportio CL ad CD quàm HM ad HI. Maior igitur ad superandum idem seu æquale impedimentum potentia requiritur in D, quàm in I. Itaque cum vis tota in rotarum & axium, diametrorum proportione consistat, fieri potest, quod dicebamus, minorem trochleam dari, quæ maiorem habeat proportionem ad suum axem, quàm maior ad suum, quo casu minor rota facilius impedimentum, quod diximus, ipsa maiori rota seu trochlea superabit. Veruntamen quoniam ex materia fiunt tum axes tum rotæ, nec rei natura patitur axes subtiles, & imbecilles magna pōdera sustinere posse, idcirco crassiores fiunt, quę crassitudo cum proportione magis à magnarum rotarum diametris superetur; fit hinc maiores rotas datâ axium paritate

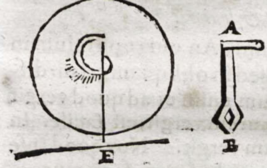
ritate facilius impedimentum superare quàm minores, & hoc videtur sensisse Philosophus in ipsa quæstionis huius propositione, Hinc aurigæ vulgo axungiâ (quæ inde nomen trahit) axium asperitates mitigant, vt minor in rotando, ex fricatione fiat resistentia. Concludimus igitur, facillimè trochleam illam pondus trahere, quæ cum maxima sit, axem habet minimum, eumq́ue axungiâ aliaue vnctuosa materia perfusum. De manubrijs, quæ rotarum axibus aptantur, nemo ferè verba fecit; nos igitur de his aliquid; siquidem res ad speculationem, qua de agimus, nẽpe Mechanicam pertinet.

Manubria vectes sunt, & ad vectium naturam reducuntur, eorum scilicet, in quibus fulcimentum est inter pondus & potentiam. In his autem attenditur proportio, quam habet manubrij longitudo ad ipsum axis semidiametrum, eo enim faciliùs mouent, quo eorum longitudo ad axium semidiametros proportionem habuerit maiorem. Duabus autem partibus constant, alterâ, quæ ab axe ad angulum; quæ verè vectis est; alterâ, cui manus ipsa admouetur, ex qua res tota manubrium dicitur. Fiunt autem manubria hæc vt plurimum amouibilia, sunt tamẽ ceu rotarum ipsarum partes, & rotis ipsis commodè affigerentur, nisi in rotatione à transuersarijs, quibus rotæ sustinentur, impedimentum fieret.



Esto enim rota AB, cuius axis E, terebretur autem in F, ibiq́ue paxillus affigatur FK. Sit & alia rota CD, cuius axis G, manubrium axi appositum GHI. Sint autem rotæ æquales & axes æquales. Sint etiam æqualia ipsa spatia EF, GH, hoc est, manubrij

nubrij GHI longitudo. Dico, eâdem facilitate moueri AB rotam à potentia in FK, quâ mouetur CB, à potentia posita in HI, datis ipsi nempe potentijs æqualibus. Producatur enim IH, vsque ad rotæ CD latus in L, & LG ducatur, & FE in rota AB iungatur. Erunt igitur FE LG inter se æquales. Sunt autem eorum circulorum semidiametri, qui à punctis FL, in ipsa rotatione describuntur. Ita igitur se habebit potentia applicata in L ad diametrum semidiametrumue axis rotæ CD, vt se habet potentia applicata in F, ad diametrum semidiametrumue axis E rotæ AB, sed spatia sunt æqualia & potentiæ æquales, quare nihil refert, vtrum manubrium lateri affigatur, vel axi à latere rotæ separatum applicetur.



Duplex autem est manubriorum forma; altera enim rectis partibus constat, altera verò curua est tota, sed rectis vtimur vt manibus apprendamus, curuis verò vt locum illis apponamus, & pedis pressione ceu in molis lapideis, quibus gladij acuuntur fieri assolet, conuertantur. Cur autem manubria hæc curua fiant, ea videtur ratio, ne videlicet manubrij capite supra centrum in linea quæ per centrum transit, cõstituto, factâ interim pressione motus à centro, ad quod directè fieret pressio, impediretur. Curuitas autẽ facilitatem quandam habet, ex qua factâ modicâ flexione axis caput, dum premitur ab ipsa perpendiculari linea leniter abducitur. quæ cum cessent in manubrijs quæ manu aguntur, ideo alia forma, nempe ex rectis partibus passim fiunt. Esto igitur illud quod ex rectis partibus AB, curuum verò CD, linea verò, secundum quam pede fit pressio

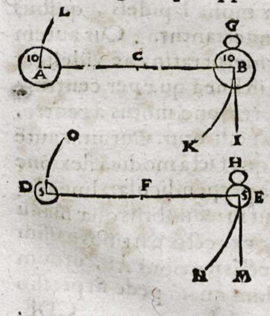
CDE. Hæc itaque de manubrijs ſeu vectibus nos conſideraſſe ſit ſatis.

Quæri interim poſſet, Cur duabus datis rotis æqualis magnitudinis inæqualis ponderis, circa æquales axes conſtitutis leuior faciliùs moueatur & citiùs quieſcat; grauior verò difficilius moueatur & tardiùs ceſſet à motu, ea videtur ratio, quod grauior reſiſtens magis, cum ſuperatur impreſſam vim ſuſcipit, & diutiùs retinet, quod ceſſat in leuiore.

QVÆSTIO X.

Dubitat Ariſtoteles, Cur faciliùs, quando ſine pondere eſt, moueatur libra, quàm cum pondus habet. Simili modo rota, & eiuſmodi quidpiam, quod grauius quidem eſt, item quod maius & grauius minori, & leuiori?

BReuiter autem ſoluit. ait enim, An quia non ſolum in contrarium quod graue eſt, ſed in obliquam etiam difficulter mouetur? In contrarium enim ei ad quod vergit onus mouere difficile eſt, quo autem vergit, eſt facile. In obliquum autem haudquaquam vergit. Nos quod ipſe non fecit figurâ ipſa appoſitâ rem clariorem faciemus.

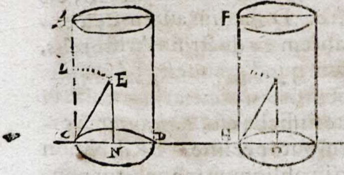


Eſto libra AB, cuius fulcimentum C, pondera vtrinque appenſa AB, quorum vtrumque ponderet 10. Item libra DE, cuius fulcimentum F pondere vero appenſa D, E, ipſis A, B, dimidio leuiora, nẽpe S. Addatur ponderi B pondus G, & ponderi E pondus H, quorum ſimiliter vtrumq; ponderet S, nutabunt igitur libræ ponderibus appoſitis, &

BG

BG secetur in K,EH verò in N,grauius est autem GB, est enim IS, ipso EH, quod est 10. Difficiliùs autem descendet BG, quàm EH. hoc autem ex doctrina Aristotelis, quia non solum in contrarium quod graue est, sed in obliquum etiam difficulter mouetur, in contrarium enim ei ad quod vergit onus mouere difficile est, quò autem vergit facilè in obliquum autem puta per lineas BK,EN non vergit onus. Difficiliùs ergo in obliquum mouebitur pondus BG ipso pondere EH. vtrumque autem in descensu retrahitur nempe à perpendicularibus BI, EM & retractionis quidem anguli sunt æquales & æquales ipsæ retractiones. Sed grauius est pondus GB. quod autem grauius est, violentius descédit eo quod est leuius. maiori igitur nisu atque impetu cum cætera paria sint, descendet pondus BG, ipso EH, quod è diametro Aristotelis assertioni est contrarium. ex alijs igitur principijs veritas ipsa est eruenda. Dicimus autem id ex proportionum fieri inæqualitate; quia enim is ad 10. proportionem habet sesquialteram, 10. verò ad 5. duplam, maiorem proportionem habet EH ad oppositum pondus D, quàm BG ad pondus A, facilius ergo trahet libra DE leuior pondus D, quàm ipsa AB, grauior pondus A, quod vtique fuerat ostendendum. Alia quoque caussa & hæc accidentalis ad hunc effectum pariendum concurrit, axium nempe ad fulcimenta, in quibus rotantur, fricatio. quo enim maius est pondus cæteris paribus, quod nos in præcedente quæstione demonstrauimus, eò maior fit ipsa collisio.

Porrò huius quoq; speculationis est, Cur æqualia & similia corpora in æqualibus similibusque basibus constituta eodem similique plano fulta, ponderibus tamen inæqualia, non eâdem facilitate euertantur, sed horum grauiora difficilius.



Sit enim Prisma seu Cylindrus ABCD, cuius grauitatis centrum E in plano CI, basi fultus CD. Sit & alter Cylindrus FGHI, cuius grauitatis centrum K fultus basi HI æqualis quidem & similis ipsi AD. Sit autem grauior FGHI, ipso ABCD. Dico, pari potentiâ vtrumque impellente, facilius euersum iri Cylindrum AD, ipso FI. Ducantur EC, KH, & æquales potentiæ applicentur punctis BG, pellentes Cylindros ad partes AF. Euersio autem non fiet donec facta corporis conuersione circa puncta CH, grauitatis centra E, K trãsferuntur in L, M, in ipsis scilicet perpẽdicularibus ACFH. Demittantur EN, KO, perpendiculares ipsis CD, HF. Et quoniam CNE, HOK anguli recti sunt, erunt EC KH ipsis EN, KO, maiores, quare & LC, MH ipsis EN KO, maiores attolluntur ergo in ipsa euersione, grauitatum centra E in L, K in M. At quod grauius est, difficilius contra sui naturam mouetur, ideo difficilius euertetur corpus FI, ipso AD, quod fuerat demonstrandum.

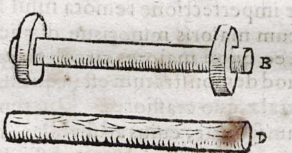
QVÆSTIO XI.

Dubitat Philosophus, Cur super scytalas facilius portentur onera quàm super currus, cum tamen ij magnas habeant rotas, illæ verò pusillas?

OPtimè respondet dubitationi. An, inquiens, quoniam in scytalis nulla est offensatio; in curribus verò axis est, ad quem offensant. Desuper enim illum premunt, & à lateribus. quod autem est in scytalis ad isthæc duo mouetur & inferiori substrato spatio, & onere superimposito, to, in vtrisque enim ijs reuoluitur locis circulus, & motus impellitur. Tam appositè paucis verbis veritatem explicauit, vt ferè quicquid insuper addatur, superuacaneum videri possit. quicquid tamen sit, ad maiorem claritatem aliquantulum in hac ipsa quæstione immorabimur.

Rotatas scytalas proponit hîc Aristoteles. Coniunctas autem esse rotas ipsis scytalis est intelligendum, nempe, vt simul rotæ cum scytalis conuertantur. Secus enim axium & Rotarum fieret offensatio, cuius offensationis vim & effectum cum nouerit Aristoteles, vel hoc ipso loco teste, mirum est, nihil de ea egisse quæstione 9. vbi nos hac de re fusissimè tractauimus.

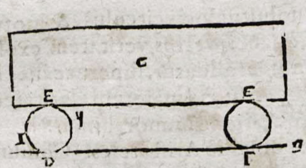
Cæterùm quod de rotatis scytalis scribit Philosophus, notandum, à Pappo quidem lib. 8. & à nostris Mechanicis passim absque rotis Cylindrica simplici videlicet, & tereti formâ ad vsum adhiberi. Esto igitur Aristotelis quidem scytala AB, Pappi verò seu vulgaris, & communis CD.



His non modò lapicidæ passim, sed & nautæ nauiumque fabri subducendis & mari inducendis nauibus vtuntur, quod varare dicunt vernaculè, Hispanico, vt arbitror, vocabulo. ea enim natio teres lignum baculumue appellat Varam.

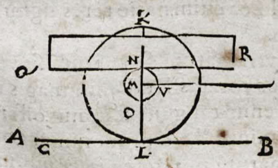
Quæri autem posset, vtra harum formarum sit vtilior atque commodior? Nos rotatas laudamus magis in plano duroque solo, minus enim tangunt & minus offensant; in molliori autem & minus duro proponimus non rotatas, siquidem rotæ sui naturâ pondere pressæ solum facillimè scindunt & absorbentur.

Quatenus autem ad vsum pertinet. Esto horizontis



planum AB, ſcytalę duę CD, EF, Pondus verò eis impoſitum G, tangens ipſas in pūctis CE, ſcytalæ autem planum in punctis D, F, Pellatur à potentia quapiam pōdus G ad anteriora, nēpe ad partes E. rotabuntur igitur ſcytalæ & pars quædam ſcytalæ D, in qua ſit contactus aſcendet in I, C verò deſcendet in H, nulla re motum impediente, quippe quòd nulla ponderis ſcytalarum, & plani ad inuicem fiat offenſatio. Præterea cum ſcytalarum centra ab horizontis plano æqualiter diſtent, pondus quidem horizonti æquidiſtanter mouetur, & ideo eius centrum grauitatis nequaquam, in motu qui ſit, eleuatur.

Cæterùm materiæ imperfectione remota nihil refert ad facilitatem, vtrum maioris minoriſue diametri ſint ſcytalæ, vt ea poſita eo quod maiores circuli faciliùs offendicula ſuperent, quod demonſtratum eſt in quæſtione 8. eo vtiliores ſunt ſcytalæ, quo craſſiores. Quatenus autem ad plauſtri naturam ſpectat, cuius ad ſcytalas Philoſophus fecit comparationem, vt oſtendamus difficilius ex eo moueri pondera.

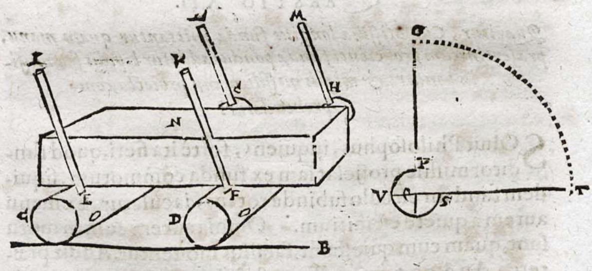


Eſto plauſtri rota KL, cuius centrum M, axis verò NO circa quem rota ipſa conuertitur KL. Funis quo rota ex axis centro M trahitur MP, pondus vero QR. Quoniam igitur pondus axem premit in N, axis autem rotæ modiolum in O, & eodem

tem-

tempore potentia quæ trahit in P, axem admouet modiolo in parte V. duplex itaque fit ex fricatione seu offensatione impedimentum, infra nempe, vbi O, & ad latus vbi V. quæ quidem offensiones currus motum reddunt difficiliorem, quæ quidem difficultas eo maior erit, quo maior fuerit pondus axem premens, & minor proportio semidiametri rotæ KM, ad axis semidiametrum MO. Cur igitur scytalis facilius pondera transferantur quam plaustris, apertè ex dictis ad Aristotelis mentem demonstrauimus.

Cæterùm quod ipse reticuit, nos dicemus, nempe validissimè enormia pondera per scytalas moueri, si scytalis ipsis vectes adiungantur. Et sanè motus erit tardissimus, veruntamen tarditas ipsa facilitate, quæ inde fit, vberrimè compensatur.



Esto igitur horizontis planum AB, scytalæ CD, foramina in scytalis EFGH, vectes foraminibus inserti IE, KF, LG, MH. Pondus vero scytalis impositum N. Applicatis igitur quatuor potentijs extremitatibus vectium I, K, L, M, ijsque in anteriora propulsis, fiet scytalarum rotatio,

tio, & ponderis N translatio ad anteriores partes B. Esto item seorsum scytala PR, cuius centrum Q, vectis eidem per centrum insertus O, P, Q, R. facto igitur vectis motu O P Q R fiet ex O; centro autē Q circuli quadrans O T. existente igitur O in T erit P in S. facta quartæ partis ipsius scytalæ rotatione. Et quoniam ex eodem centro sunt quadrantes P S O T. erit vt O Q ad Q P. ita quadrans O T, ad quadrantem P S. Maxima autem est proportio O Q, ad Q P. Maxima igitur proportio O T ad P S. Ex magno igitur motu O ad T, paruus fit scytalæ motus à P in S. tardius igitur progreditur scytala, quæ longioribus vectibus rotatur, vis tamen maxima, quippe quod vt se habet Q P, hoc est, Q R ad Q O, ita potentia in O ad pondus quod premit in P vel in V. Facillimè itaque pondera vectibus & scytalis per horizontis planum transferri, ex istis patet.

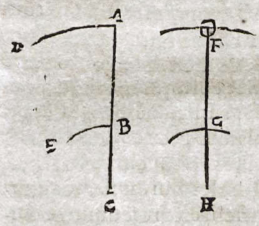
QVAESTIO XII.

Quæritur, Cur Missilia longius funda mittantur quam manu, præsertim cum proijcienti fundæ pondus addatur lapidis seu missilis ponderi: & minus missili, manu proiecto, comprehendatur?

SOluit Philosophus, inquiens, fortè ita fieri, quòd funditor missile proijciat iam ex funda commotum, siquidem fundam circulo subinde rotans, iaculatur, ex manu autem à quiete est initium. Omnia autem cum in motu sunt, quàm cum quiescunt, facilius mouentur. Addit præterea, An & ob eam caussam est, sed nec minus etiam, quia in fundę vsu manus quidem fit centrum, funda verò quod à centro exit? quantò igitur productius fuerit quod à centro est, tanto citiùs mouetur; iactus autem, qui manu fit, fundæ respectu breuior est.

Hæc Philosophus. Et sanè perquàm appositè, itaq; illi

illi prorsus assentirer, nisi pro comperto haberem, in iactu qui fundâ fit, non esse manum ipsam motus centrum, sed potius partem illam brachij, quæ humero iungitur, & ideo motum eo fieri velociorem, quo longior est linea quæ ab humero ad summitatem fundæ est, ea quæ ab humero ad manum ipsam. Illud quoque mirabile est, quod non obseruat Aristoteles, nempe à funditoribus in ipso eiaculandi actu, tardam fieri circa caput fundæ rotationem. Quamobrem considerandum est, quo pacto fiat à tarditate velocitas. Respondemus, velocitatem acquiri non ex simplici, quæ circa funditoris caput fit, rotatione, sed ex eo impetu qui fit in ipsa lapidis emissione, qui quidem impetus si ante vel post illud tempus fiat, quod à funditore captatur, cassa prorsus & inualida fit ipsa iaculatio.

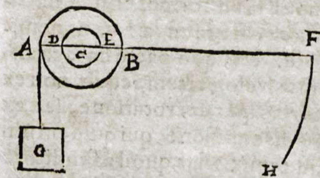


Esto funda AB, manus B, brachium BC. Vt igitur se habet CH, ad CB, ita velocitas AD ad velocitatem BE; Vidimus nos pueros, arundini ad caput scissæ, paruos lapides inserentes, arundinemque manu rotantes longissimè lapides ipsos proijcere; Arundo FG, lapis F, manus G, brachium GH.

QVÆSTIO XIII.

Quæritur, Cur circa idem iugum, maiores collopes (vectes sunt, quos alij scytalas appellant, vt Pappus & Heron) faciliùs quàm minores mouentur: & item suculæ, quæ graciliores sunt eadem vi quam crassiores?

IDeo hoc fieri posse docet Philosophus, quòd tam iugũ quam sucula cẽtrum sit, prominentes autem collopum longitudines eæ lineæ quæ ſunt à centro. Celeriùs autem moueri & plus ab eadem vi quæ maiorum ſunt circulorũ quàm quæ minorum. quippe quod ab eadem vi plus trãſferatur illud extremum quod longius à centro diſtat. In gracilioribus verò ſuculis datâ collopum paritate plus eſſe id quod à ligno diſtat.



Eſto iugum ſuculæ maior, AB circa centrum C, minor verò circa idem centrũ DE. Collops autẽ AF, pondus quod per iugum attollitur G. Ait igitur Ariſtoteles, ſuculas, iugaue AB, DE ceu centra eſſe, à quibus extat colops AB, ex maiori quidem, totâ ſui parte BF, ex minori autem EF. quo igitur, ait, longior fuerit collops extans, eo maior, & ideo velocior ad partẽ F per maiorem circulum FH, fiet collopis motus & ponderis eleuatio, at maior eſt collops EF ipſo BF, facilius ergo mouebitur pondus per ſuculam DE, ex collope EF, ab eadem vi, quam per ſuculam AB, & collopem BF.

Hæc ſenſiſſe videtur Ariſtoteles, qui craſſa, vt aiunt, Minerua rem pulchram & ſubtilem eſt proſequutus. Dicimus igitur primò, inſtrumentum illud quod Latini ſuculam, id eſt, ſcroſulam, à ſtridore arbitror qui in conuerſione fit, appellauere, Græci verò ὄνον, id eſt, Aſinum, quippe quod ceu Aſinus pondera ſuſtineat portetque. Hanc eandem Machinam veteres Mechanici vocauere Axem in Peritrochio, cuius nos imaginem, è Pappo in 8. Collect. Mathematicarum deſumptam in ipſo huius noſtri operis initio, inter quinque Potentias propoſuimus. Huius vim inter antiquos diligentiſſime examinauêre Heron, & ipſe-

ipſemet Pappus, inter iuniores verò Guilibaldus eo Tractatu quem hac de Potentia Mechanicis ſuis inſeruit. Summa eſt, hanc Machinam ad vectem reduci. Nec verum eſt quod ſcribit Ariſtoteles, iugum ſuculamue centra eſſe, hæc enim centrum habent, quod in figura ſuperius poſita notatur ſigno C. igitur vt ſe habet FC, ad CA, ita pondus G ad potentiam in F; eſt autem maior proportio FC ad CD, quàm FC, ad CA. faciliùs ergo mouebit potentia quæ in F, pondus in D, quàm eadem potentia F, pondus in A, hoc eſt, G. Huius naturæ ſunt quoque Ergatæ, quas machinas noſtri, Græco luxato vocabulo Arganos appellant. Suculæ enim reuera ſunt, poſitione tantū ab eis differentes, non enim plano horizontis ergatæ æquidiſtant, ceu ſuculæ & Axis in Peritrochio, ſed eidem fiunt perpendiculares. Cæterùm facilitatem à velocitate non oriri ſuperius demonſtrauimus.

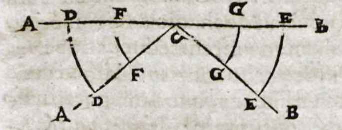
QVAESTIO XIV.

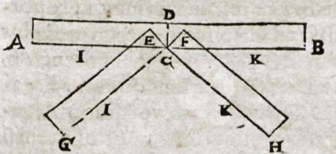
Proponitur dubitatio, Cur eiuſdem magnitudinis lignum facilius genu frangatur, ſi quiſpiam æque diductis manibus extrema comprehendens fregerit, quàm ſi iuxta genu. Et ſi terræ applicans pede ſuperpoſito manu hinc inde diducta confregerit quàm propè.

SOluitur à Philoſopho paucis verbis, An quia ibi genū centrum eſt, hic verò ipſe pes? quanto autem remotius à centro fuerit, facilius mouetur quodcunque: Moueri autem quod frangitur neceſſe eſt.

Eſto lignum quod frangi debet AB, genu vel pedis locus C, manuum latè diductarum ſitus DE, minus diductarum FG; Itaque quoniam DE magis à centro C diſtant quàm FG, velocius mouebuntur puncta DE ipſis FG, ergo inde facilius fiet fractio quam ex FG. Hæc ille ex ſuis

 prin-





principijs. Nos diligentius, si fieri poterit, effectus huius caussam perscrutemur. Esto igitur in secunda figura lignum oblongum AB, cuius medium C, linea ducatur CD perpendicularis ipsi AB. Admoueatur genu pũcto C, manus verò diuaricentur in AB, facta igitur vtrinque impressione, lignum non frãgetur, nisi partium in CD coniunctarum separatio fiat, sitque altera in E, altera verò in F, fractum ergo erit lignũ, & centro C immobili permanente, partes facto angulo GCH erunt in GC, HC: Modò lignum suæ integritati restituetur, & denuò admoto genu puncto C, manus diducantur in I, K, quæ loca viciniora sint ipsi C, quam AB, Dico hinc difficilius fractionem fieri quam ex AB. Consideramus enim in integro ligno AB, duos vectes ACD, BCD, quorum anguli concurrunt in commune fulcimentum C, Sunt autem vectes angulati, & eius naturæ, quam examinauimus in quæstione 5. Est igitur resistentia, qua ligni partes vniuntur in D, loco ponderis: superanda hæc est, vt ligni fiat fractio. Dico id facilius cessurum, si fiat ex punctis A, B, remotioribus quam ex IK, ipsi puncto C propioribus: etenim vt AC, ad CD, ita resistentia quæ fit in D ad potentiam in A, item vt se habet IC ad CD, ita resistentia in D ad potentiam in I, sed minor est proportio IC ad CD, quam AC ad CD. ergo facilius potentia quæ est in A, resistentiam superabit, quæ est in D, quam ea quæ est in I, quod

quod fuerat demonſtrandum. Idem autem intelligendũ eſt de parte CB; eadem enim eſt ratio. Cur igitur longiora & graciliora ligna facilè frangantur, ex iſtis clare patet: nempe quia maxima eſt proportio longitudinis ad craſſitudinem, cuius quidem craſſitudinis ſpatium loco partis illius in vecte ſuccedit, quæ pertingit à fulcimento ad põdus, hoc eſt, ad ipſam reſiſtentiam. Sed nos hac eadem de re nonnulla in declaranda quæſtione 16. perpendemus.

QVAESTIO XV.

Proponitur inueſtigandum, Cur litterales crocæ (glareas dicunt Latini, vel calculos, quos vmbilicos appellat Cicero lib. 2. de Orat.) rotundâ ſint figurâ, cum aliquando ex magnis ſint lapidibus teſtisue?

AIt Philoſophus, ideo fortaſſe fieri, quòd ea quæ à medio magis recedunt, in motionibus, celerius ferantur; medium eſſe centrum, interuallum vero quæ à centro, ſemper autem maiorem ab æquali motione maiorem deſcribere circulum; quod autem maius in æquali tempore ſpatium tranſit, celerius ferri; quæ autem celerius ex æquali feruntur ſpatio vehementius impetere, quæ autẽ impetunt, impeti magis, & ideo quæ magis à centro diſtant, neceſſe eſſe confringi, quod cum glareæ ſeu crocæ patiantur, neceſſariò rotundas fieri. Hactenus ille, & ſanè probabiliter. Verum enimuerò aliter ſe res habere videtur: ſiquidem enim à rotatione ex maiori à centro diſtantia id fieret, maiores quidem glareæ crocæue eſſent rotundiores, at nos non maximas modò, ſed & minimas, eaſque magis angulis carere, & ad rotunditatem accedere videmus. Præterea non moueri eas circa centrum palam eſt, imò vt varia ſunt figura, ita varijs quoque motionibus, ex agitatione moueri. Id ſanè exploratiſſimum eſt, angulos omnes, & eminentias quaslibet in corporibus esse infirmiores, offensionibus enim expositæ sunt, nec resistendi habent facultatem. Itaque in attritione quæ fit in eorum agitatione perpetua, eminentiæ contunduntur, & superficies ipsa paullatim leuigatur.

Esto angulatus lapis ABCD. Dum igitur perpeti motione atq; assiduâ versatione agitatur, ferturque, eminentiæ angulique, vtpote debiles & imbecilli, conteruntur, & inde figura fit quædam irregularis, ad primam quidem lapidis formã accedens, leuis tamen & quouis angulo carens, qualis est E remotis ABCD, angularibus eminentijs.

Hanc eandem ob caussam, sculptores antequam marmoribus vltimum læuorem inducant, dentato malleo primum quidem vtuntur, tum demum eminentiores particulas radula facilè amouentes superficiem ipsam læuem & adæquatam reddunt.

Hinc etiam nostrates Architecti, in arcium propugnaculis efformandis acutos angulos deuitãt, vtpote debiliores, & magis offensionibus obnoxios. quod nec Vitruuium latuit, qui ideo lib. I. cap. 5. ita scribit: *Turres itaq; rotundæ aut polygoniæ sunt faciendæ, quadratas enim machinæ celerius dissipant; & angulos, Arietes tundendo frangunt, in rotundationibus autem, vti cuneos ad centrum adigendo lædere non possunt.* Hæc ille. Cur autem nostri rotundas figuras alias vtiles reijciant, ab ijs petendum qui in ea facultate versantur. Porrò quod ad hanc eandem speculationem facit, videmus, antiquas statuas, vt sæpius auribus, naso, digitis, manibusue atque pedibus carere, quippe quod imbecillæ sint partes, & facilè quouis occursu mutilentur. Quæ omnia

mnia cùm vera ſint,nemo, vt arbitror, dixerit, abſolutè, quod voluit Ariſtoteles, id ex rotatione velociori & partium à centro remotione,fieri.

QVAESTIO XVI.

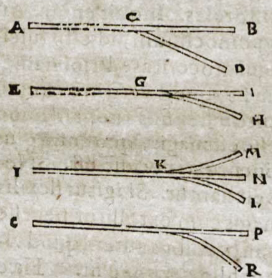
Dubitatur,quare,quò longiora ſunt ligna,tāto imbecilliora fiant, & ſi tolluntur,inflectuntur magis: tametſi quod breue eſt,ceu bicubitum fuerit, tenue,quod verò cubitorum centum craſſum?

EX ſuis principijs ſoluit Ariſtoteles. Inquit enim: An quia & vectis & onus & hypomochlium, id eſt, fulcimentum in leuando,fit ipſa ligni proceritas? Prior namq; illius pars ceu hypomochlium fit, quod verò in extremo eſt,pondus: quamobrem quanto extenſius fuerit id quod à fulcimento eſt,inflecti neceſſe eſt magis; quo enim plus à fulcimento diſtat,eo magis incuruari neceſſe eſt. Neceſſariò igitur extrema vectis eleuantur. Si igitur flexilis fuerit vectis, ipſum inflecti magis cum extollitur neceſſe eſt,quod longis accidit lignis,in breuibus autem quod vltimum eſt,quieſcenti hypomochlio depropè fit. Hæc ſubiectâ figurâ ob oculos ponimus.

Eſto longum ac flexile lignum AB, manu eleuetur in A, flectetur itaq; in B,& declinabit in C. etenim manus quæ ſuſtinet in A,fulcimenti loco ſuccedit: longitudo vero AB ponderis vices refert,atque vectis,quare quo longius abfuerit à fulcimento,id eſt,manu extremum B, eo magis flectetur; ſi autem lignum breuius fuerit,nempe terminatum in D, nequaquam flectetur,eò quòd eius extremum D minus à fulcimento quod eſt in A ſit remotum. Hæc igitur eſt mēs

Ari-

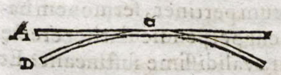
Ariſtotelis, cuius quidem ſententiam non damnamus; quippiam tamen addimus. Dicimus autem materiam, quatenus ad hanc contemplationem ſpectat, in duplici eſſe differentia. aut enim rarefactionis & conſtipationis eſt incapax, vt in chalybe videmus, nitro, metallo, marmore, aut capax quidem, & hæc duplex: Vel enim natura nata eſt ad rectitudinem quandam, vt arborum flagella virgæque, aut non item, ceu ſtannum, plumbum, & cætera eiuſmodi.



Eſto primò vitreum corpus gracile, procerum, teres AB, manu capiatur in A, itaq; pondere ipſius corporis prævalente ad partes B, quia in C puncto, quod circa medium eſt, ex parte ſuperiori non fit rarefactio, nec in inferiori conſtipatio, nec interim datur penetratio corporum, fit fractio à ſuperiori parte, & pars CB à reliqua parte AC, auulſa & ſeparata cadit in D, ſuccedit autem ipſa ſeparatio rarefactioni. Porrò quod materias haſce non flexibiles diximus, ſed frangibiles, non ideo negamus vel ſenſu docente, aliquam in ijs fieri flexionem. Si autem lignea fuerit materia, eaq; flexibilis, vt EF, ſi manu eleuetur in E, prævalente pondere in F flectetur vbi G. ibi enim à parte ſuperiori fit rarefactio, ab inferiori verò conſtipatio, & pars GF declinabit in H, quæ declinatio eò vſque procedet, quo rarefactio & conſtipatio competens naturæ illius materiæ, quæ flectitur ad ſummam intenſionem deuenerint; tunc ſi vis maior ingruerit, frangetur omnino: ſi ſecus facta ibi reſiſten-

resistentia, vbi rarefactio fit & constipatio post inclinationem sursum feretur pars inclinata & nutans, tum in contrariam partem tendens reflectetur, vt videre est in virga IN. Declinans enim in KL, repellente ea quæ infra K fit materiæ condensatione, impetu ex descensu acquisito facta reflexione ascendit in KM, donec paullatim circa pristinam rectitudinem reuertatur, & hic quidem motus vibratio dicitur, agitatioue. Si autem virga plumbea fuerit, naturâ non factâ ad rectitudinem, puta OP, proprio vincente pondere, ad partes declinabit QS, fietq; in QR rarefacta, nempe superiori parte ea constipata inferiori in Q, nec reflectetur, quippe quòd eius natura condensationem & rarefactionem commodè patiatur, nec facta sit ad rectitudinem.

Porrò tripliciter fieri potest horum oblongorum corporum eleuatio, nempe vel extremorum altero, aut si ambobus, si vtrinque suspendatur, vel alicubi inter extrema. De priori modo iam egimus. Modò suspendatur in medio vt AB, in C. eo igitur casu cum fulcimentum sit in C, vtrinq; fit flexio in D, & E, & id quidem si materia flexionem patitur: sin minus, fractio fit in C. Si autem ab extremis fiat suspensio, vt in AB, tunc ceu duo vectes fient, quorum fulcimenta in extremis AB. Pondera autem communia in medio vbi

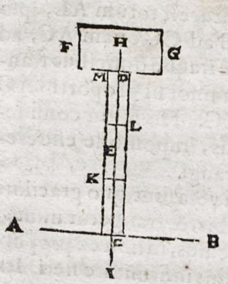


C remotissima enim ea pars est ab extremis AB. Cedente igitur materia suomet ponderi, siquidem inflexibilis fuerit, frangetur, & fiet partiũ separatio in C, duoque inde corpora AD, BE. Si autem flexionis capax, vt AB in postre-

ma figura, facta ex contrario, nempe in inferiori parte circa C rarefactione, in superiori verò condensatione, pondere præualente curuabitur, fietq; lignum quidue aliud huiusmodi, vt ADB, nec amplius pondere suapte naturâ inferiùs vergente ad rectitudinem reuertetur.

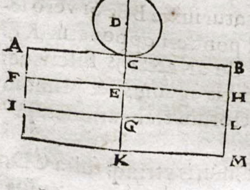
Cæterùm cur oblonga & graciliora corpora facilius illis, quæ contrario se habent modo, frangantur, ex mechanicis principijs in quæstione 14. apertè demonstrauimus. Modò vt ex hac contemplatione, quæ aliàs inutilis videtur, aliquam vtilitatem capiamus, & ex his quæ contemplabimur, Architecti prudentiores fiant, isthæc ipsa, de quibus agimus, ad rem ædificatoriam commodè aptabimus. Transferamus igitur cogitationem ad eam trabiũ compagem, quæ ad tecta sustinenda ex transuersario arrectarioq; fit, & duobus cauterijs, quam nostri à Latinis detorto vocabulo Biscauterium dicunt. Perscrutabimur enim, vnde illi tanta ad sustinendum vis, & quæ compagem hanc consequantur passiones. quamuis enim fabri meræ praxi, quod vtile est efficiant, nos meliorum ingeniorum gratiâ, rei ipsius caussas diligenter examinatas in medium proferemus; nec de hac re tantùm agemus, sed de Cameris quoque, fornicibus eorumque vitijs & virtutibus quatenus ad Mechanicum pertinet, sermonem habebimus. Quærimus primo, cur perpendiculariter erectę trabes superimposita pondera validissime sustineant? Et sane hoc omnes norunt, sed non per caussas.

Esto horizontis planum, illudque solidissimum, & impenetrabile AB, trabs eidem ad perpendiculum erecta CD fulta basi vbi C grauitatis centrum F. pondus superimpositum FG, cuius grauitatis centrum H: Sint autem H & E in eadem perpendiculari, quæ ad mundi centrum HEG. Itaque eo quod tum ponderis tum trabis centra grauitent in perpendiculari, illa verò fulciatur in C, totius



tius ponderis moles recumbet in C: non deſcendet autem in I, propterea quod ſupponatur ipſum planum AB, impenetrabile. Igitur vt pondus H deſcendat in G, alterum duorum eſt neceſſarium, nempe vel trabem ſubiectam comminui, aut eius partes ſeſe penetrare, & plura corpora eſſe in eodem loco, puta KC, quorum hoc ſecundum naturæ penitus repugnat, illud vero primum, penè impoſſibile. Diuidatur enim trabs in partes æquales tres, lineis KL, ipſa igitur KC infima ſuſtinet mediam KL, hæc verò ſupremam LD, hæc autem põdus, ipſum ſuperpoſitum in H. Se igitur ſuſtinent partes. Sed illud totum partibus conſtat. ergo pondus totum à trabe tota, hoc eſt, à ſe toto ſuſtinetur.

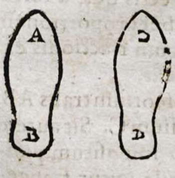
Præterea in præcedenti quæſtione monſtrauimus tunc facilem eſſe gracilis & oblongi ligni fractionem, cũ maxima eſt longitudinis ad craſſitudinem proportio. Hîc verò contrà accidit, etenim MD pars vectis quæ à fulcimento eſt ad potentiam minimam habet proportionem ad rectam DG, quæ à fulcimento ad locum fractionis extenditur, vbi C, quod vt euidentius pateat,



Eſto ſeorſum trabs AB, cuius medium C. Sit autem pondus D impoſitum puncto C. facilè igitur frangetur lignum AB, propterea quòd maxima ſit proportio AC ad CE; reſiſtentia verò fiat in E, addatur vniaturq;

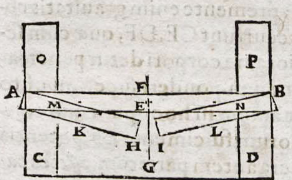
ligno AB lignum FH. Craſſius igitur eſt totum AL, ipſo AH, & ideo minor proportio AC ad CG quàm AC, ad CE. Addatur adhuc & IM. Longè itaque difficiliùs frangetur in K propterea quòd longè minor ſit proportio AC ad CK quàm eiuſdem ad CE & CG. His igitur conſideratis, & demonſtratis concludimus, impoſſibile eſſe erectam trabem ponderi cedere, & frangi.

Dicet autem quiſpiam, hęc ſi vera ſunt, quo gracilius fuerit fulcrum, eo validiùs ſuſtinebit, & frangetur minus, quod oppido falſum eſt. Reſpondemus, id non ex proportionum naturâ, ſed ex materiæ ipſius infirmitate fieri. Ita quoque in vecte non materiam, quatenus ad vim pertinet, ſed proportiones partium conſideramus. Vtrumque igitur requiritur ad fulcri validitatem proportio longitudinis ad craſſitudinem debita, & materiæ ipſius robur & fortitudo. Præterea, quoniam pondus, cui fulcrum reſiſtit, vel ex natura premit, vel ex violentia, illud quidem per lineam perpendicularem, quæ ad mundi cētrum, hoc autem lateraliter & diuerſimodè, varia fit fulcrorum diſpoſitio. Cuius rei ſumma hæc eſt, vt ſemper contra impetum ſupponantur.



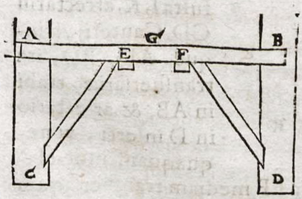
Eſto enim horizontis planum AB, eidē perpendiculares CADB, itaque ſi naturaliter pondus premat ex C, fulcrum ſupponetur AE. Si autem ex F ipſum GE, ſi verò ex H, ſupponatur iuxta BE. Si verò ſecundum I ponderi opponatur KE. Hæc nos de arrectarijs fulcriſue; nunc de tranſuerſarijs, & inclinatis agemus, & primum de tranſuerſarijs, quatenus ad tectorum trabeationes ſpectat.

Eſto tranſuerſaria trabs AB, muris vtrinq; fulta CD, cuius



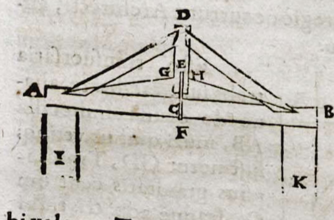
cuius grauitatis centrum E, in perpẽdiculari FEG, quæ quidem ad mundi centrum vergit. Itaq; eodem tendente grauitatis centro, si pondus quod premit in E, non præualeat vnioni partiũ ipsius materiæ quæ est in E, resistet trabs suomet ponderi, nec frangetur. Si autem vel infirmitate materiæ, aut vitio, vel maxima existente proportione AF ad FE, fractio fiet in E, & secutâ partium separatione duæ fient vtrinque trabes AH, BI, quorum grauitatis centra KL. Erunt igitur duo vectes AE, BE, quorum fulcimenta MN, quamobrem si proportio EM ad MH ita præualeat, vt pondus quod est in E, superet pondus muri O superimpositi, & item muri P, corruent quidem trabes, & murorum fiet hinc inde dissipatio. Si autem non præualuerit ea, quam diximus, proportio, suspensæ remanebunt vtrinque trabes vt AHBI.

Huic difficultati egregiè occurrunt Architecti, aliquando autem hoc modo:



Esto transuersaria trabs suâ gracilitate, aliaue de caussâ imbecilla AB, muri quibus vtrinq; sustinetur CD, Trabis ipsius grauitatis centrum G. Itaque adpactis trabi lignis EF, capreolos addunt muro vtrinque fultos CE, DF, eorum capita adpactis lignis admouentes EF, sed & tunc validissima fit colligatio, si inter E & F capreolorum capita integrum lignum trabi supponatur EF. Ratio autem validitatis patet; premente enim grauitatis cẽtro in G, fulcra hinc inde succurrunt CE, DF, quæ cum seipsis fieri non valeant breuiora, ne corpori detur penetratio, resistunt & robustissimè ipsi ponderi superimposito contranituntur. Videntur autem in hoc opere duo considerari vectes, GH, GB, quorum fulcimenta EF, potentia premens vtrinque G. Pondera autem parietum partes capitibus trabis impositæ in A & B. Quoniam igitur parua est proportio GE ad EH, parua potentia premens in G, maximè autem pondus in A, fieri non potest trabem frangi aut muros vtrinque dissipare in AB. Possunt etiam totius trabis tres partes considerari AE, EF, FB, quarum fulcimenta quatuor A, E, F, B, Diuiso igitur pondere & multiplicatis fulcimentis impossibile est trabem conuelli & vitium facere.

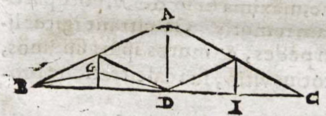
Sed & tectorum contignationes imbecillaq; transuersaria Mechanici corroborare solent, additis nempe arrectaria trabe atque cauterijs.



Esto enim transuersaria trabs AB parietibus vtrinque fulta I, K, arrectariũ CD. Cauterij vtrinque AD, BD, ita transuersariæ trabi in AB, & arrectario in D inserti, vt nequaquam inde elabi valeant. Tum ferrea fascia EF mediam transuersariam trabem AB, à parte inferiori ipsi arrectario connectens. Debet autem arrectarij pes vbi C, aliquantulum à transuersaria trabe distare, ne deorsum ex pondere vergente paululum arrectario ipsam transuersariam premat. His igitur

gitur ita constitutis pondus quidem transuersariæ trabis, quod suapte naturâ premit in medio vbi C, ferrea fascia, arrectariæ trabi affixa distinetur, Arrectariam cauterij sustinent, hos verò transuersariæ capita AB, quibus induntur. Tota igitur eiuscemodi operis vis in eo consistit, vt probè cauterij transuersariæ & arrectariæ trabi inserantur. fixis enim cauteriorum pedibus in AB, non descendẽt à partibus seu capitibus D, ijs verò stantibus stabit & arrectarium, quo inde suspenso transuersaria trabs ei ex ferrea fascia alligata nequaquam pendebit. Stabit ergo compages tota & suapte vi robustissimè connexa totius tecti pondus sustinebit.

Quoniam autem vsu venire solet, cauterios nimia longitudine debiles, aliquando tum proprio tum extraneo cedentes ponderi deorsum vergentes pandare, Architecti capreolis hinc inde suppositis, ceu fulcris, huic medentur infirmitati.



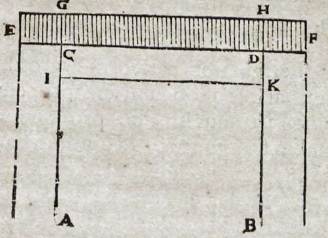
Sint enim cauterij debiles hinc inde AB, AC, media trabs arrectaria, quam Monachũ dicimus AD. Cauteriorum mediæ partes E, F, in punctis igitur E F, vtpote maximè ab extremis distantibus debiles cauterij valde laborant. Itaque suppositis vtrinque arrectariolis EH, FI, eorum capitibus E, F, duos cauteriolos sibi ipsis ad pedem arrectarij in D, resistentes apponunt. quibus ita constitutis nec E, nec F ad partes H, I, descendere valent. Capiatur enim inter EH, quoduis punctum G, & BG, DG, connectantur, erunt autem BG, DG ipsis BE ED breuiores ex 21. primi elem. Tunc igitur punctum E fiet in G cum BE, ED fient in BG, DG, quod non cedentibus B, D, & sibi ipsis breuioribus factis partibus

bus BE, ED, prorsus est impossibile. stabunt igitur in eorum rectitudine cauterij AB, AC, nec pandabunt, quod fieri querebatur.

Hîc autem damnandi veniunt ij, qui transuersariæ quidem trabis capitibus cauteriorum pedes non inserũt, sed ea vice transuersariolo quodam medios cauterios vtrinque connectunt ad instar elementi A, quam compagem, capram, appellant. Sint enim cauterij hinc inde AB, AC, quorum medias partes connectit transuersariolum DE. Dico igitur colligationem istam magnopere improbandam. Sunt enim AB, AC vectes, quorum commune fulcimentum A, potentiæ hinc inde diuaricantes B, C, pondera inter fulcimentum & potentias DE. quoniam igitur vt DH ad AB, ita potentia in B, ad pondus in D, parua quidem potentia, pondus in D distrahet & superabit: facillimaq; inde fiet transuersarioli à capreolis ipsis vtrinque reuulsio: Et quoniam centrum quidem est A, facta in D, E, parua diuaricatione, maxima fit in BC, vtpote partibus ab ipso centro A quam remotis. Calcitrant igitur liberi prope cauteriorum pedes, & muros ipsos summos, non sine magno operis totius vitio, sua calcitratione propellunt.

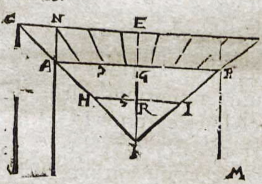
Hæc nos de trabeationibus, modò ad fornicum camerarumq; naturam stilum transferemus; id enim suadet vtilitas, imo & necessitas ipsa. Pauci enim ante nos hæc tractarunt, & sanè his probè non cognitis aut neglectis, Architecti fabrique ingentes persæpe incurrunt, & inexplicabiles difficultates. Dicimus igitur primò, coctiles lateres, & non cuneatos lapides ad rectam lineam dispositos, non stare.

Sint enim muri vtrinque AC, BD. Ducatur horizonti æquidistans CD, iuxta quam lateres lapidesue non cuneati, seriatim collocentur EF. Dicimus amoto armamento,



mento, hoc eſt, prohibente ipſo lateres ruere. Producantur enim AC in G, BD verò in H, cum ipſis CG, DH, æquales fiant CI, DK, & recta IK iungatur, erit igitur GD ſpatium ipſi CK ſpatio ſimile quidem & æquale, quod cùm ita ſit, nihil prohibet quin tota laterum GD moles in ſpatium CK transferatur, & corruat.

Si autem cunei ipſi lateresue, cuneatim diſpoſiti, ita ſint vt ad vnum centrum tendant, licet ad rectam lineam collocentur, non delabentur, ſed ſtabunt; quod ita oſtendemus.



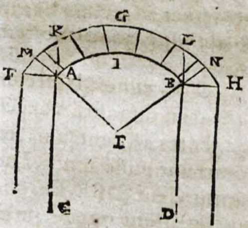
Sint cunei lateresue cuneatim diſpoſiti ABCD, tendentes ad centrum, ſeu commune punctum E, Ducantur CAE, DBE, ſintque muri vtrinque ponderi reſiſtentes CL, DM, Demittatur perpendicularis, quæ ad mundi centrum FGE ſecans AB, in G, Tum fiat GK æqualis GF & per K ipſi AGB parallela ducatur, HKI claudens ſpatium AHIB. Quoniam igitur vt EC, ad EA, ita CD ad AB per 4. propoſ. lib. 6. maior erit CD ipſa AB, & eâdem de cauſſa maior AB, ipſa HI, & idcirco maius ABDC ſpatium, ſpatio AHIB. Non igitur poteſt linea CD, fieri in AB, neque AB, in HI, neque ſpatium totum CABD, transferri in ſpatium AHIB non data (quod naturæ ipſi repugnat)

O gnat)

gnat) corporum penetratione. Stabunt ergo cunei, quod fuerat demonſtrandum.

Verumenimuero, debilis hæc ſtructura eſt, & eo debilior, quo vani latitudo fuerit maior, cuneorum verò altitudo minor. Idem enim patitur quod epiſtylia in ſpecie Aræoſtyla, quæ, vt ſcribit Vitruuius lib. 3. c. 2. propter interuallorum magnitudinem franguntur. Id quoque habet vitij, quod cunei ita diſpoſiti ſuo pondere incumbas vtrinque violentiſſimè pellant. Vtilis tamen eſſe poteſt ad portarum & feneſtrarum, quæ in medijs muris ſunt, & mediocri vano aperiuntur, ſuperliminaria.

Si verò ad minorem circuli portionem curuetur Camera, vtilior quidem erit ſtructura ea ipſa, de qua locuti ſumus; non tamen omninò ſine vitio.

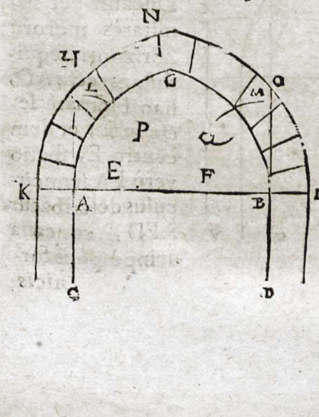


Eſto fornix ex minori circuli portione AB, cuius incumbæ AF, BH muris fultæ AC, BD. Conſtet autem vel ex lapidibus cuneatis, vel ex coctilibus lateribus ad E cẽtrum tendentibus. Sitq; fornicis linea exterior FGH, interior AIB. Ducantur EA, ED, & producantur in M, N. Quoniam igitur vt EM ad EA, ita MGN ad AIB, maior erit MGN linea ipſa AIB, quamobrem fieri non poteſt vt aptetur lineæ AIB, & in eius locum deſcendat. Stabit igitur, incumbis vtrinque non cedentibus. Validè autem ſpeciem hanc, loca quibus incumbit, propellere, ita oſtendemus.

Producatur in eadem figura CA in K, & DB in L. Partes igitur quæ muris ad perpendiculum fulciuntur, ſunt AKF, BLH, minimæ illæ quidem, maxima verò pars eſt

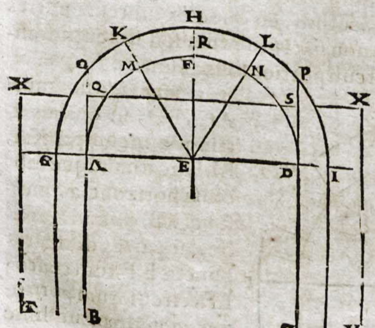
eſt extra fulcimenta, nempe tota AKLB quæ idcircó ſuopte pondere deorſum vergens & in incumbas vtrinq; pellens aperitur, & facillimè vitium facit. Eiuſdem ferè naturæ ea ſpecies eſt, quæ vel ex media, vel ex minori ellipſis ſecundum maiorem diametrum fit ſegmento. Vtilior tamen hæc eſt, præcipuè circa incumbas, propterea quod partes habeat erectiores, & circulari illa de qua egimus, magis fultas. circa medium autem poteſt videri debilior, quippe quod ellipſis ibi circulo curuetur minus.

Ea verò forma, qua mirum in modum delectati ſunt Barbari, qui declinante imperio Italiam inuaſerunt, & bonam emendatiſſimamque antiquorum ædificandi rationem deturparunt, ex duobus conſtat circuli portionibus, quamobrem Albertus lib. 3. hoſce arcus, compoſitos, appellat. Circinantur autem hoc pacto, diuiſa nempe ſubtenſa, in partes tres, eaſque æquales, ponitur circini pes in altero diuiſionum puncto & pars circuli deſcribitur, mox in altero puncto circini pede collocato alia circuli portio lineatur, quibus arcus ipſe integratur. Appellant autem tertium acutum, eo quod ex ſubtenſa in tres partes diuiſa, arcus non fiat rotundus, ſed in acutum angulum ex duabus circuli portionibus deſinens.



Sint igitur muri AC, BD, in quibus vtrinque incumbæ KA, BI. Ducatur itaque ſubtenſa horizonti æquidiſtans AB, quæ in tres æquales partes diuidatur punctis E, F, tum centris EF, circulorum portiones deſcribantur hinc AG, HK, inde verò BG, IH,ex quibus arcus totus integratur. Vtilis hæc quidem ſpecies eſt,licet inuenuſta, propterea quod haud violenter incumbas vtrinque repellat,& in ſummo magnis ſuſtinendis oneribus ſit apta. Producantur CH in N,DB verò in O,ſitque centrum grauitatis AG in L, partis vero BG in M. Quoniam igitur centra hæc ob elatam portionum conſtitutionem quam proxima lineis AN,BO,fulcimentorum fiunt,maximè ſuſtinẽtur, & deorſum potius quam lateraliter incumbas ipſas premunt. Si quid tamen habẽt vitij, illud eſt quod grauitatis centra momentum habentia ad interiorem partem verſus PQ vim faciant, & niſi partes magno ſuperimpoſito pondere comprimantur, partes quæ ſunt circa HG, ſurſum pellentes aliquali ſibi rectitudine comparata corruunt,facta nempe circa L, M, coniunctarum partium ſeparatione.

His hoc pacto explicatis de ſemicirculari fornice agemus,quæ cæteris omnibus vtilior eſt,& longè pulcherrima, quamobrem Antiquis Architectis omnibus inprimis admodum familiaris:



Eſto vanum ABCD, muris vtrinque clauſum. Ducatur per sũmitates murorũ horizonti æquidiſtans recta AD, hac bifariam ſecta in E, eodem centro E, ſpatio verò EA ſemicirculus deſcribatur AFD, concaua nempe ipſius fornicis

nicis pars; tum eodem centro, ſpatio verò EG. circinetur GHI eiuſdem fornicis pars conuexa. Poſt hæc productis lineis BH, CD, in OP, ſecetur fornix tota in tres æquales partes AGKM, MNLK, NDIL, & KME, LNE iungantur, ſint autem partium ipſarum grauitatis centra QRS. Eſt autem R in ipſa perpendiculari HE. Quoniam igitur partium AGKM, DILN, quæ vtrinq; ſunt grauitatis centra QS, in ipſis ſunt fulcimentorum lineis OH PD. ſuâ ſponte fulcimentis eas ſuſtinentibus partes ipſæ ſtabunt. Pars autem media KMNL deorſum vergente per ipſam HE lineam grauitatis centro, ſi parumper vel incumbæ vel partes vtrinque AGKM, DILN cedant, vtpote quæ à fulcimentis eſt remotiſſima, magno impetu ſuopte pondere deorſum feretur. quæ igitur in his ſemicircularibus fornicibus partes ſtabiliores ſint, quæ verò caſibus obnoxiæ, ex his quæ diximus, clarè patet.

Cæterùm cur incumbis manentibus fornix ſtet, ea cauſſa eſt, quod partes exteriores GK, KL, LI, maiores ſint inferioribus & oppoſitis AM, MN, NG; quod ſuprà demonſtrauimus.

Si quid autem vitij in hac ſpecie eſt, illud quidem eſt, quod ſumma pars KMNL deorſum vergens magnâ vi partes, quæ vtrinque ſunt, repellat, ex qua re ſolidarum partium fit ſolutio, & inde ruina.

Huic difficultati vt occurrerent peritiores Architecti, plura excogitârunt remedia. Primum enim parietes hinc inde ita ſolidos, craſſos & firmos faciunt, vt ſuapte vi reſiſtentes dimoueri loco nequeant, vel paraſtatas addūt vt in figura TX, VY. Præterea & ferrea claui ex incumba in incumbam ducta & vtrinque firmata contrarias partes validiſſimè connectunt, quæ calcitrantes (ita enim loquuntur noſtrates *Architecti*,) fornicis pedes cohibent, & ſolidum ne ſoluatur impediunt. qua in ſpecie dubitandū

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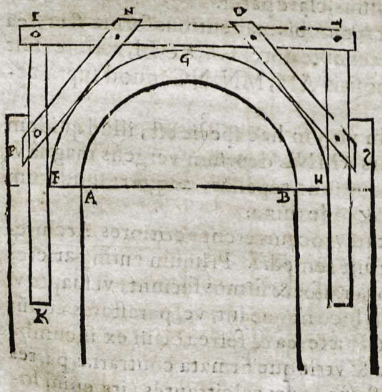
eſſet, an optimo loco ſita ſit clauis, quæ per centrum? Et ſanè videtur, quippe quod circa incumbas impetus fiat maior. Ego autem vtilius ibi poni arbitror, vbi puncta q. ſ. hoc eſt, in medio tertiarum illarum partium, quæ vtrinque incumbis inſiſtunt, propterea quod primus impulſus ex media parte quæ impendet, ibi fiat. Raro tamen boni Architecti eo loco aptare ſolent, eo quòd eiuſmodi claues vel pulcherrimis ædificijs minuant gratiam. Vnde fit vt nunquam ſatis laudetur Lucianus ille Benuerardus Lauranenſis Dalmata, qui nullibi apparentes eas poſuit in admirabili illa Vrbini Aula, quam Federico Feltrio, feliciſſimo æquè & inuictiſſimo Duci, ædificauit.

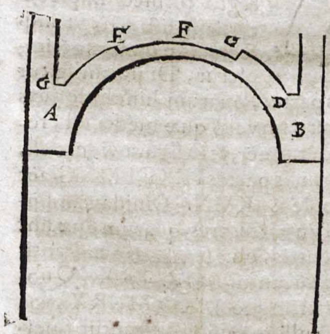
Tertio denique modo huic infirmitati medentur, vt videre eſt in ſequenti figura, in qua vanum ADBC, muri vtrinque AF, BH, fornix verò FGH. Itaque dum muros



exſtruunt, arrectarias trabes, robore aliaue materia firmiſſima, illis inſerunt, quales ſunt IFK LHM, ea proceritate vt futuri fornicis ſuperent ſummitatem. Conſummato enim fornice, nondum tamen exarmato, tranſuerſariam trabẽ à ſummo fornicis dorſo parumper eminentem in punctis I, L, arrectarijs trabibus validiſſimis clauibus connectunt, tum punctis NP, Oq, capreolos tranſ-

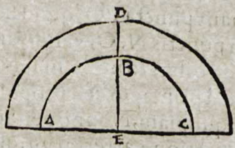
transsuersario, & arrectarijs ferreis, clauis affigunt. Quibus ita concinnatis, facta fornicis validâ pressione in G, incumbisque F, H, ad exteriora repulsis, AB spatium non fit maius. Repulsis enim incumbis & muros propelli necesse est, & cum muris ipsas insertas trabes, IK, LM. At varicari non possunt, nî secum trahant puncta PQ, quod fieri non potest, propterea quod in punctis N, O, validè distineantur. Itaque spatio AB non dilatato nulla fit ipsius fornicis dissolutio, quod vtique à principio ceu propositus finis quærebatur. Sed dicet quispiam, Nonne pendebit transuersaria trabs in ipsa distractione arrectariorum, pressa in punctis N, O? aut parum dicimus, aut nihil. Cum enim PQ proxima sint punctis FH, quæ cum arrectarijs à muro distinentur, magna in ijs fit vtrobique resistentia.

Rebus igitur ita se habentibus cum obseruassent Architecti, ob enormitatem ponderis fornices in tertia illa parte quæ summa est laborare, quãtum tertijs vtrinque partibus soliditatis addunt, tantundem ex illa parte suprema demere solẽt, vt videre est in subiecta figura, in qua partes A, B, solidæ & crassiores, quibus hærent partes, quæ CE, DG crassæ quidem & illæ, tum vero summa EFG, alijs subtilior. Minus igitur grauante pondere in F, minor fit ad incumbas pressio, aut si qua fit, à partiũ ACE, BDG soliditate haud inualidè sustinetur.



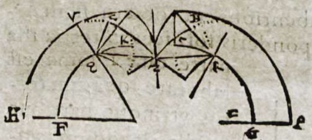
Cæte-

Cæterùm admonet nos locus, vt aliquid de fornicum dissolutionibus in medium afferamus: caussis enim morborum cognitis, facilius periti medici adhibere solent remedia.



Esto enim semicircularis fornix ABC, cuius centrum E, perpendicularis verò quæ per centrum DBE, semicirculi ABC, diameter AEC, incumbæ vtrinq; A, C. Itaque si nulla fiat incumbarum repulsio, stabit fornix; si verò fiat, ruinam faciet.

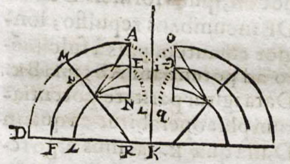
Pellantur itaque ad exteriores partes, vt in secunda figura, H in F, & C in G, ex qua pulsione cum maius fiat spatium quod integro fornice implebatur, iam distractis vtrinq; fornicis partibus nõ impletur, Diuiditur igitur



locus maior factus in tres partes, quarum hincinde duas replent fornicis partes, tertiam verò quæ media est, replet insertus, ne vacuum detur, aër, vt in figura videre est, in qua solutæ vtrinque fornicis partes HIKF, PMNG, aër autem medius spatium replens IKMN. Diuidantur singuli quadrantes FK, GN, in partes tres, quarum duæ sint hincinde FQ, GR, & à centris, quæ separatis quadrantibus facta sunt in ST, rectæ ducantur SQV. TRX. Quoniam igitur tertiæ partes vtrinque VIKQ MNRX propria grauitate depressæ, nullum quo sustineantur fulcimentum habent, corruent quidem. Ducantur autem rectæ QI, RM, constituentes cum ipsis QV, RX pares angulos VQI MRX. Itaque centris QR partes QIRM ad infe-

inferiores partes deuoluentur, fientque QI, RM, vbi QZ, RZ. Si autem QI, RM perpendicularibus quæ à punctis QR ad perpendicularem DE ducuntur, fuerint maiores conuenient alicubi in ipsa perpendiculari, & altera alteram sustinebit; si autem æquales tangent se & nihilominus fiet ruina, si minores nec se inuicem tangent, & nullâ re prohibente deorsum corruent. tangant autem se in pũcto Z. quo pacto igitur fornices incumbis cedentibus in medio aperti, dissoluãtur & ruinam faciant, ex istis patet.

Ex demonstratis quasi ex consectario habemus fornices quo fuerint crassiores dato pari incumbarum secessu, ruinæ minus esse obnoxios quàm tenuiores, hoc est, maiori apertione indigere ad ruinam crassiores quam tenuiores, quod licet ex iam dictis resultet, nos tamen clarius ex subiecto schemate demonstrabimus.



Esto enim crassioris fornicis pars quidẽ ABCD, tenuioris EFCD circa idẽ centrum R. Ducatur autem RM, secans CD in G. EF in H AB, in M. Centro igitur G fiet euersio portionum fornicum MD, HD, Ducantur GA, GE & producta AD in N ipsi AN perpendicularis ducatur GN. quoniam igitur GE cadit in triangulo AGN erit ex 21. propos. lib. 1. elem. GA, maior GE. Corruente igitur maioris fornicis portione MD, recta GA centro G punctum A describet portionem AI, minoris interim ex GE, describente EL, at cadenti angulo A occurrit in perpendiculari IK in puncto I angulus oppositæ portionis, O, ipsi autem E cadenti per EL non occurret punctum P, cadens per Pq eo quod neutrum eorum pertingat ad perpendicularem IK. Tenuioris ergo fornicis partes è suis locis auulsæ ex eadem aperitione ruinam facient, quod non contingit partibus crassioris. quod sanè fuerat declarandum.

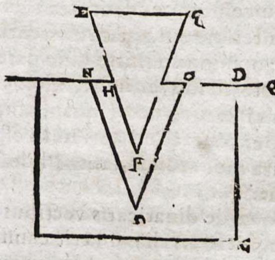
Quæritur adhuc, quare grauiores fornices in summis ædificijs non sine vitio fiant?

Esto ædificium ABGH, cuius vtrinq; muri ABCD, EFGH, maiorum summitates AD, EH, mediæ murorum partes KL, fornicum summus quidem DIE, medius verò KML. Dico, magis cedere pulsos muros summos circa DE, quam in medio circa KL. Sunt enim muri BA, GH ceu vectes quidam, quorũ extremis partibus à fulcimentis BG remotissimis potentia admouetur, hoc est, ipsius fornicis DIE ad DE incumbans repulsio; longior est autem pars à fulcimẽto ad potentiam AB, ipsa BK: Data igitur paritate potentiarum plus operabitur ea quæ in D, illa quæ K. facilius ergo repellentur muri in DE quàm in KL. Alia quoque ratio intercedit, siquidem pondus muri superioris ADK, premens inferiorem murum KBC, cum sua grauitate firmiorem, & pulsionibus minus obnoxium reddit. Difficilius enim propellitur id quod graue est quã quod leue, vt nos quæstione 10. demonstrauimus.

Qvæstio XVII.

Quærit Aristoteles, Cur paruo existente cuneo magna scindantur pondera & corporum moles, validaq; fiat impressio?

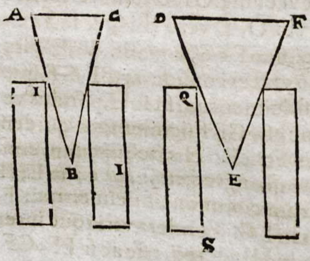
IN parua re magnum negotium. Etenim quæstio hæc clarifclarissimorum virorum ingenia magnopere fatigauit. Ex quibus Aristoteles inter veteres, Guid. Vbald. inter recentiores ad vectis naturam (ne quid in Mechanicis ad vectem non reduci putaretur) cuneum ipsum trahere conati sunt. Nos autem pro veritate certantes, si in horum sententiam vltrò non transierimus, multa venia digni à non iniquo iudice existimabimur. Aristotelis mentem clarè & fusè explicat G. Vbald. in Mechan. vbi de Cuneo peculiariter agit.



Esto igitur scindendum quippiam ABCD, Cuneus EFG, cuius pars HFI scissuræ inserta HI, facta igitur valida percussione in EG, fiet vt cum EG fuerit in NO, H sit vbi N, A vbi P, itemque I vbi O, D verò vbi Q & facta erit scissio NSO, toti nempe cuneo EFG, æqualis. Vult igitur Aristoteles, duos in cuneo vectes considerari EF, GF, quorum alterius, nempe EF, fulcimentum sit in H, pondus vero in F; alterius autem, hoc est, GF fulcimentum quidem sit in I, pondus verò itidem sit in F. His nequaquam consentiens G. Vbald. aliam viam ingreditur. Ait enim EHF vectes quidem esse, quorum commune fulcimentum F, potentias verò mouentes in EG. Pondera vtrinque inter fulcimenta & potentias, vbi HI, idemq; esse ac si EF, GF, seorsum à cuneo considerati in puncto F, adinuicem fulti atque distracti pondera pellerent H in NP, I verò in O, Q. Verumenimuerò quoniam cunei angulus non mutatur, nec vertex ipse centri vllum prorsus præbet vsum, nec eius latera vtrinque distracta ad contrarias partes diducuntur,

cuntur, vectes in cuneo hoc pacto considerare videtur à veritate alienum. Aristotelis autem solutionem falsam esse, clarè patet. quo pacto enim F pellet ex fulcimento H ipsam ligni partem OS, & idem F ex fulcimento I pellet oppositam partem NS, si inuicem contendentes extremæ vectium partes in F, altera alteri ne quicquam operentur, est impedimento? Et sanè opinionis falsitas inde patet, quòd videamus materiæ partes scissas, in ipso scissionis actu facta distractione à cunei vertice nequaquam tangi. At eiusmodi operationes per contactum fieri nulli est ignotum. Solutio igitur ista meo iudicio, tanto Philosopho prorsus videtur indigna.

Porrò G. Vbald. ijs quæ de diuaricatis vectibus in medium adduxerat non acquiescens alias quærit caussas, cur cuneus minoris anguli validiùs scindat. Idq; ex quodam lemmate demonstrare conatur, figura autem eius ita ferè se habet.



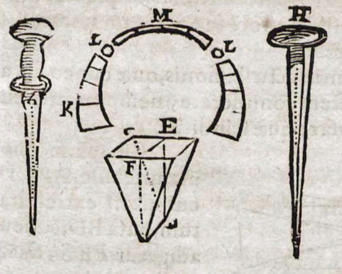
Esto cuneus ABC, item alius DEF. Demõstrauit igitur ex assumpto, quo acutior fuerit angulus BIM, eo faciliùs pondera moueri, & ideo facilius ceu vecte AB moueri pondus I quàm vecte DE pondus Q. Ingeniosè quidem. At magnam hæc apud me habent difficultatem. Si enim ita se habet AB, ad BI, vt DE, ad EQ (ipsæ enim DE, EQ supponuntur æquales) ergo eadem æqualisue potentia æqualiter mouebit pondera I & Q. quod ipsi eiusdem demonstrationi prorsus concludit contrarium. Nec meo quidem

quidem iudicio id ſequi videtur, propterea quod ex Pappo ea quæ in planis inclinatis mouentur, redigantur ad libram. Ratio enim valde eſt diuerſa, ſiquidem pondera quæ in planis inclinatis mouentur, certa habent fulcimenta & determinatas tum brachiorum tum ponderum proportiones, quæ omnia in cuneo, nec quidem mente concipi poſſe, clarè patet.

His igitur difficultatibus conſideratis, Nos cunei vim, ad alia eſſe principia referendam pro comperto habemus. Ordimur igitur hoc pacto. Cuneo quidem res diuidi certum eſt. Cæterùm quæ natura diuidere apta ſunt, tria ſunt, punctum, linea, ſuperficies. Puncto enim linea, lineâ ſuperficies, ſuperficie autem corpus ipſum diuiditur. quæ omnia à Mathematico abſque materia conſiderantur. De diuiſione autem quæ fit ex puncto, nihil agit Mechanicus, qui corporibus quidem vtitur, ad cuius naturam non trahitur punctum, cuius partes ſunt nullæ. At non lineis & ſuperficiebus modò corpora diuiduntur, ſed etiam corporibus, quod verum eſt, at ea corpora ad linearum & ſuperficierum naturam quodammodo aptari facilè docebimus. Dicimus igitur, duplicem eſſe Cuneorum ſpeciem, linearem vnam, ſuperficialem alteram. linearem appello, quæ ad lineæ naturam magnopere accedit. Tales ſunt orbiculares illæ cuſpides, quibus ad perforandum vtimur, & ideo vernaculè Pantirolos vocamus. Acus item ſutorij, & cætera quæ non ſecus ac linea in punctum deſinunt, & imaginariam quandam lineam ceu axem in eo puncto deſinentem continent. Ad lineam quoque referuntur lateratæ cuſpides oblongæ, & ſubtiles ceu ſubulæ, claui, enſes, pugiones, & his ſimilia, quæ cum adacta validam faciant partium ſeparationem ad cunei naturam nõ referre magnæ videretur dementiæ. Et tunc quanto magis corpora hæc ad linearem naturam accedunt, eo magis

gis penetrant. Sed & hoc idem in rebus non ab arte, sed ab ipsa natura productis facile est cognoscere. Quis enim non experitur, quàm validè culex, infirmissimum animal, & ea paruitate qua est, hominum & cæterorum animaliũ, cutes aculeata proboscide penetret? Id vtique non alia de caussa fit, quod ad imaginariæ lineæ subtilitatem quam proximè accedat. Vespæ quoque, Apes, Scorpiones aculeis istis ceu linearibus cuneis vtuntur. Nec refert, vt diximus, vtrum laterati sint, ceu subulæ, & claui, vel rotundi & vtrum plura pauciorave latera habeant, dummodo in punctum & aculeatam aciem desinant. Altera porro cuneorum species superficiei naturam sapit, acie siquidem in lineam desinit, quæ superficiei est terminus, quãobrem huc ea omnia referuntur, quæ acie ipsâ scindunt, ceu sunt cunei propriè dicti, de quibus hoc loco est sermo, cultra, enses, asciæ, secures, scalpra lata, & cætera eiusmodi, quibus corpora acie scinduntur. Quidam his addunt serras, quibus haud prorsus assentimur. Etenim alia ratione diuidunt, sicut & limæ solent, deterendo enim, nõ scindendo ferri, ligni, & marmorum duritiem diuidunt & domant. His igitur cõsideratis, si daretur ex materia quapiam infrangibili cuneus, qui maximè ad superficiei naturam accederet, vel paruo labore tenacissima ligna validissimè scinderet, & ideo optimè res gladijs illis diuiditur, qui magis ad superficiei naturam accedunt. Ex quibus omnibus, nî fallimur, clarè patet, cur acutiores angulo cunei obtusioribus facilius scindant, quæ quidem ratio longè ab ea distat, ex qua cæteri ferè omnes Cuneum ad vectis naturam referre hactenus contenderunt.

Cæterùm vtramque eorum quos diximus, cuneorũ speciem solertissima cognouit Natura, & ideo quoniam res vel contusione vel perforatione, vel secatione conficiuntur, triplicem dentium qualitatem dentatis animalibus



bus dedit, Molares, qui &.Maxillares appellantur, quibus cibus contunditur, Canini, quibus fit perforatio, Anteriores, quibus cibus ſcinditur, quos ideo τμητικοὺς, id eſt, ſecantes appellant Greci.

Molares KK, Canini L, L, Temnici ſeu ſecantes M. Cuneus orbicularis lineariſque AB, in quo axis linea eſt, ad cuius naturam accedit AB cuneus ſuperficialis CD, accedens ad ſuperficiei naturam, quam vitro imaginamur EFGD, in aciem cunei deſinentem GD, Lateratus lineariſque cuneus, clauus HI.

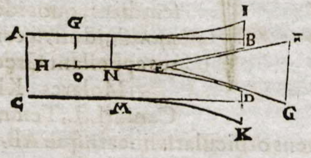
Cunei autem omnes dupliciter ſunt efficaces, vel enim malleo, vt in ijs fit, quibus ligna ſcinduntur & ſcalpris fieri ſolet, adiguntur, vel impulſu & preſſione, vt in gladijs fit, pugionibus, cælatorum ſcalpris, ſubulis, & cæteris eiuſmodi. Quidam etiam ſunt, qui licet mallei ictu non adigantur, malleum coniunctum habent, ceu ſunt ſecures, ligones, Aſciæ, & his ſimilia, quæ ex percuſſione ſemetipſa ſcindendis rebus inſerunt & validè penetrant. De vi autem & efficacia ictus ſeu percuſſionis hic ſuperſedemus aliquid, ea de re, in ſequenti quæſtione verba facturi.

Multa hîc addere potuiſſemus ad Cochleam ſpectantia, quippe quòd Cochlea cuneus ſit Cylindro inuolutus, qui quidem ad mallei, ſed vectis virtute ſibi adiunctâ, validiſſimè operatur, & ſexcentis inſeruit vſibus. Veruntamen cùm de hac ſpecie egregiè diſſerat G. Vbaldus,

con-

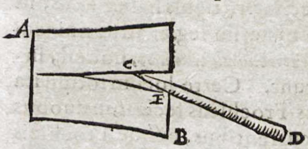
conſultò hanc diſputationem omittimus; idque hac quoque de cauſſa, quod nihil de cochlea, ac ſi eam non nouiſſet, locutus ſit Ariſtoteles.

Poſſumus autem in actu ſciſſionis, quæ cuneo fit, aliâ tamen ratione vectem conſiderare, nempe non in cuneo quidem, ſed in ipſa re quæ ſcinditur.



Eſto enim quippiam ſciſſile ABCD, cui alteri extremitatum, puta BD, cuneus adigatur EFG, fiatq; ſciſſio per longitudinem ſecundum lineã EH. facta igitur ex cunei ingreſſu partiũ ſeparatione B, expelletur in I, D verò in K. fient igitur materiæ ſciſſæ partes AIBH, CKDH, ceu duo vectes, quorum hinc inde in corpore ipſo fulcimenta L, M potentiæ vtrinque dilatantes BD, pondus verò materiæ reſiſtentia, in ſeparationis loco vbi N. Ducatur NL, quanto itaque BN maiorem habebit proportionem ad LN, eo faciliùs reſiſtentia quæ in N, ſuperabitur. Mutatur autẽ aſſiduè in ipſa ſciſſione fulcimentum, & cũ fulcimento ipſa proportio. Pertingente enim ſciſſione in O, fulcimẽtum fit in P. quo caſu ſciſſura eſt facilior, quippe quod maiorem habeat proportionem BO ad OP, quã BN ad NL. Hoc autem experiuntur materiarij, qui primis ictibus, ſecuriculâ nondum probè adactâ, & nondum factâ notabili ſciſſione difficultatem ſentiunt, mox factâ iã ſeparatione facillima paullatim fit materiæ totius ſeparatio. Hoc idem & nos abſque cunei vſu experimur, cum baculum aut quippiam tale manibus diductis ſcindimus. à principio enim difficultatem ſentimus, deinde ex ea quã diximus proportione ſciſſio ipſa fit apprime facilis. Vtimur

mur etiam vecte cuneato ad ſcindendum & aperiendum: adacto enim ſciſſuræ cuneo, idque manu malleoue, tum ab altera extremitate preſſo, valida fit ex vectis vi cõtinui corporis ſeparatio. Materia ſciſſilis AB ſcalprũ ceu vectis cuneatus CD, cuius fulcimentum E, pondus verò vbi C, potentia vbi D, quo caſu quo maior eſt proportio DE ad EC, eo eſt ipſa ſciſſio leuior & facilior.



QVAESTIO XVIII.

Quærit hic Ariſtoteles, Cur per Trochleas ab exigua potentia ingentia moueantur pondera?

DE Trochlea Pappus, & veteres: inter recentiores egregiè admodum, vt omnia examinauit in Mechanicis G. Vbaldus. Nos tamen interim poſt clariſſimos illos viros aliquid quod nouitatem & ſubtilitatem ſapiat, de noſtro penu promemus. Et ſanè inuentis quidem addere res eſt facilis, at quod inuentis addas inuenire haud adeo facile. Sed nos primum Philoſophi ipſius dicta ad trutinã reuocemus. Ita autem quæſtionem proponit; Cur ſi quiſpiam Trochleas componens duas, in ſignis duobus, ad ſe inuicem iunctis contrario ad Trochleas modo circulo funem circumduxerit, cuius alterum quidem caput tignorum appendatur alteri, alterum verò Trochleis ſit innixũ & à funis initio trahere cœperit, magna trahit pondera, licet imbecillium fuerit virium?

Obſcuriſſima expoſitio, & nî res eſſet vulgò per ſe nota, deque ea Vitruuius & Mechanici non egiſſent, difficile vtique eſſet ex eius verbis ſenſum aſſequi.

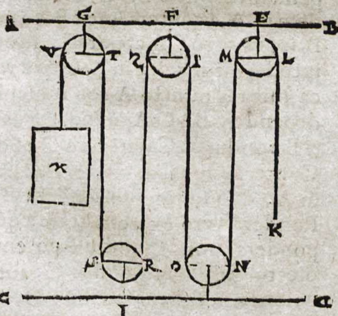
Q Tigna

Tigna ſanè vocaſſe videtur ea ligna, quæ à Vitruuio Rèchami dicuntur, in quibus nempe ipſi inſeruntur orbiculi. Etſi de tignis eiuſmodi aliud quippiam ſentire videatur Picolomineus. Græca lectio pro tignis habet ξύλα, id eſt, ligna; item vbi Leoniceni verſio legit, ad ſe inuicem iunctis, textus habet συμβαίνουσιν ἑαυτοῖς ἐναντίως, hoc eſt, inuicem ex oppoſito concurrunt. Certè locum totum ita redderem: Cur ſi quis duas Trochleas fecerit, in duobus lignis ſibi ex oppoſito concurrentibus, eiſque Trochleis circumpoſuerit funem, cuius alterum caput alteri lignorum ſit annexum, alterum verò Trochleis cohæreat, vel apponatur. Si quis alterum funis principium trahat, magna trahat pondera, etſi trahens potentia ſit exigua? Nos verbis figuram, & figurâ verba ipſa elucidabimus.

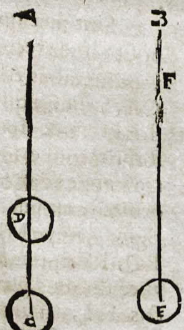
Sint duo ligna ex oppoſito concurrentia, in quibus Trochleæ, hoc eſt, orbiculi AB, funis ductarius DABC, cuius alterum caput religatum eſt ligno trochleæ A, vbi eſt C. Trochlea A loco ſtabili commendata, vbi E. Pondus alteri ligno Trochleæ appenſum F. Tracto itaque fune DABC, eleuatur & trahitur pondus F. Ex quibus clarè patet, Philoſophũ propoſuiſſe Trochleam duobus tantum orbiculis munitam, quod vtique ſatis erat ad explicationem. Inquit autem, faciliùs vecte quã manu pondus moueri. Trochleam verò (id eſt, orbiculum; ita enim eſt intelligendum) eſſe vectem, aut vectis virtute operari. Ita autem videtur argumentari. Si vnicâ Trochleâ plus trahitur quàm manu, multò faci ius & velocius id fiet duobus, quibus plus, vt ipſe ait, quàm in duplici velocitate pondus leuabitur. Summa dictorum eſt, ex multiplicatione orbiculorum pondus ipſum imminui, & minori difficul-

tate

tate leuari, quod sanè verum est. Nos tamen nonnulla cõsiderabimus. quod ait, vecte facilius moueri pondera quam manu, semper non est verum. Si enim vectis pars quæ à fulcimento ad manum breuior fuerit illâ, quæ à fulcimento ad pondus difficilius vecte pondus mouebitur quam manu. Idem quoque accidet, si eo modo vecte vtamur, quem obseruat Guidus Vbald. Tract. de Vecte prop. 3. Posita nempe inter fulcimentum & pondus sustinente potentiâ. Præterea quod asseruit Aristoteles, Trochleas ad vectem reduci, verum quidem est, sed aptius dixisset ad libram, etenim vectis vtcunque à fulcimento diuiditur. Libra verò quod & orbiculis ex centro accidit, semper bifariam. Ad hæc videtur ille ad orbiculorum multiplicitatem Trochlearum vim referre. Si enim, ait, vnicâ Trochleâ pondus facile trahitur, id multo validius pluribus fiet. Veruntamen non absolutè ex orbiculorum multiplicatione id fieri ita ostendemus.

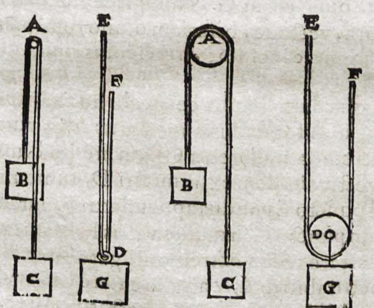


Sint duæ oppositæ lineę rectę, vtpote trabes AB, CD, inuicẽ æquidistantes & ipsæ stabiles: superiori tres appendantur orbiculi ex pũctis E, F, G, nẽpe ML, PQ, TV, inferiori autẽ duobus punctis IH, nempe NO, RS. Erunt igitur in vniuersum quinque, indatur per eos funis ductarius KLMNOPQRSTVX, ex cuius extremitate pendeat pondus X, Trahatur funis in K. Dico ex multiplicatione orbiculorũ, trahenti pondus nequaquam minui. Sint autem orbiculorum diametri, LM, NO, PQ, RS, TV, applicetur potentia in S. Erit igitur ad hoc vt sustineat æqualis ponderi X, orbiculi enim TV semidiametri sunt æquales. Transferatur potẽtia in q, & ita deinceps donec perueniatur in K, vbi funis ipsius est principium, Idem est igitur seruata semper semidiametrorum æqualitate ac si potentia quæ est in K, applicata intelligatur in T vel in V. vbicunque enim collocetur, ponderi erit æqualis. Nihil igitur rebus ita dispositis, orbiculorum multiplicatio ad facilitatem operatur. Alia itaque ratio quærenda est, quam non satis explicasse videtur Aristoteles. Probabimus autem, nullam ex superioribus orbiculis fieri ponderum imminutionem, sed totam vim in inferioribus consistere. At nos interim quippiam quod ad rem faciat, proponamus.



Esto punctum A, cui rectæ appendantur lineæ BAC, diuisæ quidem in A, sit autem lineæ BA caput B, ipsius verò CA caput C. Modò intelligantur vnitæ in A, sitque vnica linea à puncto A ceu funiculus dependens BAC; Appendatur capiti B pondus B. Capiti vero C, põdus C, inter se æqualia. Potentia igitur in A, duo sustinebit pondera BC. Pondera verò ex æqualitate æqueponderabunt. Quod si B potentia dicatur sustinens pondus C, aut C potentia sustinens pondus D, vel duæ potentiæ inter se æquales, nihil refert. Vtcunque enim id sit, fiet æquilibrium. Habemus igitur ex istis ad sustinendum pondus ex superiori parte appen-

appenſum potentiam requiri ipſi ponderi æqualem. Animo poſthæc concipiatur alia recta linea DEF, cuius integra longitudo ſi extenderetur, eſſet DE, EF. Appendatur in E pondus E æquale alteri ponderum B vel C, ſint autem duæ potentiæ pondus E ſuſtinentes D, F. Vtraque igitur dimidium ſuſtinebit ponderis E, ſed potentia quæ ſuſtinebat pondus B, in C erat ipſi B æqualis, vbi appenſio ponderis erat in ſuperiori parte in A, hîc autem, vbi appenſio eſt in parte inferiori, vtraque potentia dimidium ſuſtinet appenſi ponderis. Videmus igitur illam appenſionem quidem pondus nullatenus imminuere, hanc verò pondus ipſum, bifariam diuiſum, ſuſtinentibus potentijs impartiri. Hæc in lineis, Mathematicâ vſi abſtractione, conſiderauimus, nunc verò eadem mechanicè perpendamus.



Sit igitur punctum A, vt in ſequenti figura clauus paxilluſue, cui appenſus funiculus BAC, & funiculi capitibus pondera BC, ſit quoque anulus D, per quem traiectus funiculus EDF. Anulo autem cōiunctum pondus G. His igitur ita conſtitutis, eadem demonſtrabuntur quæ ſuperius, nempe oportere vt fiat æquilibrium B, C, eſſe æqualia, tum potentias, quæ ſunt in EF pondus G inter eas diuiſum ſuſtinere. Porrò volentes Mechanici

 funi-

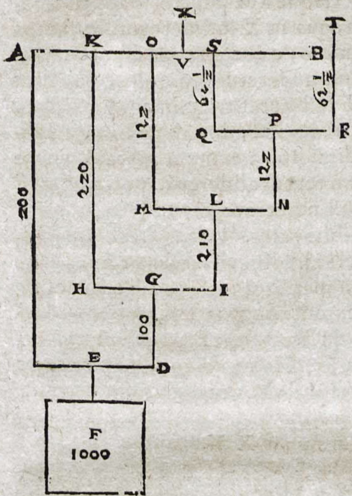
funiculos circa paxillum, & anulum ad attollenda & deprimenda pondera mouere incommodè illis vtique succedebat, clauo & anulo motum difficilem facientibus. Quamobrem vt difficultati occurrerent, ad locum claui clauo ipsi orbiculum circumposuerunt, & anuli itidem loco orbiculum aptauerunt. Hæc autem agentes rei ipsius naturam non mutauerunt, sed sibi, vt diximus, ex orbiculis maximam commoditatem atq; facilitatem comparârunt.

Ex his principîjs tota Trochlearum ratio pendet, quæ tamen alia quoque consideratione in idem tendente examinari potest, quod quidem fecere veteres, & ipse, qui veteres optimè imitatus est, Guid. Vbaldus.

Vidimus vtique nos, à potentia quæ est in B, pondus par sustineri in G, Potentiam autem quæ est in E dimidiũ sustinere ponderis quod est in G. Nos igitur iisdem insistentes adiecta libra, vecteue, bifariam diuiso rem ipsam ex subiecto diagrammate lucidiorem faciemus.

Esto linea quædam stabilis ceu trabs horizonti æquedistans AB, cui in A funiculus annectatur AC, cuius extremum C vecti cuidam alligetur CD, in medio diuiso vbi E, tum alteri vectis eiusdem extremitati D, funiculus nectatur DG, & à puncto E pondus appendatur F. puta librarum mille, Tum puncto G in medio vectis HI, funis religetur DG, & ex altero vectis extremo alligato fune HK commendetur loco stabili in K, & ab alio capite vectis vbi I ad medium vectis MN, vbi L, funis annectatur IL, tum ex vectis capite M, funis commendetur MO, loco stabili in O, & alteri capiti N, funis NP, qui alligetur medio vecti QR in P, & ex Q, funis QS. Commendetur loco stabili in S, & alteri vectis extremo R funis alligetur RT, cui quidem potentia sustinens applicetur in T. Dico igitur,

rebus



rebus ita dispositis, potentiam in T ita se habere ad pondus F, vt vnum ad sexdecim, hoc est, in proportione esse subsexdecupla. Sunt autem hic vectes quatuor inferiorum cubiculorum loco, CD, HI, MN, QR, quorum centra E, G, L, P. quoniam enim A hoc est, C, vnà cum potentia G, hoc est, D, sustinet pondus F alterum ponderis dimidium sustinebit C, alterũ vero D. erunt igitur vtrinque libre quingentæ. Tum potentia in K, hoc est, in H, vna cum potentia in L, hoc est, in I sustinebunt quingenta. Quare vtraq; ducenta quinquaginta, sed hoc totum bifariam diuiditur inter potentias, O, id est, M, & P, id est H. erunt igitur vtrinque centum viginti quinque. Ea autem summa iterũ bifariam diuiditur, hoc est, inter potentias S, id est, Q & T, id est, R, quare vtraque sustinet sexaginta duo cum dimidio. Sed numerus iste ad Millenarium ita se habet vt vnum ad sexdecim. Hinc colligimus, pondus totum inter loca stabilia diuidi, nempe A, K, O, S, & ipsam potentiam quæ sustinet in T, & locis ipsis stabilibus quindecim partes integri ponderis, potentia verò T sextam decimam tantùm

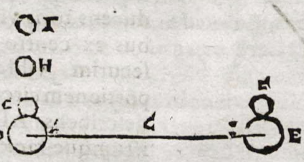
tantùm commendari. Itaque si ex puncto V appenderetur AB, in X potentia, quæ in X sustineret mille, minus sexaginta duo cum dimidio, quod quidem à potentia in T sustinetur; quod si alius adderetur orbiculus, & fierent quinque, potentia in T sustineret trigesimam secundam partem integri ponderis, hoc est, dimidium librarum sexaginta duarum cum dimidio, nempe triginta & vnam cum quarta parte, si item textus adderetur, potentia in T sexagesimam partem sustineret integri ponderis, hoc est, libras quindecim & $\frac{5}{8}$ libræ vnius. Vnde patet clarè ponderis diminutionem fieri ex orbiculis inferioribus, non autem ex superioribus, superiores autem addi non necessitatis quidem, sed commoditatis gratiâ: neque enim absque superioribus vnico ductario fune fieri posset attractio & ponderis ipsius eleuatio. Hactenus igitur nobis isthæc de Trochleæ natura & vi post alios, considerasse sit satis.

QVÆSTIO XIX.

Dubitat Philosophus, Cur si quis super lignum magnam imponat securim, desuperq; magnum adijciat pondus, ligni quippiam quod curandum sit, non diuidit; si verò securim extollens percutiat, illud scindit, cum alioquin multo minus habeat ponderis id quod percutit, quam illud quod superiacet & premit?

POterat Aristoteles, nî fallimur, rem breuius & vniuersalius proponere. Scilicet cur motus ponderi addat pondus & efficacius ex motu quam ex immoto pondere mota res operetur. Soluit autem. An, inquiens, ideo fit, quia omnia cum motu fiunt, & graue ipsum grauitatis magis assumit motum, dum mouetur quam dum quiescit? Incumbens igitur connatam graui motionem non mouetur, motum verò & secundum hanc mouetur & secundum

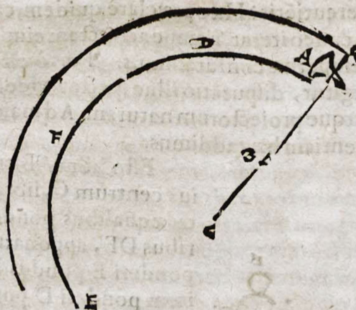
dum eam quæ est percutiẽtis? Hæc præclarè quidem, cætera autem, quæ de cuneo iterat, nempe ad vectem eius operationem referri superius confutauimus. Porrò effectus huius, de quo agitur, disputatio illuc spectat, videlicet ad cadentium atque proiectorum naturam. Ad maiorem autem rei euidentiam hæc addimus.



Esto libra AB, cuius centrum C, librata æqualibus ponderibus DE, apponatur ponderi E pondus F, item ponderi D pondus G ipsi ponderi F æquale, æquilibrabit itidem, Modò non apponatur simpliciter pondus G sex ex H in lançem A dimittatur, tunc sanè non æquilibrabit, sed libram deprimet. Duo enim in pondere dimisso considerantur pondera; naturale scilicet, & quod motu ipsi moto, ponderi est acquisitum. Itaque quo motus fuerit maior, puta si cadat ex I, grauitas ex maiori motu fiet maior. quod vtique efficacius fieret si pondus G non dimittetur modo remoto prohibente, sed proijceretur. Tunc enim tria concurrerent, grauitas naturalis, grauitas acquisita ex naturali motu, & ea quæ naturali adijcitur ex violentia. Pondus igitur securi impositum & securis ipsius naturalis grauitas naturali tantum grauitate operantur, & ideo minus efficaciter. Huc autem ea ferè pertinent quæ nos à principio de duobus centris retulimus, naturalis nempe grauitatis, & acquisitæ.

Cæterùm cur mallei & securis ictus sit violentissimus, ideo fit quod non ex vnico neque duplici, sed ex triplici grauitate operetur. Esto enim securis A, cuius manubrium AB, brachium vero securi vtentis BC, erit igitur C

R locus



locus vbi humero brachium iungitur, motus ipsius centrum, attollit autem securim is qui percutit,& retro ad scapulas reducens totis viribus ex centro C securim vibrat, portionem circuli describens ADE ictumque faciens in E. Vires igitur acquirit securis, tum ex naturali grauitate, cadens ex D, in E, tum ex proprio pondere, tum etiam ex violentia eidem à percutiente impressa. Fiunt autem motus tam naturalis quàm violentus eo validiores, quo maius est spatium, quo res mota mouetur, idque precipuè cum violentia ipsam secundat naturam. Itaque maior fit ictus in E quàm in F, & in F maior quàm in D. Item violentius feriret percutiens, si manubrium esset longius, puta BG. Tunc enim maior esset circulus GH, & motus tum prolixior, tum velocior. quo igitur longiora habet brachia is qui securi malleoue vtitur, data virium paritate, ex eadem ratione validius percellit. Est autem securis, vel malleus cuneatus, vel cuneus malleatus manubrio insertus. An autem operetur efficacius cuneus malleo percussus, aut cum manubrio motus, vt fit in securi, data aciei & ponderis æqualitate, difficile est determinare. Certè validius, & certius fieri scissionem ex cuneo & malleo, ea ratio est, quod cuneus adactus, nec inde remotus eam interim seruat, quam antea fecerat partium separationem, quod

quod quidem ſecuri non accidit, quæ adacta ad nouam percuſſionem faciendam extrahitur.

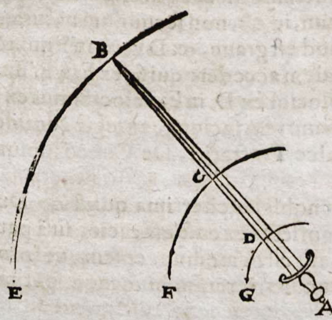
Hoc etiam conſideramus, ſecuris in circulo motum, ex A in D, eſſe videndum, id eſt, non ſecundum naturam, ſurſum enim fertur quod eſt graue, ex D verò in F mixtũ: magis autem ad naturalem accedere qui fit ex F in E. Tardior ergo ex A in D, velocior ex D, in F, velociſſimus ex F in E; quædam quæ ad hanc rem faciunt, egregiè conſiderat Guid. Vbald. in calce Tractatus, De Cuneo; ipſum conſule.

Ad hæc ſuccurrit nobis pulcherrima quæſtio. Dubitari enim poteſt, vtrum ictus ex enſe efficacior ſit à parte quæ eſt circa aciem, aut circa medium enſem, vel prope manubrium capulumue; etenim hinc inde ſunt rationes.

Eſto quidem enſis AB, cuius capulus A, ſpiculum verò B, centrum grauitatis C, pars capulo proxima D. Librato itaque gladio tres fiunt circulorum portiones BE, CF, DG, quæritur quo loco ictus ſit validior, nempe in E, in F, vel in G. Videtur validiorem futurum in E, quippe quod ex maiori ſemidiametro AB, maioris ſit circuli portio BE, & ideo velocior motus ex B in E. Contra efficaciorem futurum apparet in F, propterea quod ibi ex centro C totius fiat grauitatis impreſſio, fieri autem validiſſimum in G, licet ibi motus ſit tardior inde videtur, quod ſi conſideretur enſis vt vectis, cuius fulcimentum eſt A, potentia premens in B, ponderis vero loco reſiſtentia rei quæ percutitur in D. Maior eſt autem proportio BA, ad AD, quam BA ad AC, & ideo violentior fiet preſſio ex ictu in D, quã in C. Hiſce hoc pacto conſideratis, putarem ictum efficaciorem fieri in F ex medio C, quam ex extremis & oppoſitis partibus EG. Licet enim in B velocitas ſit maior, deeſt ibi pondus. Si enim enſis iterum vt vectis conſideretur, e-

 runt

runt AB, duo fulcimenta ſuſtinentia pondus in C, vbi grauitatis eſt centrum. Si igitur paria fuerint ſpatia BC, CA, in B erit dimidium ponderis C, quantum ergo velocitate præualet ictus in B, tantũ ponderis amittit. D verò plus quidem de pondere participat, ſed velocitatis habet minimum, in C verò velocitas eſt mediocris, tota tamen ipſius ex grauitatis centro ponderis fit impreſſio.



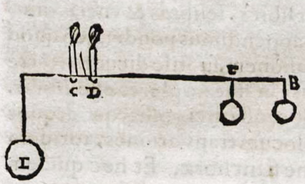
Quidam, quod huc pertinet, vt ex acie ipſa quæ longius à capulo abeſt, violentiſſimum facerent ictum, Argentum viuum, quod ſui naturâ grauiſſimum quidem eſt & mobiliſſimum in canali à manubrio ad verticem excauato infundunt, quo in gladij deſcenſu ad verticem velociſſimè delato illuc transfert grauitatem totam, quare tum velocitate tum grauitate concurrentibus ictus fit violentiſſimus & longè validiſſimus.

QVAESTIO XX.

Dubitatur, Cur ſtatera qua carnes ponderantur, paruo appendiculo, magna trutinet onera, cum alioqui tota, dimidiata exiſtat libra, altera vero parte ſola ſit ſtatera?

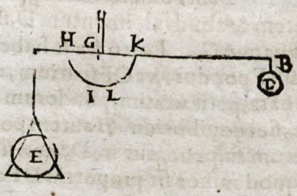
SOluit Philoſophus, inquiens, ſtateram ſimul, & vectem eſſe & libram, ipſius verò libræ centra ſeu fulcimenta eſſe

eſſe ibi vbi ſit ſuſpenſio. Pondera verò hinc inde in lance & appendiculo, loco ſcilicet æquipondij, appendiculo ſuccedente. Reducit autem demonſtrationem ad ea quæ ſtatuit ipſe Mechanica principia; nempe ad circulum & circuli virtutem. Ait igitur, appendiculum licet parui pō-deris ſit, ideo maiori ponderi virtute æquari, quod longius à centro, hoc eſt, ab ipſo fulcimento ſiſtatur. quicquid tamen ſit, ſtateram eſſe vectem, res eſt exploratiſſima.



Eſto igitur ſtatera AB, cuius appendiculum currens F, fulcimentum centrumue C, lanx quæ catena ſuſpenditur E ſpatium à loco fulcimenti ad appendiculum CF. quod verò à fulcimento ad catenam, ex qua lanx appenditur AC. Intelligatur autem & aliud fulcimentum D, ſitque maius ſpacium AD, quam AC. Porrò ita ſe habeat pondus in E ad appendiculi F pondus, vt CF ſpatium, ad ſpatium AC, quo caſu ſeruata, permutatim, ponderum & brachiorum proportione, fiet ęquilibrium. Si autem ponderibus ita conſtitutis iterum ſuſpendatur in D, non fiet æquilibrium, propterea quod minor ſit proportio DF ad DA, ea quæ eſt FC ad CA. Minor ergo eſt proportio FD ad DA, quam ponderis E ad pondus F, & idcirco facta ſuſpenſione præualebit pondus E ponderi F. Itaque vt iterum fiat æquilibrium, neceſſe eſt iterū proportiones brachiorum ſeu ſpatiorum proportionibus ponderum æquare. Transferatur igitur (lancis interim immoto pondere) ipſum appendiculum in B, fiatque vt FC ad CA, ita BD ad DA. Stabit autem iterum ſtatera ad eam redacta quam diximus brachiorum & ponderum permutatam proportionem.

Nos ſtateris vtimur ex duplici fulcimento, altero propiori, altero à lance ſeu loco, vbi lanx appenditur, remotiori, illa grauiora appendimus pondera, & non per vncias & libras, ſed per libras tantum & ſelibra ponderamus; & hoc ſtateræ latus eo quod minus minutè ſit diuiſum, vulgo noſtrates Groſſum, hoc eſt, rude & craſſum appellant. Aliud verò, cum fulcimentum eſt loco appenſionis lancis vicinius, & per libras, ſelibras & vncias diuiditur, quo quidem minora appendimus pondera, eò quod exquiſitioré contineat diuiſionem, ſubtile dicunt. Rectè igitur dicebat Philoſophus, in ſtatera plures eſſe libras, quanquam & ea quoque de cauſſa dici poſſit, quod, quot ſunt appendiculi, è loco in locum translationes, totidem ex proportionum variatione fiant libræ. Et hoc quidem ſenſiſſe videtur Ariſtoteles.



Poſſemus & alio modo ſtatera vti, nempe ſtabili appendiculo, mobili autem fulcimento. Eſto enim ſtatera AB, cuius lanx C appenſa in A, appendiculum verò ſtabile D, appenſum in B, Apponatur ipſi lanci C, pondus E. Vnicum ergo fiet corpus CEABD conſtans ex lance, libra & ponderibus. Habet ergo hoc totum grauitatis ſuæ centrum, quod quidem vbi ſit eſt ignotum. Ex illo autem inuento ſi corpus totum appendatur, partes æqueponderabunt. Appendatur autem, puta in G, ſit autẽ grauitatis centrum in H. Quoniam igitur H eſt extra fulcimentum G, declinabit ſtateræ pars GA, centro G per cir-

circuli portionem HI, à centro grauitatis in ipsa descensione descriptam. Si autem grauitatis centrum fuerit vbi K, eo quod ibi quoque sit extra fulcimentum G, descendet pars GB, describente interim grauitatis centro K, circuli portionem KL. Itaque si stateram totam cum ponderibus trahamus pellamusq; vltro citroq;, immoto appendiculo erit aliquando fulcimentum in ea linea perpendiculari vel loco ipso, vbi est grauitatis centrum, quo casu statera stabit, & tunc ita erit diuisa, vt fiat brachiorum & ponderum eadem ratio, ordine permutato. Hic autem modus ideo non est in vsu, quod molestum sit libram seu stateram cum ponderibus vltro citroque transferre, quæ difficultas commodè appendiculi mobilitate vitatur.

QVAESTIO XXI.

Quæritur, Cur facilius dentes extrahunt Chirurgi, denti forcipis onere adiecto, quam si sola manu vtantur?

REspondet Philosophus, An quia ex manu, magis quam ex dentiforcipe lubrius elabitur dens? An ferro id potius accidit quam digitis, quoniam vndique dentem non comprehendunt, quod mollis facit digitorum caro; adhæret enim & complectitur magis. Hæc secunda ratio videtur primam destruere, & contrarium prorsus sententiæ, quæ in problemate proponitur, asserere. Si Græca ad verbum reddas ita habent: An magis ipsa manu labile est ferrum, & ipsum vndique (dentem nempe) non complectitur, caro autem digitorum cum mollis sit, adhæret magis, & vndique congruit. Certè vt sententia non sit contraria propositioni, Græca versio ita videtur concinnanda: Vel magis è m. n. c l. ibitur, mollis enim est digitorum caro, ferrum autem circumplectitur, & hęret magis. quicquid sit, Græcam lectionem contrarium ei quod quæritur,

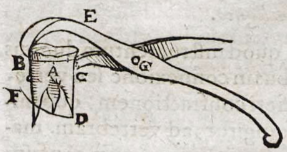
tur,affirmare certum eſt. Picolomineus,Ideo,inquit,digitorum caro mollis minus aptè extrahit, quod dentem totum comprehendere non poteſt,quod ferrum ob ſuam durítiem & conſtantiam commodiſſimè facit. Senſum ex mente reddidit,quod ex verbis non poterat. Subiungit denique Ariſtoteles, An quia dentiforcipes ſint duo contrarij vectes vnicum habentes fulcimentum, ipſam ſcilicet inſtrumenti partium connexionem. Hoc igitur ad extractionem vtuntur **, vt facilius moueant. Figuram hoc pacto proponit Philoſophus.

Eſto dentiforcipis alterum quidem extremum vbi A, alterum autem quod extrahit B, vectis vbi ADF, alter vectis, vbi BCE, fulcimentum verò CGD connexio vbi G. Dens autem pondus: vtroque igitur vecte B,& F ſimul comprehendentes mouent, Hæc ille. Attamen rem ipſam ſubtilius conſiderantibus aliter videtur habere, ac ipſe aſſerat. Et ſanè dentisforcipis brachia vectes eſſe, quorum commune fulcimentum eſt in ipſo centro vbi vertebra, nemo negauerit. Dentem autem eſſe pondus, ego quidem abſolute non dixerim. Pondus autē hîc proprie eſt ipſa dentis durities, cuius reſiſtentia eo facilius ſuperatur, quo maior eſt proportio brachiorum à manu ad vertebram, ad partem illam quæ à vertebra eſt ad dentem. At dentis ex conſtrictione fractio nihil facit prorſus ad extractionem: id tamen operatur brachiorum longitudine dentiforceps, quod valide ex vectium oppoſitorum vi dentes conſtringit & extractioni commodum reddit & facilem. Neque enim totus Dentiforceps hic ceu vectis vnicus operatur, quod fit in forcipibus quas Tenaleas vocamus, quibus è tabulis claui reuelluntur, qua de re nos quęſtione 6. verba fecimus. Quo pacto autē

dentis

dentis ex Dentiforcipe extractio ad vectem reducatur, ſubtilius eſt perpendendum, neque enim res eſt in propatulo.

Dicimus igitur, tum dentem ipſum, tum dentiforcipem vectes eſſe, varia tamen ratione & ſatis ſane diuerſa. Dens enim fit vectis eius nempe naturæ quæ fulcimentum habet in angulo, quo caſu ipſius Dentiforcipis partiũ, quibus Dens apprehenditur, ea quæ longior eſt potentiæ mouentis loco ſuccedit, breuior vero fulcimentum facit, Dentis vero reſiſtentia ponderis vices refert.



Eſto enim dens quidem A, cuius diameter BC, longitudo vſque ad extremas radices CD, pars dentiforcipis breuior CG, longior BG. Fit ergo vectis BCD, habens fulcimentum in C. Dente igitur apprehenſo in BC, & manu dentiforcipe ceu vecte ad inferiora compreſſo C, fit fulcimentum centrumue. Stante enim puncto C, trahente autem potentia quæ eſt in B, fit motus ipſius B, per circuli portionem BE, radicis vero D, fit motus per DF, & inde ipſius dentis extractio facilis. Quibus conſideratis vt rem ad proportiones quatenus fieri poteſt reducamus, dicimus, quo maior fuerit proportio BC, ad CD, hoc eſt, partis vectis, quæ à fulcimento ad potentiam ad eam quæ à fulcimento eſt ad pondus, eo facilius fieri dentis auulſionem, quod vtique demonſtrandum fuerat.

Porro quod in calce quæſtionis addit Philoſophus, Dentes commotos facilius manu extrahi quam inſtrumento, nulla ratione probat. Ego autem arbitror, huc pertinere ea verba, quæ ſuperius habentur, videlicet ferrum

rum quidem non vndique dentem comprehẽdere, quod mollis facit digitorum caro, quæ idcirco adhæret & complectitur magis. An autem ita sit, alij videant, nobis enim digito rem ostendisse fuerit satis.

QVÆSTIO XXII.

Hîc quærit Aristoteles, Cur nuces absque ictu facile confringuntur instrumentis quæ ad eum faciunt vsum, & hoc licet multum auferatur virium, cessante motu & violentia, quod accidit dum malleo confringuntur. Addit præterea, citius fieri confractionem graui, & duro instrumento ferreo videlicet quàm ligneo.

SOluit, inquiens, id fieri quod instrumentum duobus vectibus constet, coëuntibus in connexione seu vertebra, & idcirco eo violentius fieri confractionem, quo minus est spatium à nuce, quæ frangitur, ad vertebram: maius verò quod à vertebra ad extremitates, quæ confringentis manu comprimuntur. Ait igitur, & id quam opposite, vim ex vectibus ictus loco succedere & idem operari. Esto igitur instrumentum, de quo agimus CDBF, ex duobus vectibus constans, quorum alter CAF, alter verò DAB vertebra seu connexio A locus vbi nux frangitur K, manubria vero BF. quo igitur prolixiores erunt AB, AF, breuiores vero ACAD, violentius fiet cõfractio. Erit autem nucis resistentia loco ponderis A, fulcimentum BF loco potentiæ. Itaque nî maior sit proportio potentiæ ad resistentiam, quam brachij à potentia ad fulcimentum ad eam partem quæ à fulcimento est ad nucem, non fiet confractio. eo autem magis superabit, quo

maior

maior fuerit pars vectis quæ à potentia ad fulcimentum.

Quod autem addit Aristoteles, eo maiorem fieri vectium eleuationem, hoc est, instrumenti aperitionem, quo magis nux quæ frangitur, fuerit propior fulcimento, hoc est, ipsi vertebræ, facile ostenditur ex conuersa 21. propos. lib. 1. Elem. si enim ab extremitatibus vnius lineæ ad easdem partes constituantur duæ lineæ maiores concurrentes in angulo, & ab ijsdem extremitatibus duæ aliæ minores, quæ intra triangulum à maioribus constitutum cadant, maiorem angulum continebunt. At talis est angulus qui fit in instrumento, cum partes vectis à vertebra ad nucem fuerint breuiores. magis ergo dilatantur vectes, & magis dilatati magis comprimuntur, magis autem compressi validius frangunt, quod dixerat Aristoteles.

Cæterum & illud quod scribit, ex grauiori & duriori materia instrumentum citius fractionem facere, quam ex leuiori & minus dura, ex parte quidem materiæ verum est, nec pertinet ad proportionem, quæ sane in huiusmodi instrumentis formæ ferè habent rationem. Nos hisce instrumentis non vtimur. Sunt autem similia instrumentis illis, quibus figuli cretaceas pilas ad chirobalistarum vsum facere & efformare consueuerunt.

QVÆSTIO XXIII.

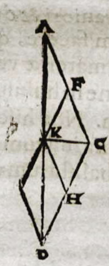
PVlcherrimam proponit hoc loco Philosophus contemplationem, eamque ad mixtos motus pertinētem. Mixtorum autem motuum speculationem antiquis Mechanicis fuisse tum vtilem tum etiam familiarem, norunt ij qui norunt quæ de lineis spiralibus Helicisue, cyssoidibus, conchoidibus & alijs eiuscemodi scripta & contemplata reperiuntur, quibus tum ad duarum mediarum pro-

 portio-

portionalium inuentionem, tum ad circuli quadrationem vti solent. Quod autem hîc quærit Aristoteles, ita se habet.

Cur si duo extrema in Rhombo puncta duabus ferantur lationibus, haudquaquam æqualem vtrumque eorum pertransit rectam, sed multo plus alteram? Item cur quod super latus fertur, minus pertranseat quam ipsum latus. Illud enim diametrum pertransire certum est, hoc vero maius latus, licet hoc vnica, illud autem duabus feratur lationibus?

Difficile hoc intellectu prima fronte, & sane admirabile, itaque intentam contemplationem requirit. Nos primo cum Aristotele, rem totam explicabimus, tum aliquid fortasse non pœnitendum nostro de promptuario proferemus.



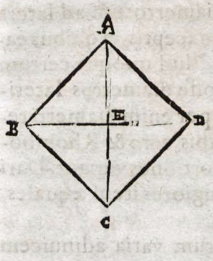
Esto itaque Rhombus ABCD, cuius latera AB, BD, DC, CA, diametrorum maior AD, minor BC, secantes se inuicem in puncto seu figuræ centro K. Sunt auté ex ipsius Rhombi natura latera æqualia & parallela, Angulorum vero qui maiori diametro opponuntur, recto maiores, qui vero minori minores. His igitur consideratis, intelligatur punctum A moueri peculiari & simplici motu, per lineam AB, ab A versus B, & eodem tēpore moueri totam lineam AB, versus lineam DC, hac tamen lege, vt semper eidem DC feratur parallela, & eius alterum extremorum feratur per AC, alterum vero per BD, Intelligatur etiam punctum B moueri eodem tempore proprio motu, eoque simplici, per eandem rectam BA, versus A, & cum eadem, vt dictum est, mota; ferri versus

ſus CD. Erunt autem ſemper AB puncta in eadem linea quæ mouetur, ſibi inuicem ex contrarijs partibus occurrentia. Itaque cum ex duobus motibus ſemper proportionalibus, hoc eſt, laterum proportione ſeruata, recta producatur, vt demonſtratum eſt à principio, vbi productio circuli ex Philoſophi mente eſt declarata, vtraq; puncta quæ eandem laterum proportionem ſeruantia mouētur, rectas lineas producēt A quidem AD, B autem ipſam BC. Feratur igitur A, tum mixto tum ſimplici motu per diametrum AD. B vero quoque tum mixto, tum proprio per diametrum BC, ſupponitur autem motus omnes ſimplices, tum punctorum, tum etiam lineę, à qua puncta ipſa feruntur, æquali velocitate fieri. Illud igitur mirabile eſt, cuius etiam ratio quæritur, quo pacto eodem tempore eademque velocitate latum A quidem totam percurrat AD maiorem, B vero totam BC, eamque longe minorem? Porro neceſſe fuit rem in Rhombo ſpeculari, non autem in quadrato & altera parte longiori rectangulo, in quibus diametri (quod Rhombo non accidit) ſunt æquales. Imaginemur igitur A, proprio motu percurriſſe ſpatium AE, nempe ipſius AB lineæ dimidium. Erit igitur in E, item lineam totam AB eodem tempore pertranſiſſe dimidia oppoſitarum linearum, ACBD, & eſſe translatam, vbi FKG. Quoniam igitur æquali celeritate lineæ AB extremitas A, translata eſt in F & A, punctum per eam motum in E, erit ſpatium AE, æquale ſpatio AF. Ductis igitur lineis FKG, EKH lateribus AB, AC æquidiſtantibus, erit figura AEKF. Rhombus ſimilis quidem Rhombo ABCD, recta igitur FK æqualis erit oppoſitæ AE. quare A punctum translatum erit ex mixto motu in K. Eodem pacto quoniã punctum B. eadem velocitate mouetur verſus A, & linea AB verſus CD, cum B fuerit in E extremum lineæ motæ BA, nẽpe B erit in G, æquales ergo ſunt BE, BG & Rhombus EBGK, circa diametrum BKC ipsi Rhombo ABCD similis, & ideo GK æqualis oppositæ BE & BG æqualis EK. Cum ergo B confecerit spatium BE, erit ex mixto motu in K, superato nempe spatio BK, idque eodem tempore quo A percurrerat totum spatium AK. Ex æquali igitur simplicium motuum velocitate, in æqualia spatia AB puncta pertransierunt, quæ res miraculo, cuius dilutio quæritur, præbet occasionem.

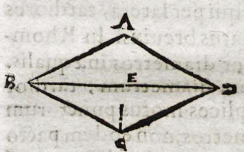
Porro quod de dimidijs diametris demonstratum est, possumus & de totis eadem ratione concludere, quippe quod eadem sit proportio partium ad partes, quæ totius ad totum. Hæc igitur prima est pars propositæ quæstionis. Secunda vero dubitatio ita habet; Nempe mirum videri punctum B, cum peruenerit in C, extremum lineæ BA, videlicet ipsum B, translatum esse in D, licet æqualiter moueantur linea BA, per lineam BD, & punctum B per lineam BA. sitque BC ipsa BD maior. Primam dubitationem hoc pacto soluit Philosophus; A fertur tum proprio, tum alieno motu, hoc est, lineæ AB versus oppositam partem CD, Itaque cum vterque motus deorsum vergat, motus fit velocior. Contra vero B proprio quidem motu fertur versus A, hoc est, sursum, alieno vero, hoc est, lineæ BA versus D, hoc est, deorsum, qui motus cum inuicem aduersentur, motus ipse fit tardior, non igitur est mirum, A eodem tempore maius spatium pertransire quam B.

Hæc solutio non modo vera videtur, sed mirabilis & ipsomet Philosopho dignissima, cui quidem temerariũ iudicaremus contradicere, nî in genere versaremur, in quo non probabilia quæruntur, sed demonstrata, sed vera. Futilem igitur esse rationem hanc ipsius Aristotelis pace, hoc pacto ostendemus.

Esto quadratum ABCD, cuius diametri AC BD secantes sese in E, moueatur eodem pacto BA, versus CD, item



item A, versus B, & B versus A, itaque punctum A tum proprio tum alieno, hoc est lineæ illud deferētis motu deorsum trudet, hoc est, versus CD. Motus ergo velocior erit motu puncti B, quod lationibus fertur ferè contrarijs, hoc est, ex B versus A sursum, cum linea autem B A versus C deorsum. Velocius tamen non mouetur, quippe quod æquali tempore æquale spatium vtrumque punctum conficiat. Stante igitur caussa sequi debuisset effectus; non sequitur autem, Aristotelis igitur caussa non est caussa. Rhombo quoque inuerso idem clarius ostendemus hoc pacto: Sit Rhombus A B C D, cuius diametri A C, B D secantes sese in E. Mota igitur linea A B versus C D, nempe deorsum & A quoque deorsum versus B, contra vero B quidem sursum versus A, deorsum vero versus C, erit B tardior A, sed contrarium fit, quippe quod longior sit B D, per quam mouetur B ipsa A C, per quam mouetur A.



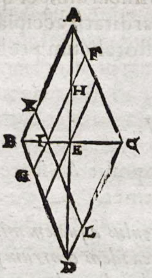
His igitur non satisfacientibus veriorem si per imbecillitatem nostram licuerit, huius effectus caussam inuestigabimus. Rationibus igitur & veritate contra auctoritatem & probabilitatem est nobis pugnandum: quod & intrepide faciemus.

Dicimus igitur, in quouis parallelogrammo sit illud quadratum aut altera parte longius, vel idem Rhombus Rhomboisue semper mixtos motus proportione seruata fieri

fieri per diametros. Cæterum diametrorum ad latera proportiones esse varias (quadratis exceptis, in quibus eadem est semper) exploratissimum. Illud quoque certum est, in rectangulis nunquam dari posse diametros lateribus vtcunque captis æquales, semper enim diametri rectis angulis subtruduntur. In Rhombis vero & Rhomboidibus diametrorum ad latera proportiones variant. Dari enim possunt diametri lateribus longiores item æquales, & lateribus quoque ipsis breuiores.

Itaque diametrorum & laterum varia adinuicem ratione se habentibus, attentis proportionibus, mixtorũ & simplicium motuum diuersa fiet, & varia comparatio. in quadratis motus mixtus, qui per diametros semper velocior erit simplici qui per latera, Idem quoque in altera parte longiori, in quo mixti quidem motus per diametros erunt velociores, simplices vero qui per latera, tardiores quidẽ, sed ex illis tardior qui per latus breuius. In Rhombis autem mixtus motus qui fit per diametros inæqualis. Velocior enim qui per longiorem diametrum, tardior qui per breuiorem. Itaque simplices motus punctorum per latera ad eum qui fit per diametros, non eodem pacto se habent. Porro cum Rhomboides variæ sint diametrorũ ad latera habitudines, varia quoque dari potest proportio. aliquando enim diametri dari possunt lateribus maiores quandoque, alter eorum minor. Si autem Rhombus in duos soluatur triangulos, alter diametrorum datur æqualis æqualibus lateribus æquicrurium triangulorum; itaq; in istis mixti motus per diametros ęque veloces erunt simplicibus, qui per latera longiora, velociores autem illis qui per latera breuiora. His igitur hoc pacto non perfunctoriè consideratis, facile ex proprijs caussis, nî fallimur, hocce Aristotelicum & mirabile Problema soluitur.

Esto



Eſto enim Rhombus ABDC, cuius diameter longior AD maior ſit tum lateribus, tum etiam altera diametro BC. ſecent autem ſe inuicem diametri in E. Ducaturque ipſis AB, CD, parallela FG ſecans longiorem diametrum AD, in H, breuiorem vero BC in I. & per I ipſis BD AC parallela ducatur KIL, Cum ergo B mixto motu per diametrum BC erit in I & A per diametrum AD, mixto ſimiliter motu erit in H, & quia motus mixti fiunt per diametros, vt dictum eſt, vt ſe habet AD ad BC, ita AE ad EB, per 15. propoſ. 5. elem. item vt AE ad EB, ita per 4. propoſ. 6. AH ad BI. eſt enim IH ipſi AB parallela. Longior eſt autem AH ipſa BI, quippe quod AE longior ſit ipſa EB. motus igitur mixtus puncti A per diametrum AD vſque ad H velocior eſt motu B, per diametrum BC vſque ad I. *Mota igitur linea AB* mouebuntur communia eius & diametrorum BC, AD puncta, quibus ſecantur ſemper diametrorum proportione ſeruata. Quibus ita ſe habentibus, nil mirum eſt punctum A motum per AD velociorem eſſe mixto motu puncti B, quod per minorem diametrum fertur BC. quod fuerat demonſtrandum, quatenus vero ad ſecundam problematis partem pertinet, dicimus Propoſitionem non eſſe vniuerſalem. Si enim Rhombus detur, ex duobus æquilateris triangulis conſtans, breuior diameter lateribus erit ęqualis, quare non mouebitur citius motu ſimplici punctum per latus ac faciat mixto per minorem diametrum, quod vt mirum propoſuerat Ariſtoteles. Si autem latus ipſum breuiori diametro ſit lõgius, nec mirum quoque erit ſimplici motu moueri velocius quam mixto, quippe quod, vt

T dictum

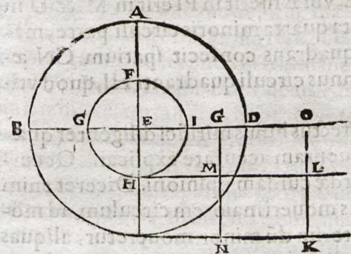
dictum eſt, motus iſti à proportionibus linearum, per quas mouentur, legem velocitatis atque tarditatis accipiant. Hæc igitur nos circa hoc mirabile Ariſtotelicum problema conſiderare ſit ſatis.

QVÆSTIO XXIV.

Mirabilem aliam quæſtionem proponit Ariſtoteles, quæ itidem ad mixtos motus pertinet.

Dubitatio eſt, quam ob cauſſam maior circulus æqualem minori circulo circumuoluitur lineam, quando circa idem centrum fuerint poſiti. Seorſum autem reuoluti quemadmodum alterius magnitudo ad alterius magnitudinem ſe habet, ita & illorum adinuicem fiunt lineæ: Præterea vno etiam & eodem vtriſque exiſtente centro. Aliquando quidem tanta ſit linea, quam conuoluuntur, quantum minor per ſe conuoluitur circulus, quandoq; vero quantum maior.

Hæc ille, qui vt probet maiorem circulum in ſua rotatione maiorem lineam pertranſire, minorem vero minorem; ait ſenſu cognoſci angulum maioris circuli, id eſt, eius qui maiorem habet circumferentiam, eſſe maiorem, eius vero qui minorem, minorem. Ita autem ſe habere circumferentias vt ſe habent anguli, & eandem proportionē habere per quas tum maior, tum minor circulus circumuoluuntur. Ad quorum clariorem intelligentiam ea reuocare oportet in memoriam, quæ dixit de maiorum circulorum ad minores circulos nutu. Hic enim, quod ibi quoque fecerat, ſectorem ipſum angulum appellauit, angulum vero maiorem maioris circuli ſectorem, & minorem angulum minoris ipſius circuli ſectorem dixit. Claudit igitur dicens: quoniam circumferentiæ ſe habent vt anguli, hoc eſt, vt ſectores, maior erit circumferentia maioris circuli, & ex conſequenti maior linea, per quam circumcumuoluitur,ea per quam minor. Demonſtrationem vero ex ſenſu petijt. Sat autem erat ſi dixiſſet, ita ſe habere circumferentias vt ſe habent diametri ſeu ſemidiametri, & ideo lineas in rotatione deſcriptas inuicem ſe habere vt diametros. Obſcuriuſculè,hæc ſua figura oſtendit Ariſtoteles.Nos igitur claritatem amantibus, noſtram aliquanto,nî fallimur,clariorem,proponemus.



Eſto circulus maior ABCD, minor FGHI, circa idem, & commune cẽtrum E. Circumuoluatur maior ad partes D. Sint autẽ diametri, maioris quidẽ AEC, BED, minoris verò FEH, GEI, ſitque CD, quadrans maioris, HI vero minoris circuli. Moto igitur maiori circulo ſecũdum abſidem,cum D fuerit in K erit CK ipſi CD æqualis, fietq; DE ex puncto K perpendicularis ipſi CK, eritq; vbi KO,& quia punctum I eſt in linea DE,erit I facta quadrãtis rotatione in linea KO vbi L, centrum vero E in ipſa KO,vbi O. Reuoluto igitur quadrante maioris, & confecto ſpatio CK minoris circuli quadrans HI conficiet ſpatium HL, quod ipſi CK ſpatio eſt æquale. quod autem in quadrantibus fit,in totis etiam fit circulis. Motus igitur minor circulus circa centrum E, vnica rotatione æquauit ſpatium rotationis maioris circuli. Mirabile itaque eſt minorem circulum eodem tempore & circa idem centrum circumuolutum, lineam pertranſiſſe æqualem circumferentiæ maioris circuli. Nec ſecius admirationem facit rotato minori circulo, maiorem vna circumuolutũ lineam metiri circumferentiæ minoris circuli æqualem. Rotetur enim minoris circuli quadrans HI per rectam HL. erit igitur punctum I vbi M, æquali existente recta HM, ipsi curuæ HI. Tunc autem facto motu centrum E erit vbi P, existente EP, ipsi HM æquali, demittatur autem ex P per M, ipsis HL CK perpendicularis PMN. Et quoniam in eadem linea sunt DIE, vbi E fuerit in P I erit in M, & D in N. quamobrem rotata quarta minoris circuli parte, maioris interim circuli quadrans confecit spatium CN æquale ipsi HM, hoc minus circuli quadranti HI, quod vtique est admirabile.

Porro caussam effectus huius mirifici diligenter quærit Philosophus, & inuentam accurate explicat. Occurrit autem primo absurdæ cuidam opinioni. Diceret enim quispiam, ideo tardius moueri maiorem circulum, ad motum minoris, quod interim dũ minor moueretur, aliquas inter rotandum moras interponeret, minor vero ad motum maioris spatia aliqua transiliret, & ita spatiorum fieri adæquationem. Porro demonstrationem aggressurus hęc assumit principia. Eandem ęqualemue potentiam, aliquã magnitudinem tardius quidem mouere, aliquam vero celerius. quod autem natum est aptum moueri, tardius moueri, si simul cum non apto nato moueri, moueatur, quam si separatim moueretur, celerius autem si non simul cum eo moueatur. Esto enim corpus A leue quidem & aptum natum moueri sursum, cui connectatur B, aptum natum moueri deorsum, Si quis igitur mouere conetur corpus A sursum difficilius mouebit, & tardius iunctũ nempe ipsi B, quam si ab ipso esset seiũctum. Pręterea quod non suo, sed alieno motu mouetur, impossibile esse plus eo moueri qui

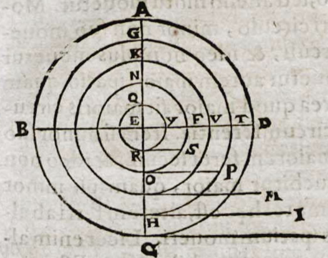
mouet.

mouet,ſiquidem non ſuo,ſed alieno motu mouetur. Moto igitur ſuo motu maiori circulo, minor non ſuo mouetur,ſed motu maioris circuli, & ideo non plus mouetur quam ille moueatur,mouetur autem maiori ſpatio quam ex ſe moueretur,propterea quod maior ſit maioris circuli,à quo ſimul defertur, circumferentia. Item ſi minor ſuo motu circumuoluatur,maiorem feret ſecum, & ideo non plus in ſua rotatione mouebitur maior, quam ipſe minor circulus moueatur. Summa rei hęc eſt,alterum ferri ab altero & latum ad ferentis ſpatium moueri. Licet enim altero moto,alter interim moueatur,nihil refert. Eſt enim ac ſi is qui fertur,nullam habeat motionem, aut ſi eam habeat,ipſa nequaquam vtatur. quod non fit ſi vterque ſeparatim circa proprium centrum moueatur, tunc enim magnus magnum, paruus vero paruum ſpatium conficit. Hinc decipi ait Ariſtoteles illum,qui putat vtrumque circulum per ſe ſuper idem centrum in rotatione moueri, licet enim videatur,reuera non eſt. Id enim vtique certum eſt,cum à maiori circulo minor fertur, circa maioris centrum motum fieri. Si vero maior à minori feratur circa minoris circuli centrum motum fieri. Hæc ferè Philoſophi eſt mens, cuius ſolutionem eſſe certiſſimam, & ex veris cauſſis non dubitamus.

Hinc ad aliam eamq́ue certam aſſertionem tranſimus. Dicimus enim, nullam materialem rotã circa axem eidem affixum,dum rotatur,poſſe eundem locum ſeruare, niſi cauum fiat, quod axem ipſum recipiat, in tranſuerſarijs quibus rota ſuſtinetur & progreſſiuum axis motum impediat.

Eſto enim rota ABCD, cuius centrum E, diametri AEC,BED,eſto alia minor rota GH,item minor KL,tum minor NO, & adhuc minor QR, circa idem centrum E. Rotetur itaque ſecundum abſidem integri quadrantis

 ſpa-



ſpatium CD, eritque D, in F, item ſi ex rota GH, ex quadrante HT, erit T in I. Exalijs item minoribus in M, P, S. erit itaq; longiſſimũ ſpatium CF, breuiſſimũ vero RS, Mota igitur rota circa circulũ ſeu axem, QR, maior rota ſpatio mouebitur RS, quod ſi intra QR, circa centrum E alij infiniti imaginentur circuli, quo propiores centro fuerint, eo maioris rotæ progreſſus erit minor, donec ad centrum deueniatur, vbi cum non ſit circulus, nullus fiet progreſſiuus motus, ſed circa ipſum centrum nulla facta loci mutatione rotabitur. At cum nulla materialis rota circa lineam punctumue imaginarium conuerti poſſit, ideo axi ferreo alteriuſue materiæ circa quem & cum quo circumuoluatur rota, cauum ſemirotundum incidere oportet, in quo inſertus axis dum conuertitur à loco in quo conuertitur, non recedat.

QVÆSTIO XXV.

Quæritur, Cur lectulorum ſpondas ſecundum duplam faciant proportionem, hanc quidem ſex pedum, vel paulo ampliorem, illam vero trium. Item cur vectes funesue non ſecundum diametrum extendantur?

PRimam quæſtionis partem ita diluit Philoſophus, fortaſſe tantæ fieri ſolitos magnitudinis lectulos vt corporibus ſint proportionem habentes, & ideo fieri ſecundum ſpondas dupli longitudine nempe cubitorum quatuor, latitudine vero duorum.

Noſtra-

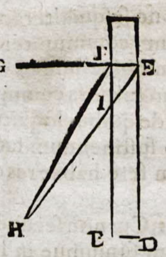
Nostrates alia vtuntur proportione, sesquialtera, videlicet, quam Græci Hemioliam dicunt, communiter enim pedes quatuor latos faciunt plus minusue, longos vero circiter sex. quod ideo fit vt in eis duo corpora commodius cubare possint. Lectuli autem, de quibus loquitur Philosophus, ad vnum tantummodo sustinendum facti videntur, quicquid tamen sit, nullam ferè habet res ex hac parte dubitationem.

Secunda quæstionis sectio ea erat, Cur non secundũ diametros funes extendantur? Restium funiumue in lectulis muniendis vsus non est apud nos. etenim feretra tantum, seu sandapilas, quibus defunctorum corpora efferuntur, funibus ad ea sustinenda inteximus.

Cæterum lectos tabulis seu asseribus sternimus, quibus saccos paleis plenos imponimus, saccis vero culcitras, & tormenta, ne tabularum durities cubantes offendat. Atqui in re facili multum laborasse videtur Aristoteles, tum etiam obscure & inuolute nimis quæstionem tractasse. Difficilem enim apud eum habet hæc explicationem, tum ea [illegible]m diximus de caussa, tum etiam quod Græca lectio & [illegible]na versio corrupta, vt apparet, præ manibus habeantur. [illegible]ne vt veritatem hoc loco vindicaret in lucem, egregie laborauit Picolomineus nec parum profecit. Cæterum cur restes non secundum diametrum extrudantur, triplicem affert Philosophus rationem. Prima est vt spondarum ligna, minus distrahantur. Secunda, vt põdus inde commodius sustineatur. Tertia, vt in ipsa textura minus restium funiumue absumatur.

Ad primam, cur extensis diametraliter funibus spõdæ ipsæ distrahantur discindanturue, nec ille nec alij docent. Ego autem demonstrarem hoc pacto.

Esto sponda ABCD, cuius longitudo AB, crassitudo AC, in ea foramen vtrinque pertinens EF, restis per foramen



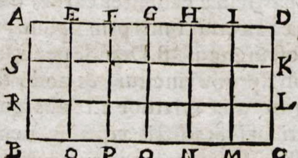
men inditus GFE, ſitque E pars ſeu caput exterius, quod nodo in E diſtinetur. Sit autem ſpondæ lignum iuxta longitudinem vt natura aſſolet ſciſſile. Vis quædam, fune ita extento applicetur in G, quę funem ipſum ad ſe violenter trahat. non diſcindetur idcirco ſponda eo quod non diametraliter funis extendatur. Modo facta capitis G translatione in H, trahatur valide funis, fiet autem preſſio valida in F. ibi enim impedimentum facit angulus, ne funis ipſa dum trahitur, rectitudinem aſſequatur. Itaque vi prævalente, ligno vero ſciſſili, minus reſiſtente, funis, aſſecuta rectitudine, fiet in HIE ſciſſa ſponda ad quãtitatem trianguli FIE, quod fuerat demonſtrandum.

Cur autem funes ab angulo in angulum extenſæ minus commode pondus ſuſtineant, ſatis patet. quo enim funis lõgior, eo debilior, & preſſio quæ in medio fit, ea videlicet parte quæ ab extremis eſt remotiſſima, magis funem fatigat. Longiores autem funes ſunt quæ diametraliter extenduntur.

Quatenus ad tertiã rationem pertinet, hoc pacto funes intexit Philoſoph⁹. Eſto lectulus cum ſuis ſpõdis AB CD, cuius ſponda AD, ſit pedum ſex, AB vero triũ, Diuidatur AD bifariam in E & BC in F. item AE in tres AG, GH, HE & in totidem ED, nempe EL, LM, MD. Similiter medietas alterius ſpõdæ BF in tres partes diſtinguatur BN, NO, OF, & FC

& FG similiter in tres FI, IK, KG, tum altero funis capite inducto per foramen A, ibique probe firmato, indatur per F, inde per I, postea per GHK CE, & in E probe alligetur: Erunt igitur funis quatuor partes æquales AF, IG, HK, EC, quibus adijciuntur particulæ cadentes extra, quæ sunt FI, GH, KC. Post hæc alterius funis principium per foramen traijcitur, quod est in angulo B. Deinde per E, inde per L, N, O, M, D, F & in F probe vincitur, & nodo facto obfirmatur. Erunt igitur aliæ quatuor alterius funis partes, tum inter se, tum etiam supradictis æquales, nempe BE, NL, OM, FD, quibus illæ pariter adijciuntur particulæ, quæ cadunt extra, videlicet EL, NO, MD. quoniā igitur quadratis ex BA, AE æquale est quadratum BE, erit BE quadratum 18. cuius latus radixue $4\frac{1}{3}$ quam proxime. Sunt autem huius longitudinis funes æquales octo. Earum igitur simul sumptarum longitudo erit pedum $34\frac{2}{3}$ vel circiter, quibus si addantur pedes sex funium qui cadunt extra, erit restis totius longitudo expansa pedum $40\frac{2}{3}$ plus minusue. Picolomineus vero ait $34\frac{2}{3}$, omisit enim particulas illas sex, quæ, vt diximus, cadunt extra. Idem rationem funium diametraliter extensarum in idem, ait esse longitudinis pedum $40\frac{1}{2}$. Hic autem eas quoq; particulas prætermittit, quæ extra cadunt. Itaque his additis clare patet, plus restium insumi diametraliter ipsis, quam lateraliter extensis. Cæterum ratio, qua Philosophus hæc probare conatur, adeo est mutila, inuoluta, obscura, vt Delio prorsus, vt aiunt, indigeat natatore. Huius loci inexplicabilem difficultatem, vidit Picolomineus, qui idcirco attestatus est, interpretes in hac exponenda fuisse hallucinatos. Certe Græca lectio versione ipsa Latina non est clarior. Nos interim ne inutilem ferè speculationem nimia diligentia, eaque fortasse frustranea prosequamur, alijs difficultatem hanc dissoluendam aut ceu Gordij nodum

dum gladio scindendo relinquemus. Sed interim subit mirari, cur veteres vtiliori modo prætermisso, inutiliorẽ fuerint amplexati. Poterant enim reticulatim hoc per lineas lateribus æquidistantes intexere.



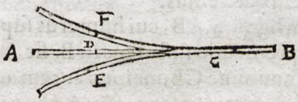
Esto enim lectulus eiusdem dimensionis ABCD, in cuius latere AD sint foramina quinque E,F,G,H,I, totidem in latere opposito QP, ONM. Duo vero in latere breuiori AB, nempe RS, & totidem in opposito KL incipiatur extensio à foramine E, per QP, F, GON, HIM & in M funis obfirmetur, tum alterius funis caput indatur si libet per K, & inde per S,R,L & in L constringatur. Sunt autem omnes EQ, FP, GO, NN, IM, pedum quindecim, quibus si addantur KS, RL, singuli pedum sex erunt pedum XXVII. quibus adiectis particulis extra cadentibus QP, FG, ON, HI, & RS, erit integra summa pedum XXXII. Vide igitur quantum hinc minus insumatur restium quam eo modo, quem probauit, & ceu vtiliorem proposuit Aristoteles. Præterea validissimum est hoc texturæ opus nec ex eo fit vera spondarum distractio scissioue, quibus haud parum obnoxia est ea ratio, quam præfert ipse Philosophus. Concludimus igitur, aut nos eius verba & sensum non intellexisse, aut veteres ipsos, quorum vsum ipse explicat, rei, quam nos proponimus, naturam & commoditatem (quod tamen vix credibile est) ignorare.

QVAE-

QVÆSTIO XXVI.

Proponitur à Philoſopho examinandum, Cur difficilius ſit, longa ligna ab extremo ſuper humeros ferre, quam ſecundum medium, æquali exiſtente pondere?

DVo hîc conſiderat, vibrationem, & pondus. Ait enim primo fieri poſſe, procera ligna vibratione impediente, difficilius ferri. Quæreret autem quiſpiam, (ipſe enim id reticet) cur vibratio hæc ferenti ſit nocua. Nos itaque id explicare conabimur.



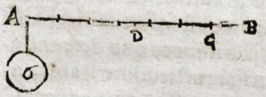
Eſto igitur lignum oblongum, flexile, & vt ita dicam, vibrabile AB, imponatur humero, eique hæreat in C, manu vero ſuſtineatur facta compreſſione in B. Nutet igitur & vibretur, in ipſa vibratione, ad partem A. Sit autem centrum grauitatis eius D, Lignum igitur in ipſa vibratione deſcendet ſua preſſus grauitate in E, tum facta ligni conſtipatione in ea parte quæ eſt inferius inter C & D, & inde reſiſtentia, eodem fere impetu quo deſcenderat, repulſum per D, nec enim in ſua rectitudine ſtabit, aſcendet in F, facta iterum materiæ conſtipatione inter C & F. Mouebitur igitur lignum ſua grauitate, motu frequentiſſimo, ſurſum deorſum, & is interim qui lignum humero fert, procedit antrorſum, impedit igitur motus iſte, qui fit ſurſum deorſum lationem, quæ fit ad anteriora; Latorem ipſum quodammodo retrahens. Si autem medio ligno ſupponatur humerus, eo quod vibratio ſit minor: breuiores enim partes ſunt, quæ à medio ad extrema minus à vibratione remorabitur ferens.

Quoniam autem non ſola vibratio in hoc lationis modo, nempe ex ligni extremitate difficultatem facit, ait

 Phi-

Philosophus, forte id fieri, quoniam licet nihil inflectatur, neque multam habeat longitudinem, difficilius tamē sit ad ferendum ab extremo, eo quod facilius eleuetur ex medio quam ab extremis, & ideo sic ferre sit facilius. Cur autem ex medio facilius eleuetur, caussam esse ait, quod eleuato medio ligno extrema sese inuicem suspendant, & altera pars alteram bene subleuet. Medium enim fieri velut centrum, vbi is supponit humerum qui eleuat aut fert. Extremorum autem interim altero depresso alterum sustolli. Nos interim Mechanicis principijs, quod ipse non fecit, rem clariorem efficiemus.

Esto enim oblongum lignum AB, cui humerus supponatur in B, manus vero premendo sustinens in B. sit autem ligni pars maxima AC, minima CB, maioris autem ad minorem proportio exempli gratia sit sexcupla. Ad hoc igitur vt fiat æquilibrium inter potentiam sustinentem in B, & pondus comprimens in A, ita se habere oportet potentiam in B, ad pondus in A, vt se habet pars ligni AC ad partem CD. Esto igitur pondus in A, puta librarum sex. Erit igitur potentia quæ in B ad hoc vt sustineat librarum triginta sex, quas si addas pōderi in A, fiet humerus in C sustinens pondus librarum quadraginta duo. Si autem humerus medio ligno, hoc est, in D supponatur, ad hoc vt fiat æquilibrium, necesse erit potentiam in B esse æqualem ponderi in A, quod est sex, quare humerus sustinebit duodecim. Vnde patet, longe difficilius portari lignum ex C extremo, quam ex D medio; quod Mechanice fuerat demonstrandum.



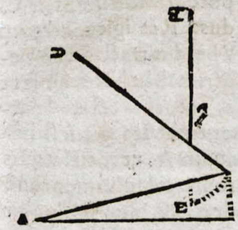
Possumus & aliter idem ostendere. Intelligatur enim ijsdem suppositis, vectem quidem esse AB, cuius fulcimentum

cimentum quidem B, pondus A, potentia ſuſtinens in C, nempe inter fulcimentum & pondus. Res igitur ad eum vectis vſum reducitur, de quo G. Vbaldus tractatu de Vecte, propoſ. 3. Quare vt ille oſtendit, ita ſe habere oportet potentiam ſuſtinentem ad pondus, vt totus vectis ad partem eius quæ à potentia ad fulcimentum. Ita igitur ſe habebit preſſio, quæ fit in C ad pondus in A, vt totus vectis AB ad partem eius CB, quæ à potentia ad fulcimentum. Erit igitur potentia ſeptupla ponderi, & ideo ſuſtinebit pondus librarum quadraginta duarum. quod fuerat oſtendendum.

Hinc alia quæſtio huic affinis ſoluitur, Cur haſta ſariſſaue ſolo iacens manu ad alteram extremitatum apprenſa difficillime extollatur?

Eſto igitur ſariſſa haſtaue iacens AB, cuius extremitati A manus ad ſuſtollendum applicetur, ſit autem pars quæ digitis capitur AC, quæritur cur pars reliqua CB difficillime ſuſtollatur? Facile dubitatio ex prædemonſtratis ſoluitur. Eſt enim C fulcimentum, ſupponitur enim loco, pugno ad ſuſtollendum clauſo, digitus index, potentia autem premens in A, vt ſuperet grauitatem CB, eſt manus ipſius carpus, hoc eſt illa manus ipſius pars, qua pondus facta ſuppreſſione ſuſtollitur. Eſt igitur AB vectis, cuius fulcimentum C, pondus B, potentia A, Itaq; quoniam maxima eſt proportio BA ad AC, maximam eſſe oportet potentiam pondus ſuſtollentem in C.

Huc etiam illud pertinet, Cur haſta ſolo iacente, ſi alterum extremorum manu ſuſtollatur, alterum vero velociſſime ſurſum vibretur, & eodem tempore manus haſtæ ſic vibratæ ſupponatur, haud magna difficultate haſtæ ad perpendiculum fit erectio.



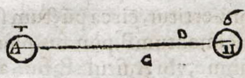
Sit enim hasta AB, quæ manu ex B capta eleuetur in C, & fiat in AC, tum facta ex C partis A veloci vibratione, ipsa extremitas A transferatur in D, sitque vbi CD, tum veloci manus depressione extremitas C transferatur in E, fiatq; EF horizonti perpendicularis; quod vbi factum fuerit, erunt in eadem linea quæ ad centrum mundi, manus ipsa quæ sustinet, & grauitatis ipsius centrum G, quare manus ipsa facta vibratione tantum portat, quantum præcise ipsius est hastæ pondus.

QVAESTIO XXVII.

Dubitatur, Cur si valde procerum fuerit idem pondus, difficilius super humeros gestatur, etiamsi medium quispiam illud ferat quam si breuius sit?

QVæstio hæc superiori est affinis. Ait autem Philosophus, caussam non esse id, quod in præcedenti quæstione dixerat, sed vibrationem: quo enim longiora sunt ligna, eo magis eorum extrema vibrantur, debiliora enim sunt & à medio remotiora, quare suopte pondere facilius nutant. Si autem breuiora sint ea caussa cessante minor fit aut nulla vibratio, quare breuiora feruntur facilius. Dupliciter autem vibratione ipsa, portans offenditur, tum ex caussa quam in superiori quæstione considerauimus, nempe quod motus sursum deorsum assiduus, progredientis motum impediat, tum etiam quod duplici pressione grauetur ferentis humerus, quod Philosophus non animaduertit.

Sit enim oblongum lignum AB, quod humero medio



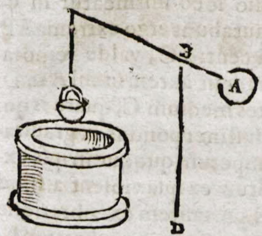
dio loco ſuſtineatur in C. nutabunt ergo extrema AB, à centro C, valde remota, cadent autem ſimul A in D, & B in E trahere ſecum conantes medium C, quare is qui in C ſuſtinet, non modo ligni ſuſtinet pondus ex grauitatis centro quod eſt in C, ſed impetum quoque in ipſa extremorum depreſſione acquiſitum ex ipſa violentia. Illud autem ſubtiliter conſideramus, portantem ex vibratione per interualla deprimi & ſubleuari. fiat enim vibratum lignum ex contrario motu, vbi FCG. alleuiabit igitur eo caſu portantem, ſiquidem impetus ex motu ipſo acquiſitus, medium C trahat ad ſuperiora. Itaq; cum eſt in DCE portans plus ſuſtinet in ACD, æquale, in FCG minus, quod vtique demonſtrandum fuerat. Eſt autem quæſtio hæc illi familiaris, quam *16.* loco explicauimus.

QVAESTIO XXVIII.

Quæritur, Cur iuxta puteos celonia faciunt eo quo viſuntur modo? Ligno enim plumbi adiungunt pondus, cum alioquin vas ipſum & plenum & vacuum pondus habeat.

RESpondet optime Philoſophus, hauriendi opus duobus temporibus diuidi, nempe dum vas ipſum vacuum demittitur, dumque extrahitur plenum: Contingere autem, vacuum facile demitti, plenum autem difficulter extrahi. Expedire nihilominus tardius, hoc eſt difficilius dimitti vt facilius extrahatur, plumbo nempe coadiuuante, & ſane Philoſophi ſolutio eſt lucidiſſima. Nos autem luci ipſi lucem aliquam adhuc afferre conabimur.

Eſto Celonium (Latine Tolenonem appellant) ABC, cuius arrectarium BD, tranſuerſum lignum AC, quod con-

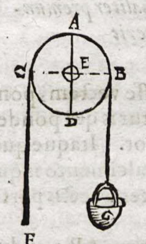


conuertitur, circa pũctum ſeu fulcimentum B, pondus, plumbumue, vbi A, ſitula E, funi appenſa CE. Dico rebus ita conſtitutis difficilem quidem eſſe vacuæ ſitulæ demiſſionem, facile vero eiuſdem extractionem. Vectis diuiſi, ſitulæ, ac ponderis, ad hoc vt fiat æquilibrium, ea debet eſſe proportio, vt quemadmodum ſe habet AB ad BC, ita ſe habeat plenæ ſitulæ pondus E ad ipſum pondus A, ſuperabit ergo pondus in A ſitulam vacuam in E nec fiet æquilibrium, itaque vt vacua ſitula demittatur, tanta vis adhibenda eſt quantum eſt ipſius aquæ, qua ſitula impletur pondus, quæ vis dum apponitur difficilem, vt dicebamus, efficit ſitulæ vacuæ demiſſionem. Plena vero ſitula ſit æquilibrium, vnde quantumuis puſilla vi adhibita, ſitula extrahitur, quaſi ex ſemetipſa ponderis appenſi virtute aſcendens. Quantum igitur pondus dum vacua demittitur impedit, tantundem plena dum extrahitur, adiuuat. Quę cum ita ſint, ſi paria ſunt difficultas in demittendo, & facilitas in extrahendo, quæ ratio hoc in negotio vtilitatis? Sane ſitula vacua, manu per funem facile demittitur, plena vero difficile extrahitur, vſu autem Celonij res permutãtur. Corporis enim proprij pondere, dum premit, adiuuatur demittens, qui per funem ſimplicem extrahendo, ab eodem proprij corporis pondere impediebatur. quod quidem ex corporis pondere, auxilium, ingentem parit in extrahendo commoditatem.

Quippiam ſimile accidit, aquas è puteis extrahentibus vſu trochleæ. Sit enim trochlea puteo imminens ABCD, cuius centrum E ſuſpenſa quidem in A, funis, cui

ſitula

ſitula ſuſpenditur FCABG,ſitula vero G. Eſt igitur diameter CED,inſtar libræ,quare vt fiat æquilibrium neceſſe eſt capiti funis F,potentiam applicare, quæ ſit æqualis



pondere ſitulæ aqua plenæ, itaque extrahens proprijs viribus corporis pondus adijciens facile ſitulam aqua plenam extrahit, ex qua re magna extrahentibus fit commoditas. Patet autem diuerſo modo extrahentes iuuare Celonium & Trochleam,ibi enim corporis mole adiuuatur demittens vacuam, hic vero qui extrahit plenam aqua ſitulam.

Cæterum Celonij partem BC, qui à fulcimento ad funem longe maiorem eſſe oportet, ipſa AB,vt ſitula in profundum poſſit demitti, quamobrem ita ſe debet habere pondus in A, ad pondus ſitulæ plenæ, vt ſe habet brachium ſeu pars BC, ad partem BA. Tunc enim ex permutata proportione efficitur æquilibrium.

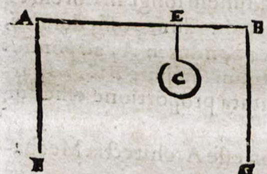
Illud addimus,nouum non eſſe Architectis Mechanicisque, tum hominum tum animalium vt commodius machinas moueant, adhibere pondera corporum. Nec enim alia ratione mouentur Rotæ illæ, quas ob hanc cauſſam ambulatorias vocant; quarum vſus ad Mangana, ad extrahendas è puteis aquas, & ad farinarias quoque molas agitandas adhibetur.

Porro Tollenonem bellicam Machinam à Celonio tum forma tum poteſtate nihil differre, videre eſt apud veteres Mechanicos, Heronem Byzantium,& alios, apud neotericos vero hac de re agunt Daniel Barbarus in Vitruuium,& Iuſtus Lipſius in librum quem de bellicis machinis edidit,elegantiſſimum.

QVAESTIO XXIX.

Dubitatur, Cur quando super ligno, aut huiusmodi quopiam, duo portauerint homines, idem pondus non æqualiter premuntur, sed ille magis cui vicinius fuerit pondus?

SOluit Aristoteles, inquiens, lignum esse vectem, pondus vero fulcimentum; res quæ mouetur is qui ponderi est proximior: mouens vero qui remotior. Itaque quo magis remotus est à pondere, hoc est, à fulcimento is qui mouet, eo violentius is premitur qui altera vectis parte eaque breuiori, mouetur.

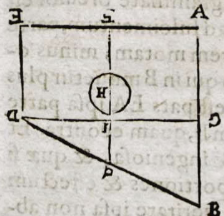


Esto lignum AB, pondus C appensum in E, vicinius extremo B quam ipsi A, sit autẽ portãtium alter quidem AF, alter vero BG, Imaginemur itaque locum E à pondere ita figi & deprimi, vt sursum quidem ferri nequaquam possit, circa vero punctum E, ceu circa centrum fulcimentumne ipsum vectem conuerti. Lignum ergo AB vectis: mouens potentia A, pars vectis à potentia ad fulcimentum AE pars eiusdem quæ à fulcimento ad rem motam EB, & quoniam quanto longior est pars vectis EA ipsa EB, eo facilius potentia quæ est in A, operatur in id quod est in B, si res ad proportiones redigatur, erit potentia in A, ad id quod mouetur seu premitur in B, vt pars vectis EB ad partem EA, sed maior est AE ipsa EB, ergo maiorem partem sustinet ponderis, & plus premitur is qui in E, & qui mouet in A. Hæc fere Philosophi est sententia: Picolomineus vero Paraphrastes apposite duos vectes in vnico ligno

gno conſiderat, alterum AB, alterum BA, in primo A eſt mouens B, motum in ſecundo B, mouens A vero motum in quibus vectibus ſemper idem & commune fulcimentum E. Et quoniam in propoſito diagrammate breuior eſt pars vectis EB, quæque à mouente ad fulcimentum, parte illa quæ ab eodem fulcimento ad rem motam, minus operatur B in A, quam A in B, & ideo qui in B mouetur plus premitur, contra vero quia maior eſt pars EA ipſa parte EB, magis operatur qui in A in ipſum B, quam econtra. Et ſane conſideratio hæc ſubtilis eſt & ingenioſa, & quæ ſi recte intelligatur, quatenus ad proportiones & effectum ipſum demonſtrandum pertinet, à veritate ipſa non abhorret, Quicquid tamen ſit, Mechanice magis hoc pacto quæſtio diluetur. Dicimus enim, pondus quidem vere eſſe pondus, non autem fulcimentum, vt ſibi fingebat Ariſtoteles: lignum vero vectem, duo autem qui pondus ſuſtinent pro duplici fulcimento haberi, vtriſque enim vectis cum appenſo pondere innititur. Poteſt etiam alter eorum pro potentia mouente, alter vero pro fulcimento, & ſic viciſſim. Eſt autem, quomodocunque res accipiatur, pondus inter fulcimentum & potentiam. Quare ex ijs quæ demonſtrauit G. Vbald. de hoc vectis genere loquens, vt ſe habet AE pars ad AB vectem totum, ita potentia quæ ſuſtinet in B, ad pondus appenſum in E, & vt BE ad BA ita potentia quæ ſuſtinet in A ad pondus quod in E. At minor eſt proportio BE, ad BA, quam AE ad AB, quare magis ſuperatur pondus in E à potentia quæ in A, quam à potentia quæ in B, & ideo plus ponderis ſuſtinet ferens in B, quam ferens in A, quod fuerat demonſtrandum.

Hinc colligimus, pondere in medio vecte appenſo ferentes æqualiter ſuſtinere, propterea quod totius vectis ad partes ipſas proportio ſit eadem, vel æqualis.

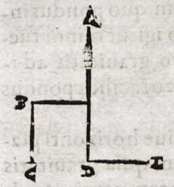
Pulchre autem dubitari poteſt, an idem prorſus contingat, ſi alterum eorum qui ſuſtinent, ſit ſtatura quidem procerior, alter vero humilior.



Sit enim vectis AB, in cuius medio pondus H libere appenſum ex C, alter portantium procerior AD, humilior vero BE. ſit autem horizontis planum DE, demittatur à puncto C ad horizõtem perpendicularis, ipſis vero AD, BE, æquidiſtans CF. Tranſibit autem per ipſius ponderis grauitatis centrum H. Dico igitur, nil referre quatenus ad pondus ſuſtinendum pertinet, vtrum portantes ſint ſtatura pares vel ne. Ducatur enim horizonti æquidiſtans GB, ſecans perpendicularem CF in I. Quoniam igitur AG æquidiſtans eſt ipſi CI erit vt AC ad CB per 4. ſexti elem. ita GI ad IB. Sunt ergo GI, IB inter ſe æquales. Intelligatur itaque pondus H, ſolutũ à puncto C appenſum eſſe libere ex puncto I, hoc eſt, ex medio vectis GB, æqualiter ergo diuiſum erit pondus inter portantes, licet alter procerior, alter vero ſtatura pumilior, quod fuerat demonſtrandum.

Si autem pondus ita vecti alligatum ſit vt libere non pendeat, vecte ex vna parte eleuato, ex altera vero depreſſo, grauitatis centrum ad eam partem verget quæ magis ab horizonte attollitur, & ad eam ipſam partem vectis à pondere ad ſuſtinentem fit breuior.

Eſto enim vectis AB, cuius medium C, pondus vecti in C alligatum CFG, cuius grauitatis centrum H eorum qui portant procerior AB, humilior BE, horizontis planũ DE. Demittatur per centrum H horizonti perpendicularis IHK, ſecans vectem quidem in I, horizontis vero planum



num in K. Poſt hæc intelligatur pondus ſolutum quidem à puncto C, appenſum vero ex puncto I. Stabit igitur ex definitione centri grauitatis nec ſitu ſuo mouebitur. Dico autem partem AI ipſa IB eſſe breuiorem, hoc eſt, punctum I cadere inter C & A. Si enim non cadat, vel cadet in C, aut inter C & B, cadat autem ſi fieri poteſt in C. Erit igitur CHK horizonti perpendicularis, ſed eidem perpendicularis AD. Erunt igitur BCK BAD anguli inter ſe æquales, ſed ipſi BAD angulo æqualis eſt CIH, quare & BCH ipſi CIH æqualis erit. Producto igitur latere IC trianguli ICH erit exterior angulus æqualis interiori ex oppoſito, quod eſt abſurdum. non ergo I cadet in C. Eadem autem ratione monſtrabitur non cadere inter CB, cadet ergo inter CA, & ideo minor AI ipſa IB. Itaque vt ſe habet BI ad BA, ita potentia in A ad pondus in I, ſed maiorem proportionem habet BI ad BA, quam IA ad AB. Ergo minor potentia requiretur in B quam in A, & ſane pars IB reſpondet potentiæ ſuſtinenti in A, at IA potentiæ ſuſtinenti in B, minor eſt autem AI ipſa IB, ergo maior potentia requiritur in B, quam in A, quod fuerat demonſtrandum.

Hoc item concludetur, ſi portantes ſtatura quidem pares fuerint, ſed per planum ambulent horizonti accliue aut decliue. Si enim pondus libere pendeat, vectis partiũ proportio non mutabitur; ſi autem libere non pendeat, is magis laborabit qui in aſcenſu præibit, minus vero qui in deſcenſu.

Hinc quoque Carrucarum ratio pendet, quæ dupli-ci manubrio vnica rota vulgo ſunt in vſu, pro vecte enim habentur, cuius fulcimentum ad contactum plani & rotæ; potentiæ vero ad extremitatem duplicis manubrij. Reducitur enim ad idem genus vectis, in quo pondus inter fulcimentum est & potentiam. quo igitur minor fuerit proportio partis vectis quæ à centro grauitatis ad ipsum fulcimentum, ad totum vectem eo facilius pondus eleuabitur.

Cur autem difficilime hæ per accliue horizonti planum pellantur, duplici fit de caussa, tum quia grauitatis centrum ad ipsum portantem seu pellentem vergit, & ideo pars quæ à fulcimento ad centrum grauitatis ponderis fit maior, tum etiam quoniam ipsum graue contra sui naturam sursus pellitur ferturque.

Quærere ad hæc quispiam posset, Cur Baiuli magna ferentes pondera, curui incedant? Dixerit autem aliquis, ponderis grauitate eos deprimentis id fieri. Nos autem duplici item de caussa id fieri putamus, tum ea quam considerauimus, tum etiam alia, nempe vt grauitatis centrum ipsius ponderis quod sustinent, in perpendiculari collocent, ne si extra ponatur is qui fert à centro extra fulcimentum posito, ad eam partem ad quam vergit trahatur, & pondere ipso opprimatur.

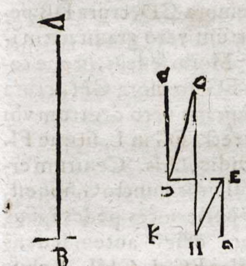
Eadem de caussa fit quoque vt ij qui magna pondera sinistro ferunt humero, in dextram partem inclinentur, qui vero dextro, contrario modo se habeant, æquatur enim pondus eo pacto, & grauitatis centrum in ipsa perpendiculari collocatur.

QVÆSTIO XXX.

Cur assurgentes omnes fœmori tibiam ad acutum angulum constituamus & pectori thoraciue similiter fœmur, quod ni fiat haudquaquam surgere poterunt?

AIt Philosophus, forte id fieri, quod æqualitas sit omnino quietis caussa, rectum vero angulum quietis angu-

angulum eſſe,& ſtationem facere, nec alia de cauſſa ſtantem ipſi terræ eſſe perpendicularem, & ideo caput & pedes in eadem linea habere,ſedentem vero non item. Tũc autem à ſeſſione ſurrectionem fieri, cum caput & pedes in vna linea collocantur, quod ſane fit cum pectus & crura acutum cum ipſo fœmore angulum faciunt.



Eſto enim ſtans AB horizonti IBK perpendicularis, cuius caput A,pedes vero B,ſedeat modo ſitque eius cum capite Thorax CD, fœmur DE, crura EF, ſintque CDE, DEF anguli recti, quibus ita conſtitutis non ſunt in eadem linea caput C & pedes F. Surgere itaque non poterit ſedens, propterea quod partes omnes corporis non ſint horizonti perpendiculares. Ad hoc autem vt ſurrectio fiat, neceſſe eſt vt ſedens retrahat quidem pedes in H, & pectore inclinato acutum cum fœmore angulum conſtituat GDE, quo caſu fient in eadem recta linea, eaque horizonti perpendiculari caput in G, & pedes in H, ex cuius ſitus natura commoda fiet ab ipſo ſedente ſurrectio. Hæc fere, licet alijs ab eo verbis explicata,ipſius eſt Philoſophi ſententia;quæ licet vera ſit,non tamen ex proprijs,hoc eſt,Mechanicis principijs eſt petita. quod quidem nos facere conabimur.

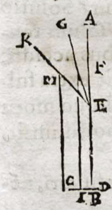
Dicimus autem primo, ſedentem non ideo quieſcere, vt ſentit Ariſtoteles, quod rectus angulus quietis ſit cauſſa, ſed propterea quod eius thoracis tum etiam fœmorum pondus ab ipſa ſede ſuſtineantur; crura vero & pedes ideo non laborent,quod partim ſuſpenſa ſint, partim ſolo ipſi innitantur. Quare cum corpus totum nec ſe ſuſti-

ſuſtineat, nec à pedibus ſuſtineatur, fitquies & laſſitudinis alleuatio. Natura autem ideo commodam hominibus ſeſſionem facere voluiſſe inde apparet, quod clunes, quibus tota ſuperior pars, & grauior nititur, carnoſam fecerit, & ceruicalis cuiuſdam inſtar mollem & facilem. Sed nos ad quæſtionem.

Eſto enim ſtans AB, cuius caput A, Thorax AC, fœmora CD, crura DB, pedes vero B, centrum vero grauitatis in ipſo Thorace E. Modo ſedeat, ſitque caput in F, Thorax FG, fœmora GH, crura HI, pedes I, grauitatis vero centrum vbi K. Producatur recta FG in L, ſitque FL horizonti perpendicularis. Centrum ergo grauitatis K fulcitur puncto G, hoc eſt, puncto L, in quo poſteriores pedes ipſius ſedis ſolo hærent. efficit autem ſedens duos rectos angulos FGH, GHI. Rebus igitur ita diſpoſitis ſeruatis rectis angulis, non fiet ſurrectio, & id quidem non ideo quod, vt ait Philoſophus, æqualitas & rectitudo angulorum quietis ſit cauſſa, ſed propterea quod centro grauitatis extra pedum fulcimētum conſtituto, non habet centrum ſtabilem locum cui in actu ſurrectionis hæreat, & fulciatur, vnde fit vt ſi ſedenti ſubtrahatur ſedes remoto prohibente, ſedens prorſus corruat. Modo retrahat qui ſedet crura, & pedes ponat in M, à puncto autem M, horizonti perpendicularis erigatur MN. erit ergo fulcimentum in M, ſed adhuc ſurgere non poterit, centro grauitatis adhuc extra lineam MN, quæ per fulcimentum eſt, conſtituto. Reclinetur autem pectus ad anteriora, & cum fœmore acutum angulum faciat ſitque vbi GO, erit igitur grauitatis centrum vbi P, hoc eſt, in ipſa perpendiculari NM, fiet igitur inde commoda ſurre-

ſurrectio, propterea quod in eadem linea facta ſint, grauitatis centrum P, & fulcimentum ipſum M. Acutum vero angulum in ſurrectione neceſſarium eſſe clare patet, non autem effectus ipſius eſſe cauſſam, vt videtur ſenſiſſe Ariſtoteles; niſi dicamus, cauſſam eſſe cauſſæ, ſiquidem acuti qui fiunt anguli centrum & pedes in eadem linea collocant, quicquid tamen ſit, nos ideo ſurrectionem fieri dicimus, quod immutatis angulis centrum grauitatis ſupra fulcimentum, fulcimento vero ſub ipſo grauitatis centro collocetur, & hæc eſt cauſſa proxima. Hæc nos ad Ariſtotelem. Modo quaſdam alias quæſtiones, nec inutiles ſed & eas non iniucundas quoque proponemus.

Primum igitur quærimus, Cur hominum & cæterorum animalium, quæ aliquando erecto corpore incedunt, pedes non quidem breues ſint & rotundi, ſed longiores potius, & in inferiorem partem porrecti? Item cur magis ad digitos quam ad calcaneum porrigantur?



Eſto homo animalue quodpiam ſtans AB, cuius pes CD, pedis pars quæ ad digitos BC. quę vero ad calcaneum BD fœmoris vertebra E, centrum vero grauitatis ipſius corporis F. Primum igitur ſtatuendum eſt, hominem & cætera fere animalia à Natura facta eſſe vt ad anteriora moueantur, & ideo omnes fere quod in ſenioribus manifeſte apparet, ad anteriora ex ipſa corporis diſpoſitione vergant. Itaque dum qui ſtat horizonti prorſus eſt perpendicularis, grauitatis centrum F in ipſa perpendiculari conſtituitur quæ ad mundi centrum AB, & ideo corporis moles pondusque fulcitur puncto B. Modo fiat ex vertebra E thoracis AE, inclinatio in anteriora, in GE & grauitatis centrum D diluetur in H, & per H perpendicularis demittatur HI, non erit ** extra pedis fulcimentum BC. Stabit ergo qui ita inclinatur, nec corruet: si autem adhuc propendeat magis, fiatque in KE, centro grauitatis constituto in M, ducatur per M perpendicularis ML, quare quoniam linea ML extra pedis fulcimentum cadit, corruet qui eo pacto inclinatur nec sustinebitur. Cur igitur natura animalibus quę erecto corpore ambulant, pedes in anteriora porrectos fecerit, hinc clare patet.

Hinc etiam ceu consectarium habemus, cur homines si impellantur, magis ad casum in posteriora quam in anteriora sint proni. Necnon etiam cur simiæ, vrsi, & si quæ cætera eiusmodi animalia diutius erecto corpore ambulare nequeant, nempe ideo quod eorum corporum moles valde in anteriora propendeat, nec ita commodo, vt humanis euenit corporibus, pedum ipsorum basibus fulciantur.

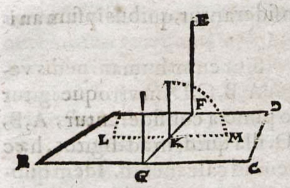
Quærere item haud importune possumus, Cur grallatores non stent erecti, nisi assidue moueantur? Solutio facilis. grallæ etenim duobus tantum punctis solum tangunt, nec porrecti beneficio, quod ambulantibus accidit, vti possunt. quamobrem grauitatis centrum fit extra fulcimentum, & ideo coguntur grallatores assiduo motu grauitatis centro fulcimentum supponere, quod dum fit, à casu prohibentur.

Potest autem id quod fulcitur, tripliciter fulciri, nẽpe aut puncto, aut linea, aut superficie.

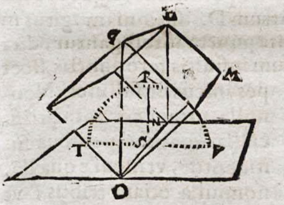
Quod puncto fulcitur, nulla re impediente ad quamuis partem cadere potest, centrum siquidem, motus, punctum est.

Quod linea fulcitur ad duas tantum partes, easque oppositas, habet casum. sit illud superficies, corpusue in latus constitutum.

Esto



Esto horizontis planum ABCD, cui ad rectos angulos insistat superficies EFGH, secundum latus FG. Sit autem ipsius superficiei grauitatis centrum I. à quo ad horizontis planum perpendicularis demittatur IK. Cadet autem in lineam FG. per propos.38. vndecimi elem.& anguli IKG IKF recti erunt. Itaque superficie EFGH circa lineam FKG ceu circa axem mota punctum I peripheriam describet LIM, & siquidem cadat ad partes CD, grauitatis centrum erit vbi M. Si vero ad partes AB, fiet vbi L. Sunt autem LKM pũcta in recta LKM, quæ quidem communis sectio est plani horizontis, & plani per IKLM, transeuntis.

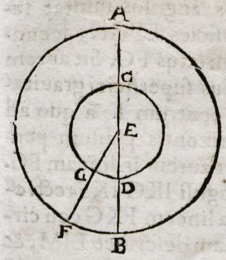


Idem quoque de corpore dicimus in latus collocato. Esto enim cubus LO, cuius grauitatis centrum R, latus vero quo fulcitur, NO, Si enim ita collocetur, vt interna superficies LNOQ ad rectos angulos horizonti sit constituta, demissa perpendicularis à puncto R, cadet in S, in ipsa linea NSO. Cadente igitur corpore fiet motus circa lineam NO, centro grauitatis interim peripheriam TRV. describente.

Hinc animaduertere licet, Cur prouidissima Natura nulli animantium vnicum dederit pedem, sed aut quaternos, aut saltem binos, & binos quidem ipsos virtute quaternos, siquidem in quolibet animantium bipedum

 pede

pede duo ſaltem puncta conſiderantur, quibus ipſum animal fulcitur.



Sint enim humani pedis veſtigia A, B, C, D, in vtroque igitur duo puncta conſiderantur, A, B, C, D, illa quidem ad digitos, hæc autem ad calcaneum. Idem quoque in auium pedibus obſeruatur, ex quibus concludimus, bipedum omnium fulcimentum eſſe quadruplex. Porro quadrupedia eo quod tota corporis mole ad inferiora vergant, quatuor fulcimenta, eaque diſtincta, & commode ab inuicem remota eadem met Natura præparauit.

Eadem quoque in artificialibus conſideramus. Sit enim vas quodpiam ABC, cuius pes vnicus, iſque rotundus BC, grauitatis vero centrum D. Quoniam igitur in pedis ipſius peripheria, infinita puncta intelligantur, dici quodammodo poteſt vas ipſum infinitis fere punctis, licet pes vnicus ſit, ſuſtineri. Nonnulla autem corpora artificialia quatuor pedibus ſuſtinentur, vt menſæ quædã, nonnulla etiam tribus, vt tripodes, qui nomen ab ipſo pedum numero ſortiuntur. Sit enim triangulum EFG, cuius centrum grauitatis H, nitatur autem tribus punctis I, K, L, ſtabit igitur. Si autem duobus tantum; non ſtabit. ducta enim IK ſi punctis tantum IK innitatur, conſtituto grauitatis centro

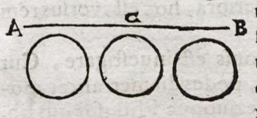
extra

extra fulcimentum IK, verget cedens versus partes, L, Si autem innitatur punctis IL, cadet ad partes K. Si vero ipsis KL, cadet ad partes I. Ex quibus apparet, inanimata corpora aut vnico pede plurium virtutem habente, aut sal* tem tribus actu, vt sustineantur, indigere.

Hinc etiam patet, cur senes, imbecilles, curui, & pedibus capti, baculi baculorumue fulcimento egeant, etenim cum hi debiles sint, & in anteriorem partem magnopere propendeant, ne grauitatis centrum extra fulcimentum fiat, baculo vel baculis indigent, quibus centrum ipsum fulciatur.

Cæterum cur duplici genu ingeniculati difficile in eo situ permaneant, ea caussa est, quod grauitatis centrum in thorace constitutum, duobus genibus fulciatur, eosque premat. quæ quidem genua eo quod natura apta nata non sint, veluti pedes, ad sustinendam corporis molem laborant, idque eo magis, quod cum ossea sint, cutem inter ossium & plani duritiem constitutam, accidit arctari, & ideo dolorem & molestiam ingeniculatis facere.

Si autem vnico tantum genu quispiam nitatur, difficultatem sentiet longe minorem. Triplici enim fulcimento eo casu ingeniculatus fulcitur. Sit enim ingeniculatus ABCDE, cuius grauitatis centrum F. dextrum vero genu, cui nititur D, sinistrum vero, quod eleuatur B. Tribus ergo fulcimentis ingeniculatus vt diximus, sustinetur, CDE. Diuiditur itaque pondus in tres partes, & ideo singulæ minus fatigantur. Magis tamen laborat punctum D, vtpote illud, cui ad perpendiculum F grauitatis centrum innititur.



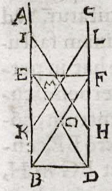
Vtique illud quoque mirabile est, Aues dormientes vnico tantum pede fulciri, & quod magis mirum est, dormientes poſſe, quod vel ipſis vigilantibus eſt difficile. Cur id Natura docente faciant, eam puto eſſe cauſſam, quod dum dormiunt, caput ſiniſtræ alæ, vt naturali calore iuuentur, ſupponunt, quapropter ad eam partem declinantes, vt interim æquilibrium faciant, pedem ſubleuant, & eo caſu ceu inutilem retrahunt atque ſuſpendunt: addita item alia cauſſa, nempe vt pedem ipſum dormientes natiuo calore confoueant.

Quæritur etiam, Cur ij qui inclinantur, vt rē quampiam à ſolo ſuſtollant, alterum crurium ad anteriora, nēpe verſus manum ipſam, quam porrigunt, extendant?

Eſto enim quiſpiam ABCD, cuius crura BC, BD, grauitatis centrum E, velit autem quippiam à ſolo tollere quod ſit in F. ſit perpendicularis, quæ per grauitatis centrum GEH. Dum igitur ad anteriora inclinatur, centrum amouet à perpendiculari, quamobrem docente Natura, crus BC ad centrum ipſum fulciendum ad anteriora, hoc eſt, verſus rem ſuſtollendam porrigitur.

Huius quoque ſpeculationis eſt inueſtigare, Cur quadrupedia dum gradiuntur, pedes diametraliter moueant. Cuius rei verba fecit ipſe quoque Philoſophus lib. de animalium inceſſu cap. 12. Nos autem ad maiorem declarationem, quod ipſe Phyſicis principijs fecit, mechanicis demonſtrabimus.

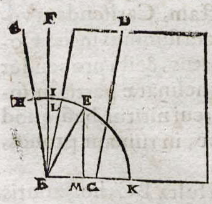
Sint duæ in plano parallelæ AB, CD, in quibus quadrupedis pedes E, F, B, D, quorum EF, anteriores, BD vero poſteriores. iungantur BDEF, eritque EBDF parallelogrammum altera parte longius, cuius diametri ducantur ED,



ED, BF, ſecantes ſeſe in G, vbi & grauitatis centrum. Moto igitur poſteriori ſiniſtro pede B in K, ſi anteriorem E, eodem tempore moueret in I, ſtantibus interim DF, ceu fulcimentis, centrum G extra fulcimenta fieret ad partes BE. Caderet igitur ad partes BE. Si autem eodem tempore moueret dextros eodem pacto centrum extra fulcimenta poſitum caderet ad partes ipſas DF. Si autem moto pede B in K, & eodem tempore F in L, & D in H, E, in I, centrum erit in diametris HI, KL, hoc eſt, vbi M, fultum quidem ab ipſis pedibus K, L, H, I. Hoc igitur pacto transfertur viciſſim cum grauitatis centro ſimul translatis fulcimentis ſeſe diametraliter reſpondentibus; quod vtique demonſtrandum fuerat.

Sane & bipedia quoque alternatim gradiendo grauitatis centrum transferunt. Dum enim dextrum crus eleuatur, centrum ſiniſtro fulcitur, & econtra.

Naturalia iſthæc ſunt; in artificialibus autem quæri poſſet, Cur Architecti, Arcium muros non ad perpendiculum erectos, ſed introrſum inclinatos conſtituant?

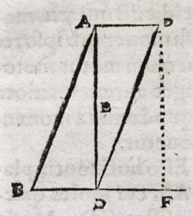


Vtique hoc faciunt, vt minus ſint ad ruinam proni. Eſto enim murus ad interiorem partem vergens ABCD, Cuius grauitatis centrum E baſis BC erigatur à puncto B horizonti perpendicularis BF, & ad eundem à centro grauitatis E demittatur EM, tum BE iungatur. Poſt hæc à puncto BG angulum cum linea horizontis BK faciens recto maiorem. Itaque murus hoc pacto conſtitutus ad interiorem partem ſuo pondere vergit, cadere autem non poteſt, vel quod viuæ ru-

rupi, cui forte hæret, fulciatur, vel antistatis, quos nostrates sperones & contra fortes appellant, innitatur. Sed nec in anteriora corruet, quandoquidem ruinam facturus, necesse est vt grauitatis centrum secum trahat in perpendiculari BF, & demum in eam quæ vltra perpendicularem est BG, facta nempe circa B, ceu circa centrum, cõuersione. Moueatur autem & ex semidiametro BE centro B portio circuli describatur EH, quæ secet BG in H, & BF in I; Et quia EM semidiametro BK perpendicularis per B, centrum non transit, erit EM ipsa BK, hoc est, BI breuior. Abscindatur ex BI, ipsi EM æqualis LB. Erit igitur punctum L infra punctum I, hoc est, ipso I, mundi centro propius. Necesse igitur erit ad hoc vt murus corruat, centrum grauitatis E facta circa B, conuersione aliquando fieri in I, vt demum transferri possit in H, sed I remotius est à mundi centro ipsis E, L, ascendet igitur graue contra sui naturam ex E in I, at hoc est impossibile; quod fuerat demonstrandum.

Ex his iisdem principijs alia soluitur quæstio, Cur scilicet Campanaria turris quæ Pisis visitur, nec non alia Bononiæ in foro prope Asellorum turrim, quam à nobili olim Carisendorum familia exstructam, Carisendam vocant, cuius meminit & Dantes Poëta summus in sua Comœdia. Propendet autem hæc in latus, & ita propendet vt perpendicularis, quæ à summo inclinatæ partis in solum demittitur, longe cadat ab ipsa, cui nititur, basi, quod sane mirabile videtur, muros nempe, in ruinam pronos, ruinam non facere.

Esto enim turris ABCD, basi fulta BC, horizontis planum BCF latera AB, DC, centrum vero grauitatis totius molis E. Propendeat autem ad partes DC ex angulo DCF. Ita autem constituta intelligatur vt perpendicularis ab A, in planum horizontis demissa per grauitatis centrum

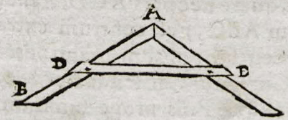


trum E extra baſim BC, non cadat, cadat autem in C. Quoniam igitur ABCD moles per E grauitatis centrum diuiditur, in partes ſecatur æqueponderantes, ſed & centrum grauitatis extra fulcimentum non cadit, quare nec pars ACD, trahet partem ABC, nec centrum extra fulcimentum poſitum locum petet centro mundi viciniorem. Cur igitur Cariſenda ſtet, & egregia illa turris campanaria quæ Piſis prope ſummum Templum marmoribus præclare exſtructa videtur, licet ruinam minentur, ſtent æternum, nec cadant, ex his quæ conſiderauimus, liquido patet.

QVAESTIO XXXI.

Cur facilius moueatur commotum quam manens, veluti currus commotos citius agitant, quam moueri incipientes? Hoc quæritur.

PRoblema hoc eſt mere Phyſicum; verumtamen quoniam ad localem motum pertinet, de quo ipſe quoque Mechanicus agit, Hiſce quæſtionibus contemplatio hæc interſeritur. Soluit autem Ariſtoteles inquiens, id fortaſſe ea de cauſſa fieri, quod difficillimum ſit pondus mouere, quod in contrarium mouetur. Demit enim quippiam de motoris potentia reſiſtens, licet mouens ipſo moto ſit longe potentius atque velocius. neceſſe enim eſſe id tardius moueri quod repellitur. Hæc verba licet de ea potentia dicta videantur, quæ rem motam in contrariam partem repellit, nihilominus illi quoque aptantur quæ rem immobilem à principio mouere conatur. eſt enim reſiſtentia rei quæ à ſtatu ad motum transfertur ceu quidã contrarius motus. Contra autem accidit illi qui rem motam mouet in ipſo motu: eo enim caſu mouens ab ipſo rei motu magnopere iuuatur, cooperatur enim motus motori, in ipſam rem motam operanti. Auget autem res mota quodammodo mouentis potentiam. quod enim à mouente pateretur, ex ſe ipſa agit res quæ mouetur.



Eſto horizontis planum AB, cui moles quædam inſiſtat, CD. Modo potentia quædam applicetur vbi E, quæ molem in anteriora propellat, id eſt, verſus B. Primum igitur, quoniam à quiete ad motum fit tranſitus, reſiſtit ſua quiete corpus graue, potentiæ impellenti, ſuperata demum reſiſtentia moles quæ moueri cœpit, fertur in F & mouetur, quare potentia quæ à principio reſiſtentiam rei non motæ ſuperauerat, pellendo rem motam pergens facilius pellit: Duo enim ſunt quodammodo motores, mouens videlicet ipſe, & motus quo res mota mouetur. facilius ergo pelletur ex F in G, quam ex D in F, & ex G in B, quam ex F in G, & eo motus fiet in progreſſu facilior atque in ipſa velocitate velocior, quo magis in ipſa motione mouetur.

Hinc ſoluitur ea quæſtio apud Phyſicos difficillima, Cur nempe in motu naturali velocitas vſque augeatur; etenim ibi Natura mouens eſt, atque eadem inſeparabilis à re mota, vrget igitur aſſidue, à principio quidem tardius, poſt hæc autem ea quam diximus, de cauſſa vſque & vſque velocius. Motus ergo fit in motu, qui motus cum ſemper à motore, & motu ipſo augeatur, creſcit ex progreſſu in immenſum. Certe cauſſam velocitatis auctæ eam eſſe, quod potentia mouens rem motam in motu ipſo moueat, nemo vt arbitror, inficias ibit, acquirit enim corpus motum pō-

deroſi-

derositatem quandam accidentalem, quæ cum ex motu perinde augeatur, ipsum motum faciliorem, eoque velociorem facit. Disputat hæc & Simplicius lib. 7. Physic. c. 11. Aristotelis de Natura libros exponens.

QVAESTIO XXXII.

Quæritur hîc, Cur ea quæ proijciuntur, cessent à latione?

HOc itidem problema est mere Physicum. Ad quod ea pertinent quæ à Philosopho tractantur libro Naturalium 8. & lib. 1. de Cœlo. Tres autem affert subdubitando rationes, An quia impellens desinit potentia, vel propter retractionem, vel propter rei proiectæ inclinationẽ, quando ea valentior fuerit quam proijcientis vires?

Quicquid dicat Philosophus, id vtique exploratissimum est. Proiecta ideo à motu cessare, propterea quod impressio, cuius impetu & virtute feruntur, non sit proiectus quidem naturalis, sed mere accidentalis & violenta, at nullum accidentale & violentum quodque, non naturale est, perpetuum est. Cessat ergo accidentalis illa impressio, eaque paullatim cessante proiecti motus elanguescit, donec quietem prorsus adipiscatur. Illud quoque notamus, quod à multis vidimus non obseruatum, nempe violentum motum violentia præualente non differre à naturali, & ideo tardiorem esse à principio post hæc, in ipso motu fieri velociorem, remittente demum paullatim impressa violentia, tardiorem, donec impetus, & cum impetu motus euanescat, & res ipsa mota quietem adipiscatur. Vnde etiam experientia docemur, ictum ex proiectis violentius fieri, si fiat paullo remotior à principio, & tunc demum esse innocentissimum, cum ibi fit, vbi proiectum ex motu plene acquisito, summam adeptum est velocitatem.

tem. Hinc videmus, vel pueros ipſos, docente Natura cũ nuces, vel aliud quippiam, parieti alliſum frangere conã-tur, à pariete moderato aliquo ſpatio recedere. Si autem eos interroges, cur id faciant, reſpondebunt, vt inde ictus valentius fiat atque efficacius. Eleganter ex Simplicij & Alexandri Aphrodiſienſis doctrina, quæ lucidiſſima eſt, quæſtionem hanc in ſua Paraphraſi explicat Picolomineus.

QVAESTIO XXXIII.

Dubitatur, Cur proiecta moueantur, licet impellens à proiectis ſeparetur; vel vt verbis Philoſophi vtar, Cur quippiam non peculiarem ſibi fertur lationem impulſore alioquin non conſequente?

SOluit, inquiens, an videlicet, quoniam primum, id eſt, impellens ipſe, id efficit vt alterum, nempe proiectum ipſum impellat, illud vero (hoc eſt proiectum) alterum impellat, hoc eſt, aërem ipſum mediumue, quod à proiecto repelletur. Ceſſare autem motum, cum res eo deuenit, vt motus eidem à proijciente impreſſus, non poſſit amplius rem proiectam mouere, & itidem rem ipſam, aërem videlicet non poſſit amplius repellere. Vel etiam quando ipſius lati grauitas nutu ſuo declinat magis quam impellentis in ante ſit potentia. Vtique res per ſe ſatis clara. etenim motus impreſſus accidentalis eſt, quod vero lationi violentæ reſiſtit principium, naturale, & ab ipſo moto inſeparabile, vincente igitur quod natura eſt, paullatim remittitur quod ex accidenti eſt, & inde proiecti fit quies. Eſt autem & hoc quoque Problema pure phyſicum, & ſuperiori, de quo immediate egimus, perquam familiare, quamobrem ex iiſdem prorſus ſoluitur principijs.

QVAE-

QVÆSTIO XXXIV.

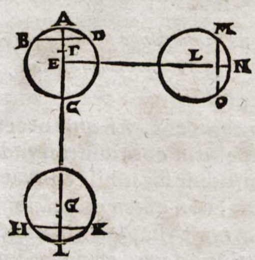
Cur neque parua multum, neq; magna nimis longe proÿci queunt, sed proportionem quandam habere oportet proiecta ipsa ad eius vires qui proÿcit?

PVlchre dubitationem diluit, inquiens, An quia necesse est quod proijcitur, & impellitur contraniti ei vnde impellitur. Quod autem magnitudine sua nihil cedit, aut imbecillitate nihil contranititur, non efficit proiectionē neque impulsionem. quod enim multo impellentis excedit vires, haudquaquam cedit. Quod vero est multo imbecillius, nihil contranititur, & impressionem non suscipit. Aliam quoque adiungit rationem, videlicet, Tantum ferri id quod fertur quantum aëris mouerit ad profundū (hoc est, ad eam partem aëris remotiorem, ad quam fertur) etenim proiectum à principio dum fertur aërem pellit, non pellit autem si nihil mouetur. Accidit igitur vt concludit Philosophus, proiecta isthæc contrarijs ex caussis minus moueri. quod enim valde paruum est nihil mouet imbecillitate sua impediente. quod vero valde magnum est, ex contraria caussa nihil mouet, nempe quod ob magnitudinem suam nihil moueatur. Vnde fit proportionem inter proiectum & proijcientem esse inprimis ad motum, necessariam. Hæc eadem præclare in sua Paraphrasi explicat Picolomineus.

Huic nos, de proiectis quæstioni, hæc addimus.

Cur proiecta corpora non sibimet ipsis secundum partes æquegrauia, si fuerint irregularis figuræ in ipso motu, secundum grauiorem partem antrorsus inuiolento, & deorsum in naturali ferantur, & dum in latione conuertuntur, sonitum edant.

Esto pila ABCD, cuius centrum E concinnata ex dispari materia leui, nempe BCD, & graui ABD. non ergo

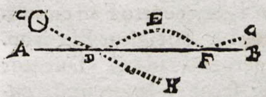


erit centrũ grauitatis & centrum molis, ſit autem grauitatis centrum F. Deſcendat corpus prohibente remoto per rectam AG. Et quoniam grauiora deorſum tendunt magis, ſi à principio motus grauior pars fuerit ſupra in ipſo deſcenſu conuertetur pila, & ſitum non ſeruabit donec ſuperior pars ea quæ grauior, deorſum fiat, vt videre eſt in pila HIK, cuius centrum eſt G. pars grauior HIK. Si autem eadem pila, laterali motu violenter feratur verſus N, ad eam quoque partem conuertetur pars grauior. facto enim molis ſeu magnitudinis centro vbi L, grauior pars fiet in MNO; quæcunque igitur ſunt corpora ita cõſtituta, vt in illis non ſit idem molis & grauitatis centrum in ipſa latione conuertentur, & eorum pars grauior antrorſus fiet. Sonitus porro in ipſo motu editi ea eſt cauſſa, quod irregulare corpus à principio incipit conuerti, & in ipſa conuerſione dum fertur aërem verberat, & ab eodem viciſſim reuerberatur, ex qua reuerberatione fit corporis rotatio dum fertur, & ipſe ſonitus, quem Græci ῥοῖζον Rhœzum appellant.

Ad hanc quoque ſpeculationem pertinet, Cur lapides ad ſuperficiem aquæ proiecti non ſtatim demergantur, ſed aliquot vicibus aquæ ſuperficiem radentes, ab eadem reſiliant.

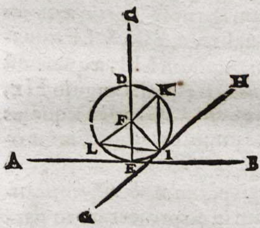
Eſto aquæ ſuperficies AB, lapis proiectus C, tangens aquæ ſuperficiem in D, & inde reſiliens in E, mox iterum eandem tangens in F, & reſiliens in G, donec violẽto motu ceſſante demergatur. Vtique lapis C, proiectus in D, niſi

nisi medio densiori, aqua videlicet, repelleretur, penetraret per D, in H. At eo resistente, & adhuc vigente impetu, fertur in E ad angulos fere pares. Dico autem fere,



siquidem maior est ADC ipso EDF, propterea quod vis non sit eadem, sed minor ea quæ ex D pellit in E. Durante igitur impetu quo pellitur antrorsum, fiunt ipsæ resilitiones, & eo cessante, resilitiones cessant, & lapis suapte grauitate demergitur.

Huc quoque spectat, Cur pila lusoria in horizontis planum proiecta ad pares resiliat, angulos nempe rectos? Esto horizontis planum AB, in quod à puncto C per lineam perpendicularem CE cadat proijciaturue pila DE, cuius grauitatis centrum F. Tangit autem planum in puncto E. Perpendicularis ergo EC, circulum DE per centrũ secat, hoc est, in partes æquales & æqueponderantes, sed dum pila cadit proijciturue,



agit in planum horizontis, vbi E, & in eodem puncto repetitur, quare cum cadens & agens diuidatur in partes æquales & æqueponderantes & item repatiens & resiliens diuidatur item in partes æquales & æqueponderantes, ita resilit repatiendo, vti egerat in cadendo, hoc est, ad angulos pares; quod fuerat demonstrandum. Modo sit planũ aliquod ita ad horizontem inclinatum, vt GH, & in illud cadat proijciaturue eadem pila. Dico eam ab eodem inclinato plano ad pares angulos resilire, non tamen rectos.

Vti-

Vtique pila cadens, planum non tanget in E. esset enim GH, vbi AB, Tangat autem in I, & à centro F ad contingentiæ punctum I, recta ducatur FI. Erit igitur FI (prop. 18. lib. 3. elem.) ipsi GH plano perpendicularis. Ducatur item per I, ipsi EC, parallela IK, secans pilæ circumferentiam in K. Agit ergo & repatitur pila in puncto I non æqualiter inæquales. etenim sunt partes KDLEI, & IK, eo quod IK secet circulum non per centrum. repellitur ergo in repatiendo non æqualiter, sed iuxta inæqualitatem earundem partium. Ducatur autem recta in circulo LI æqualis ipsi IK. Erit igitur LEI, æqualis IK, & tota KDLI æqualis toti IKDL. Vt igitur actio est per descensum iuxta rectam KI, ita est repassio per ascensum ex IL. Dico autem angulos KIH, LIG esse æquales & singulos recto minores. Connectantur FL, FK. Quoniam igitur IK portio æqualis est portioni IEL, & recta LI æqualis rectæ IK, & LF æqualis ipsi FK, & FI communis, triangulum LFI, æquale est triangulo IFK. Quare & angulus FIL æqualis angulo FIK, sed GIF, HIF recti sunt, ergo residui LIG, KIH æquales sunt inter se comparati, & recto minores; quod fuerat ostendendum.

Hinc colligimus, quo magis planum ab æquidistantia horizontis recesserit, eo pilam in eo proiectam in partes inæqualiores diuidi & ad minores ipsi plano angulos resilire. Nihil autem refert, vtrum planum, in quod pila cadit, ad horizontem sit inclinatum, vel eodem horizonti æquedistante pila non ad perpendiculas, sed iuxta aliquẽ angulum in illud proijciatur. Hæc sane ita ex demonstratione fieri ostenduntur. Veruntamen quoniam proiecta pila materialis est, & ideo nec æqualis, nec æqueponderans & sua grauitate resistens, non ad pares ex amussi resilit angulos, sed minores aliquantulum in resilitione, remittente nimirum vi in ipsa reactione. Et sane fieri non

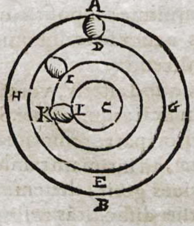
potest,

poteſt, pilam à plano reſilientem eo peruenire vnde à principio diſceſſerat; Id enim ſi daretur, æterna quoque pilæ ipſius daretur reſilitio, & paullatim vi & impetu remittente per parua interualla motus eſſet, donec res quæ mouebatur, omnino quieſcat.

Qvæstio XXXV.

Quærit hoc vltimo Problemate Ariſtoteles, Cur ea quæ in vorticoſis feruntur aquis, ad medium tandem agantur omnia?

TRibus rationibus ſoluit; quarum prima eſt: Quicquid fertur, magnitudinem habet, cuius extrema in duobus ſunt circulis, hoc in minori, illud in maiori. Et quoniam maior velocior eſt, magnitudo media, non æqualiter fertur, ſed à maiori quidem pellitur, à minori vero retrahitur, vnde tranſuerſus fit magnitudinis motus, & ipſa magnitudo ad interiorem propellitur circulum, itaque eodem pacto, è maiori in minorem propulſa in centrum tantum fertur, & ibi quieſcit.



Eſto vortex AB, cuius centrum C, magnitudo quæ fertur AD, maior circulus AFB, minor DHEG. Velocitas igitur in A maior eſt velocitate quæ in D, magnitudinis ergo extremum A, velocius rapitur in A quam eiuſdem extremum inferius D, in D. Velocitas igitur maioris circuli pellit A verſus F. tarditas vero minoris circuli D retrahit ad partes G. conuertitur itaque magnitudo inter pellentem & retrahentem circulum, donec ex-

 tremi-

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tremitas A in circulo minori fuerit vbi H, D vero vbi I, & ita deinceps eadem ratione vbi KL, donec paullatim feratur in centrum C, facto nempe à maiori in minorem circulum transitu.

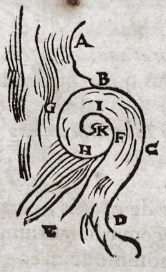
Secunda ratio ita habet, quia quod fertur, simili se habet modo ad omnes circulos propter centrum, hoc est, in quouis circulo, qui circa idem centrum fertur. Omnes autem circuli mouentur, centrum vero stat, necesse est à motu tandem id quod mouetur ad quietis locum, hoc est, in centrum ipsum peruenire.

Tertia, quoniam circulorum, qui in vorticibus fiunt, velocitas, & ideo impetus non est æqualis, sed semper exterior est interiore velocior & violentior, Æqualis autem semper in mota magnitudine, grauitas, diuersimode se habet ad circulos, à quibus mouetur, & ideo modo vincitur, modo vincit: vincitur autem à velocioribus circulis, vincit autem tardiores. Itaque quoniam sua grauitate resistens, maioris circuli motum prorsus non sequitur, ad tardiorem reijcitur, hoc est, interiorem, & sic deinceps, donec tandem centrum ipsum nanciscatur, in quo nec superans, nec superata quiescit.

Hæ sunt rationes, licet obscurissime propositæ, quibus, vt diximus, vtitur Aristoteles. acutæ sane illæ quidē, attamen haudquaquam vltro admittendæ.

Primo enim falsum videtur, quod asserit, vortices circulos esse, & circa idem centrum fieri atque rotari. Spiræ enim potius sunt, quæ ab exteriori parte remotioreq; incipientes spiraliter circumuolutæ, ad intimam tandem partem, quæ media est & centri vices gerit, deueniunt. qua veritate cognita, omnis prorsus difficultas tollitur, Cum enim ea quæ feruntur, ab aqua ferantur, aqua vero feratur spiraliter, ea quoque spiraliter ferri, est necessarium.

rium. Hæc autem clariora erunt si quo pacto vortices fiant, quispiam considerauerit.



Esto fluminis cuiuspiam curua eademque profunda ripa ABCD. Aquæ vero moles rapida EFDC, quæ quidem eo quod magno impetu deferatur in C, ripæ ipsius naturã sequens turbinatim circumuoluitur, egressa autem extra locum seu ripam B rotationis principium secundans, in seipsam spiraliter contorquetur, & verticem efficit GHFIK, cuius quidem centrum est vbi K.

Alia quoque de caussa, ex quiescente nimirum, & mota aqua fiunt spiræ verticesue. Esto enim fluminis ripa

ABC, sinum efficiens, qui aquam ex ripæ ipsius obiectu contineat quiescentem, Cursus vero fluminis liber & rectus, sit inter lineas AC, DE. Itaque dum aqua AC rapide fertur ad partes A, quiescentem ABC iuxta lineam CA lateraliter propellit, & eius quidem partem quam tangit, secum rapit, puta ex F in G. Delata igitur aqua & currente ex F versus G quiescens lateraliter eidem sese aliqualiter opponit, & currentem repellit ex G in H. Cœpto itaq; spirali motu aqua circumuoluitur secundum lineam GHK, donec perueniat ad centrum I, vbi circumuolutæ aquæ partes sese inuicem tangunt. Porro vortices isti spiræue, quod nos per Padum, Abduam, & magna flumina nauigantes obseruauimus, non eodem permanent loco, sed rapientis aquæ motum secundantes, paullatim in currentem aquã delati euanescunt, fiunt etiam eiuscemodi vortices nautis quidem valde formidabiles etiam in mari, de quibus Poëta libro Æneidos primo.

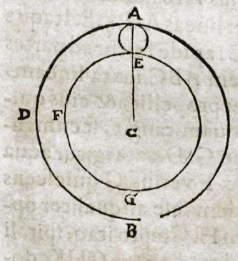
--- *ast illam ter fluctus ibidem*
Torquet agens circum, & rapidus vorat æquore vortex.

Sed & idem quoque de vorticibus, qui in fluminibus fiunt libro 7.

--- *hunc inter fluuio Tiberinus amœno*
Vorticibus rapidis, & multa flauus arena
In mare prorumpit.

Fiunt autem in mari partim occultis de caussis, partim etiam ex violentia aquarum sibi inuicem obuiantium agitatione. Sed nos hisce explicatis commode ad ea quæ dixerat Aristoteles, reuertemur.

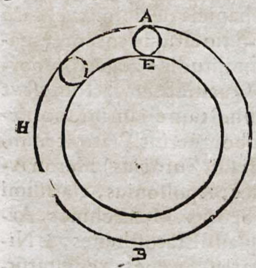
Dicimus igitur, primam eius rationem haud magni videri ponderis, siquidem non per circulos actu distinctos aqua circumfertur, sed ipsamet sua mole tota simul.



Esto enim vortex AB, cuius centrum C, semidiameter CA, fiat autem rotatio totius aquæ CA ad partes D, in linea autem AC, sit corpus aliquod aquæ rotatione circumlatū AE, inter circulos maiorem ADB, minorem EFG. velocius autem mouetur ADB, ipso EFG, citius ergo fertur pars superior ipsius corporis vbi A, quam inferior vbi E. At id nec A repellit, nec E retrahit, siquidem eodem tempore quo A permeauit circulū ADB, eodem & E percurrit circulum EFG. Itaq; A reuerso in A & E, punctum reuersum erit in E, nulla facta corporis E quoad situm, mutatione quod voluit Aristoteles.

Ad

Ad ſecundam vero dicimus, non ideo quod omnes circuli æqualiter circa centrum ferantur, niſi alia quæpiã extranea vis interceſſerit, quæ ea ab exterioribus circulis pellens agat in medium.



Tertia quoque ratio laborare videtur.

Eſto enim vortex AB, cuius centrum C, ſit autem corpus aliquod E, cuius natura apta ſit rotationi aliquatenus reſiſtere. Quoniam igitur eius reſiſtentia aliquãtulum ab aqua rapiente ſuperatur in ipſa rotatione, partim aquę impetum ſequetur, partim ſuapte natura retardabitur. Quamobrem aqua quæ eſt in A, translata in H, corpus ipſum non erit in H, ſed in G. Tardius igitur corpus quam aqua ipſa, rotationem complebit, non tamen propterea, niſi alia quæpiam adſit cauſſa, feretur in medium.

Cæterum horum vorticum effectum & cauſſam obſeruare licet, ſi vaſe quopiam aqua pleno aquam ipſam baculo manuue circulariter agitauerimus, fiet enim vortex, & ſi quippiam quod leue ſit, in aquam motam proiecerimus, ea quam diximus de cauſſa in motum ipſum, hoc eſt, vorticis ſpiræue, centrum feretur.

Hæc nos, vt vera proponimus, & fortaſſe decipimur. Certe Philoſopho tantæ auctoritatis contradicere, magnæ videtur audaciæ, aut potius inſaniæ. Quicquid tamen ſit, pro pulcherrima veritate laboraſſe, à parte aliqua laudis non fuerit prorſus, vt arbitror, alienum.

APPENDIX.

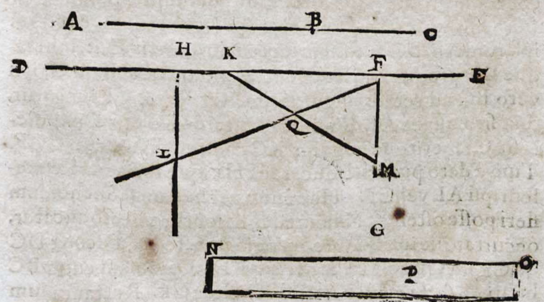
MOdum inueniendarum duarum mediarum proportionalium non tantum vtilem eſſe,ſed prorſus neceſſarium,illi norunt, qui in Mechanicis diſciplinis vel parũ fuerint verſati.Nulla enim alia ratio eſt,qua corporeę magnitudines ſeruata figura & ſimilitudine augeri proportionaliter imminuiue poſſint. Quamobrem factum eſt vt in his inueniendis tum vetuſtiſſimo tum etiam inferiori æuo,clariſſimi Viri magnopere laborauerint. Plato etenim, Eudoxus (cuius modum repudiauit Eutocius) Heron Alexandrinus, Philon Byzantius, Apollonius, clariſſimi Geometræ, Diocles, Pappus, Sporus, Menæchmus, Archytas Tarentinus,Platoni æqualis:Eratoſthenes, & Nicomedes ad has inueniendas varias rationes excogitarũt, quorum omnium modos, & inſtrumenta, demonſtrationeſq; diligentiſſime collegit,& in illos Cõmentarios coniecit idemmet Eutocius,quos elegantiſſimos in Archimedis libros de Sphæra & Cylindro ſcripſit.Nos autem ijs omnibus accurate perſpectis,& diligentiſſime ponderatis, inuenimus eos fere omnes tentando negotium abſoluere,quod ſane laborioſum valde eſt & operantibus permoleſtum. Itaque cum modum praximue inueniſſemus,ex qua is qui operatur tutiſſime & facillime ad quæſitas ipſas medias manuducitur,hunc pulcherrimæ huius facultatis ſtudioſis inuidere nefarium iudicauimus.Quod ſi quiſpiã dixerit,Balliſtarum,Catapultarum, Scorpionum, & cæterarum eiuſcemodi Machinarum vſum, olim apud nos deſijſſe,& ideo Problema hoc videri ſuperuacaneum,Reſpondemus,nulla alia ratione æneorum tormentorum pilas augeri imminuiue ſeruata ponderis ratione poſſe, innumeraque eſſe,quæ vt rite perficiantur, hæc penitus indigent ſpeculatione. Nos rem Mechanicis vtilem, Mechanicis

chanicis

chanicis noſtris Exercitationibus annectere, haud importunum iudicauimus. Sed tempus eſt, vt his breuiter præfatis, ad rem ipſam explicandã commode accedamus.

Datis duabus proportionalibus prima, & quarta duas inter eas medias in continua proportione inuenire.

ESto prima datarum AB, quarta BC, inter quas ſecundã & tertiam oportet inuenire. Ducatur recta DE, cui à puncto F, vtcunque ſumpto, perpendicularis demittatur FG, Tum ab F verſus D duplicetur quarta BC, ſitque FH, deinde ab H ipſi FG parallela demittatur HI, & ab HF abſcindatur HK, ipſius BC quartæ medietati æqualis. Poſthæc puncto K ſpatio autem medietati, primæ datarum æquali, in linea HI notetur punctum L, & ipſi HL fiat æqualis FM, & KM iungatur. His ita conſtitutis paretur ſeorſum ſcheda regulaue quæpiam NO, in cuius latere accipiatur OP, æqualis medietati primæ datarum ſeu ipſi KL. Tum regulæ latus aptetur puncto L, extremum vero O, feratur aſſidue per rectam EK, verſus K, nunquam



interim

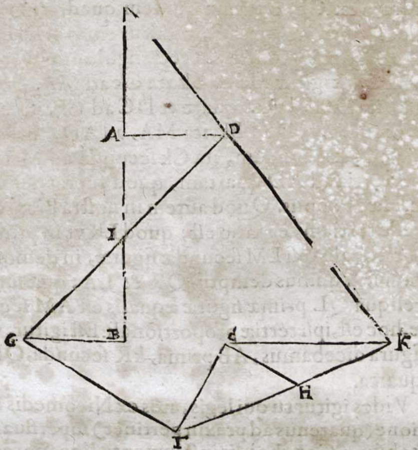
interim regulæ latere ON amoto à puncto L, idque donec punctum P, obuians incidat in lineam KM, puta vbi Q extremum vero O inueniatur in R. notato igitur in linea EK puncto R habebitur, quod quærebatur. Erunt igitur AB prima, RK secunda, QL tertia, BC quarta.

Hæc praxis ijsdem principijs demonstratur, quibus suam ex Conchoide ostendit Nicomedes. Conficit ille instrumentum, ex quo describit Conchoidē, ex qua postea duas medias venatur. Nos autem nec instrumentum construimus nec Conchoidem describimus, & duabus fere lineis rem absoluimus, vt nemo fere non dixerit, hocistud quod docemus, à Nicomedea praxi esse prorsus alienum.

Sed nos, vt eius, quam ostendimus, operationis demonstratio habeatur; ipsius Nicomedis ex Pappi libro 3. propos. 5. desumptam in medio afferemus, quippe quod isthæc ea quam in suis in Archimedem commentarijs refert Eutocius, sit lucidior.

Datis duabus rectis lineis CD, DA; duæ mediæ in continua proportione hoc modo assumuntur.

Compleatur ABCD parallelogrammum, & vtraq; ipsarum AB, BC, bifariam secetur in punctis L, E, iunctaque LD producatur; & occurrat productæ CB, in G, ipsi vero BC ad rectos angulos ducatur EF, & CF iungatur, quæ sit æqualis AL. Iungatur præterea FG & ipsi parallela sit CH, eritque angulus KCH, æqualis angulo CGF. Tum à dato puncto F ducatur FHK, quę faciat KH æqualem ipsi AL vel CF. Hoc enim per lineam Conchoidem fieri posse ostendit Nicomedes, & iuncta KD producatur, occurratque ipsi BA, productæ in puncto M. Dico vt DC ad CK ita CK ad MA & MA ad AD. Quoniam enim BC bifariam secta est in E, & ipsi adijcitur CK. Rectangulum BKC per 6. secundi: vna cum quadrato ex CE, æquale est quadra-



quadrato ex EK. commune apponatur ex EF quadratum, ergo rectangulum BKC vna cum quadrato CF æquale est quadratis ex KE, EF, hoc est, quadrato ex FK. Et quoniam vt MA ad AB, ita est MD ad DK, vt autem MD ad DK per 2. sexti, ita BC ad CK erit vt MA ad AB, ita BC ad CK. Atque est ipsius AB dimidia AL, & ipsius BC, dupla CG, est igitur vt MA ad AL, ita GC ad CK. Sed vt GC ad CK, ita FH ad HK propter lineas parallelas GF, CH. quare & componendo vt ML, ad LA, ita FK ad KH, sed AL ponitur æqualis HK, quoniam & ipsi CF, ergo & ML per 9. lib. 5. æqualis erit FK, & quadratum ex ML, æquale quadrato ex FK. est autem quadrato ex ML, æquale rectangulum BMA vna cum quadrato ex AL & quadrato ex Fk æquale ostensum est rectangulum BkC vna cum quadrato ex CF, quorum quidem quadratum ex AL æquale eſt quadrato ex CF, ponitur enim AL, ipſi CF æqualis, ergo reliquum BMA rectangulum æquale eſt reliquo BkC. Vt igitur MB ad Bk, ita Ck ad MA. Sed vt MD ad Bk, ita DC ad Ck. quare vt DC ad Ck, ita eſt Ck ad MA. vt autem MD ad Bk, ita MA, ad AD. Ergo vt DC, prima, ad Ck ſecundam, ita Ck ſecunda ad MA tertiam, & MA tertia ad AD quartam, quod fuerat demonſtrandum. Hæc Pappus. Quod autem in noſtra Praxi diximus, QL eſſe tertiam, ea ratio eſt, quod LR vt in prima figura eſt, ſit æqualis ipſi LM ſecundæ figuræ, in demonſtratione Pappi, ex quibus demptis QR & LA, quæ ſunt æquales, reliqua QL primæ figuræ æqualis eſt AM ſecundæ figuræ, hoc eſt, ipſi tertiæ proportionali: Eſt igitur, vt in prima figura dicebamus, AB prima, kR ſecunda, QL tertia, BC quarta.

Vides igitur tu qui legis, nos ex Nicomedis demonſtratione (quatenus ad praxin pertinet) ſuperflua reſecaſſe, & abſque Conchoidis inſtrumento lineaue rem ipſam confeciſſe, idque non tentantes, vt alij, ſed progredientes, & quaſi manuductos quæſitum inueſtigaſſe.

FINIS.

Typographus beneuolo Lectori.

Amice lector, antequam ad libri lectionem adis, hæc quæso errata corrige.

Pag. 2. l. 4 ciſſima l. ciſſimę. lin. 5. linearũ l. planorum. l. 11. Iedericus l. Federicus.

p. 4. l. 23. ſecetur feretur. l. 25. violentia violentiæ. l. 28. DCD. per CD. lin. penult. Natura & Violentia.

p. 7. l. 20. quæ qua. l. 25. ſparſum ſpartum.

p. 8. lin. 2. mouente l. manente. lin. 11. circumlatione. l. 22. moto mota.

p. 9. lin. 2. circumlatione. l. 6. vacua l. vnica. l. 12. deſid. conſid. lin. vlt. B l. D.

p. 10 l. 7. notione motione.

p. 11. l. 1. & 2. ſemota ſeruata. in fig. infra D redintegra G.

p. 12. l. 25. circũlata. l. 26. egreſſa. lin. 29. AD, l. AB, in fig. melius exprime literas, B. T. X. M. Q. S. F.

p. 13. l. 16. præfert profert.

p. 16. vlt. dum tum.

p. 17. l. 13. IS, 15.

p. 18. in fig. infra P repone Q. & inferius, ad ſiniſtram, G.

p. 19. l. 8. HDH l. HDQ. l. 20. CH l. CA. l. vlt. FI GI.

p. 20. l. 21. gracilis l. grauitatis. in fig. centro appone C.

p. 24. l. 13. DLE l. DCE.

p. 25. l. 2. quædã quidẽ. l 11. aduert. cõuert. l. 23. ad cõtra.

p. 26. l. 21. reſidua reſiduum. l. 31. quam quarum. in fig. infra B pone G. & inter H & G pone M.

p. 27. l. 13. propoſitio proportio. l. 20. detinent l. deſinẽtibus. in 2. fig. infra B pone D.

p. 28. l. 14. imagunculæ. in fig. redintegra B, & infra appone E.

p. 29. l. 6. HBE l. HBI. in fig. inter H & E reſtaura G.

p. 31. l. 8. them. ſchem. l. 21. habet trahet.

p. 32. l. 14. mouẽtur l. moueatur. l. 15. poſitam. in fig. ſupra B pone G.

p. 34. l. 13. ICHI. ICA. l. 22. vectes vectis.

p.35.in fig.perfice lineam AD.

p.36.l.3.hypomochlio.

p.38.infra A in quadrangulo fig.pone D.& infra F.pone H & infra G pone K.

p.39.l.5.HC l. AC.

p.42.l.7.B A,l.B fiat A. l.13.maxime intel.maxime,intel. in fig.supra D pone G,& in angulo pone B.

p.44.in fig.infra E,pone G,& supra A,D.& supra H,I.

p.45.l.25.sit l.fit.

p.46.l.27.in l.vi.

p.47.l.7.aluum l. alueũ.in fig.supra B appone A, & supra D,C. & ex A vt centro ducatur à nauibus ad lineam CD,portio circuli punctata,eiq; apponantur M,L.

p.49.in fig.2.ad finem lineæ BC appone A, & iuxta H duc lineam oblique HI superiori parallelam. & in concursu linearum ex A.C.B.appone F.& in earũ medio G.

p.51.in fig.vbi H & A sesecant pone D.

p.52.l.20.ipsi l.ad.l.vlt.ac l.AC.

p.53.l.14.ad hoc est l.ad põdus,hoc est,in fig.1.in vertebra forcipis pone A.in 2.fig.ex I fac E.

p.54.l.1.suburræ l.saburræ.

p.55.in fig.ad finist.lineæ rectæ pone G.& ex N fac H.

p.56.in fig.infra B productæ lineæ appone C,& infra E,F.

p.57.in fig.centro pone C.& in contactu,B.

p.60.in 1.fig.ad rectæ dextram pone C.

p.61.l.23.HI l. EI.

p.62.in fig.ad sinistrã D pone B.dele D & pone F.infra K pone C.dele F & pone D.ad sinistram G pone A.

pag.63.l.17.secundam per lineam.l. secũdum lineam.l. 25.perpendiculari.in fig.perfice rectam BK.

p.64.in fig.angulo restaura B.& infra C pone F.& supra C in circulo pone I.superius extra circulum restitue G.

p.65.l.3.eo l.&.l.22.FBC FBG.l.23.mai9 maioris.l.24. literam lineam.in fig.pro N pone H & inter B & E pone K.

p.66.

p.66.l.30.EG l.EQ. in fig. pró H fac N & iuxta O pro 7 fac P & iuxta S perfice Q.

p.67.l.22.DEF l.BEF.

p.68.l.16.circulo.in fig. infra E repone F.

p.69.l.11.&paralleli l.parallelę dele&.in 2.fig.ſuprema linea reſtitue A.F.D.in infima B.E.C. In 3. fig. ſic reſtitue literas,in ſuprema recta o.S.ρ. paulo infra ad lineam curuã ς.ν.λ.κ.η.In 2.recta,Q.α.Z.Y.X.β.γ.δ.ε.R.in infima curua, π.ξ.μ.θ.T.σ.

p.70.l.13.αν.l.αV.l.30.DE l.DC.in fig. ad coni baſin pone ſuperius,A,infra,E,inferius B.ad verticem coni C, in fine rectæ,I.

p.71.l.13.AEBF.

p.73.in fig.ad ſiniſtram pone B.& perfice curuam AD.

p.76.l.3.FEG.l.4.& 11.GF.l.G,F.l.5.graui⁹ l.grauitatis. l.20.LK l.L,K.in fig.infra B pone C,ſupra B,G. infra D,F. & inferius,I.inter L & A pone M & produc lineã KO vſq; ad diametrum CA.

p.77.in fig.ſupra F pone A,in centro,C.iuxta B reſtaura H,in centro,K.infra D,C pone E.& ſupra K,L. & perfice lineas.

p.78.in fig.perfice diametros.

p.79.l.17.DI.l.D,I.l.15.centra.

p.81.l.7.FL,l.F,L, l.9.axis rotæ l.axis G, rotæ.l.20.locũ l.lorum.in fig.1.ad centrum pone D,& ſupra,C.

p.82.l.16.obliquum.l.23.AB,l.A,B, l.26.F pondere l.F, pondera.l.28.& 31.S.l.5.

p.83.l.1.ſecetur l.feretur.l.2.& 18.IS l.15.

p.84.l.12.BG B,G.l.14.CH C,H.l.15.ACFH AC,FH. in fig.ad dextram A pone B. ad dextram F, G. & infra G,I inter H & I perfice O.ſupra O pone K inter F & H pone M.

p.85.in fig.ſupra C pone A.

p.86.l.16.ſit l.fit.in fig.1.ex C fac G.infra I adde A.ſupra D ex E fac C.& ad latus perfice H.infra E perfice F. & B.

p.87.l.6.maior mai⁹.l.16.CD C,D,l.17.EFGH E.F.G. H.in fig.1.ſupra N reſtaura K& ſuperius,L.infra L,G& infra C adde A.In 2.fig.perfice circellum & in centro Q.

p.88.paſſim male interpunctum.l.13.QR.QV.

p.89.l.17.CH CA.

p.90.l.26.ſeroſulam ſcrofulam.

p.91.l.29.& 30.DE ipſis FG l. D,E,ipſis F,G,

p.92.l.12.20.21.AB,l. A,B,l.19.reſtituatur l.28.IK l. I,K,

p.93.l.10.litterales littorales.

p.95. figuram inuerte, & in medio reſtaura D.ante D pone A.poſt D,B.iuxta B ad curuam adde C.

p.96.in 2.fig.ex I fac F.in 4.fig.medio adde Q.

p.97.l.10. QS.l.QP,l.25 27. AB l. A, B,in fig.ad dextrã pone B.inferius C.in 2.fig.iuxta D perfice E.

p.98.lin.15.16.cauterijs,biſcaut.canterijs, biſcant. l. 19. mera l.29.C grauitatis centrum F. C, grauitatis centrũ E.

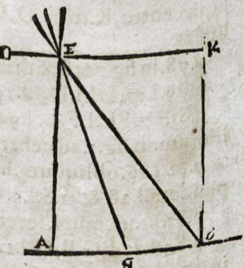
p.99.l.14.KL,l K,L,

p.100. figu a non quadrat, ſed hæc l.23. CADB CA,DB,

p.101.l.13 quorum ibid. KL. quarum K,L.l.15.MH MA l.19. AHBI AH,BI.l.29.31.EF E,F,

p.102 l.3.corporum l.6.GH. ibid EF GA,E,F,l.9.EH EA l. n.26.AB A,B, l.18. 23. & ſeqq. pag.pro cauter.lege canter,

p.103.l.4.7.AB.A,B,l.10.pẽdebit pandabit l.24.EF E,F,in fig.inter BA pone E, inter AC pone F.& infra EG pone H.



p.104.l.13.DE D,E.l.14.DH DA l.18. BC B,C, Hic deeſt figura quam ex pag.178.huc transfer,& in ea repone C.

p.105.lin.5.cum tum. in fig. ad ſiniſt. 1.lineæ pone C,ad dextram D.& infra,B.ſupra G ex E fac F. infra ex R fac K.

& in-

& inferius pone E. infra A pone L. ex D demitte perpendicularem versus M.

p.106.l.24.ED,E .

p.107.l.20.tertium verticē l.31. EF l. E,F, l.33.HK l. NK.

p.108.l.1.IH l.IN l.4. CH in N l. CA in H l.7.AN l.AH l.
13.HG l. N,G,in fig.dextro pro X fac Y.

p.109.lin.3.BH,ibid.OP.BA,O,P.l.5. QRS Q.R.S.l.8. QS.ibid.OH, Q,S. OA,l.19.NG ND.

p.110.in fig.dextro,infra H pone M,supra,perfice L. iuxta H dextrorsū perfice Q.infra A pone D.infra B pone C.

p.111.in fig.ex C fac G & ex G,C.

p.112.l.13.H in F, A in F l.28.ST.S,T, l.vlt. QR QIRM Q,R QI,RM,ibid.in fig.iuxta F ad angulum pone S,inter F & S pone A.ex R & G produc lineas vt concurrant & ad concursum pone T & supra R pone X.in arcu GRN perfice N. & supra N pone M. infra K & N perfice Z & inferius pone E,& superius D.supra K pone I.

p.113.l.3.QR Q,R,l.13.& alibi,aperitione apertione lin. 21.in H AB l.in H,AB l.29.ris re.in fig.ad dextram I,fac P. ex D fac B.inter F & R pone C. inter N & E, fac D. iuxta M restaura H.inter H & R fac G.

p.114.l.7.maiorum murorum l.14.BG B,G,l.17. DE incumbās l.D,E,incumbas l.25.cum eum. in fig. produc DK ad B,ibiq; adde C.sic & EL.ad G ibiq; adde F.

p.115.l.25.post EHF,adde, GIF,l.27.EG E,G, l.28. HI H,I,in fig.ad finist. N. pone A. vlterius P. infra A, fac B,supra O perfice G.ad sinistram O pone I.

p.116.l.22.dele IM,vel scribe IBM.in fig.1.dextro dele I.

p.119.l.16.vitro intro l.31.ad l.nō.in fig. infra A fac B. infra F,G. infra E,D.infra H,I.supra F perfice C.

p.120.in fig.supra N fac L.supra O ex G fac P.

p.121.l.23 signis tignis.

p.122.l.12. Si si l.16.AB A,B,in fig.superius adde E.

p.123.in fig. linea superiore ad sinistram adde A,ad superiorem

periorem 2. circulum adde Q & P. ad 1. inferiorem S. infra 2. H.

p. 124. l. 26. BC l. B, C. l. 30. D, l. B, in 1. fig. sic pone literas, A. B. C. in 2. sic, D. F. E.

p. 125. l. 24. BC l. B, C.

p. 127. l. 10. cubiculorum l. orbiculorũ l. 25. H. l. N. in fig. infra A pone C. & numeros corrige ex textu.

p. 128. l. 8. textus l. sextus l. 30. igitur connatã l. igitur secundum connatam.

p. 129. l. 10. DE l. D, E, l. 15. G sex l. G, sed l. 22. dimitteretur. in figura restaura literas A. B. F. G.

p. 130. in fig. exter. circulo adde H & G.

p. 131. penult. EG l. E, G.

p. 132. l. 1. AB l. A, B,

p. 133. in fig. repone A. E. F.

p. 134. l. 6. se libras. in fig. iuxta H præpone A. iuxta E, C.

p. 135. l. 5. eum l. cum.

p. 138. Vbique ex F fac E, & in figura ad nucem adde K. l. 25. BE l. B, E, l. 27. ponderis, A l. 28. fulcimentum, BE.

p. 139. l. 3. apertionem.

p. 140. in fig. perfice rhombi latera & parallelas, & ad sinistram appone suis locis E. B. G.

p. 141. l. 1. AB l. A, B. l. 21. erit igitur in E. l. 23. ACBD l. AC, BD. l. 31. B. l. B,

p. 142. l. 6. in ęqualia l. inęqualia. l. 7. AB l. A, B, l. 17. maior l. minor.

p. 143. in 2. fig. restaura perpendicularem AC.

p. 144. l. 21. inon l. non.

p. 146. l. 4. considerasse.

p. 147. in fig. infra H pone C. supra M ex G fac P.

p. 148. l. 8. DIE ibid. PI l. D, I, E, P, I, l. 11. hoc minus l. hoc est, minoris.

p. 150. l. 26. vestes restes. in fig. ad dextram C adde F.

p. 151. l. 16. tormenta l. tomenta l. 24. extrud l. extend.

p.152.in fig.superius adde A.C.

p.153.l.3.G,H,K,C,E.

p.154.l.1.scindendum l.10.& 11.Q,P,O,N,M,l.13.& 14. literas distingue cõmatibus. l.23.vera vlla. l.vlt.rare rasse.

p.156.l.13.sustinens in C.l.19.CD l.CB.

p.158.in fig.literæ reponantur iuxta textum.

pag. 159. lin. 2. AB, l. A,B, Figura non quadrat, sed hæc l.14. sustinet, in l. pen. Tolle lonē.

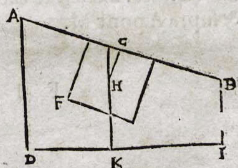
p.161.l.2.CED l.CEB l.13.qui l.quæ.

p.162.l.30.in E,& l.in B, eo.

p.163.l.2. vbique post mouens pone comma.

p.164. l.2.alter l.31. AB, l. AD, figura est inuersa. & pro D pone B.pro B,A.pro A,D.

p.165.l.15.ex l.&.figura spectat ad pag.173. Huc vero pertinet hæc.



p.167.in fig. supra B pone A. ad sinistram I. & duc lineã IB K.supra K perfice D. ad dextram fac H.postea F.

p.168.in fig.perfice lineam GH.& infra G pone L & dele I

p.169.l.9.fulcimentum.in fig.restaura F.M. & inter F, M, pone H. infra M ad C pone L. lin.penult.D diluetur l.constituetur.

p.171.in 1.fig.ad finist.F pone A, ante G,B.perfice semicirculum, & supra K pone I. supra G, H. producta linea GH & ducta HE parallela ipsi GF. In 2.fig.supra O perfice Q.& dextrorsum L.

p.172.l.4.A,B,C,D, l.AB,CD.

p.173.

p.173. figura non pertinet huc, ſed ea quæ eſt pag. 165.

p.174. in fig. ſupra E pone G.

p.175. l.30. puncto B duc B G. in fig. inter E & D fac A. infra G, H. inferius B.

p.178. Figura deeſt. & quæ hic eſt, ſpectat ad pag. 104.

p.179. l.17. proiectis. penult. innocentiſſ. violentiſſ.

p.181. l.28. in violento. vlt. non ergo idem erit.

p.183. l.26. repercutitur.

p.184. l.7. æqualiter; inæquales l.27. perpendiculum.

p.185. l.18. tandem. in fig. extra H adde F.

p.188. l.12. violenta l.31. in A, & E.

p.189. in fig. centro adde C. l.25. motum l. medium.

p.190. penult. hæc hac.

p.191. in fig. produc lineam FM vſq; ad G. infra L appone I. ex K ad L duc rectam punctatam. rectam L Q produc & vbi ea tangit rectam K E ibi adde R.

p.193. in fig. perfice rectam G K. & duc D C. & inter A & B fac L. inter B & C fac E. & duc rectam E F. & perfice F. & ſupra A pone M.

F I N I S.