TO THE BENEVOLENT READER.

When I chose to expound on hydrostatics about five years ago in my public lectures at the illustrious Lyceum in Padua, both on account of the charm of the argument, as well as regarding the usefulness considered in natural philosophy, the thought likewise entered my head, perhaps with regard to future developments, that I might publish what I had been explaining to my audience. I have persisted thereafter with this intention, and I have become more confident and confirmed about that, as I have recognised it to be approved by friends who understand more about these matters.

Archimedes in the first place, as it may be agreed, treated the elements of Hydrostatics in his Book *De Insidentibus Humido* [*Concerning Water at Rest*], but the best seeds from that tract have lain dormant in natural philosophy for a great length of time, until now they may begin to germinate, being made fertile through the ingenuity of the acute minded Galileo. And indeed not only has he explained more clearly that great light of the philosopher, the Principle set forth by Archimedes, he has increased it with some new ideas, also moreover with regard to a particular phenomenon, taken from the drawing of water, where the philosopher taught that it was not possible to raise water by the suction of pumps beyond a height of eighteen cubits, and, although the true reasoning of this may not be seen to follow, yet it has been rewarded most elegantly with the most useful discovery, since the observation of this phenomenon, not only gave rise to the experiment with Torricelli's tube [*i.e.* the barometer], but also was the opportunity by which the principles of Hydrostatics could be transferred to the air itself. For the mathematician Evangelista Torricelli, and successor of Galileo in the service of the Grand Duke FERDINANDO II of Medici, who was of the greatest ingenuity and sagacity, attending to that observation by thinking about it, began to suspect at last that the limit of twenty two cubits height from pumps could arise from a determination of the atmospheric pressure, so that he might be able to be more certain about this matter, he tested it out with the quicksilver experiment, and as he had preconceived, the outcome corresponded. Yet so noble a discovery could not remain hidden for a long time, for a little after its arrival, it began at once to spread abroad in France and other regions, and the curious minded were converted to this line of thought. Hence Blaise Pascal, the sharpest of talented young men, eager to be experimenting from the reports brought from Italy, with all the experiments repeated found, not without considerable joy, to be in agreement with the truth, and he published both the processes and outcomes of the experiments in a certain little book *De Gravitate Atmosphaerae* (*The weight of the atmosphere*), to which he prefixed another ingenious tract *De Aequilibrio Liquorum* [*The Equilibrium of Liquids*]. The endeavors of Pascal in turn aroused the interest of the English, and among these that of the most celebrated of the experimental natural philosophers Robert Boyle, who was most readily captivated by his paradoxes with hydrostatic experiments, and from innumerable experiments repeated with success, he brought forth to be remembered; truly all these were handled more widely and were to be increased much more by Borelli & Mariotte, the works of whom are better known, as they shall not need any review, for both these authors, besides Hydrostatics, also examined many things pertaining to hydraulics, with the motion of water and other

matters, in which, as I have lauded Torricelli before, and Benedict Castelli themselves carrying the torch ; truly Guglielmini then raised the teaching of the motion of water more, and happily applied it to rivers; and truly with these men praised the most celebrated Peter Varignon has gone further by far, who extended the most that part of hydraulics which considers the measure of flowing liquids in two outstanding papers presented in the Proceedings of the Royal Academy of Paris, the first of which was about all kinds of water clocks; the other truly a discussion about the out flowing of liquids and the measurements of these from a declared improved outlet. And before these two praiseworthy men the greatest Geometer Isaac Newton has written a golden work, because *The Mathematical Principles of Natural Philosophy*, in which he has treated together the forces and dispositions of fluid bodies further, where these are being referred to, which are about the elastic force of the air, the density of the atmosphere, which are about the resistances of shapes advancing in fluids, about the motion of bodies in mediums with resistance, about the movement of the air in the production of sound, and explained other matters presented : and to add as an example of this of the emotions stirred up, the illustrious Leibniz and our most noble Huygens do not wish to begrudge in public on a daily basis their thoughts about the motion of bodies in a resisting medium [*i.e*. a comment on the Newton Leibniz controversy at the time]; which argument Varignon later handled generally beyond praise. But going down to the more recondite geometry it is the most celebrated Bernoulli brothers, worthy of most merit, who have considered different problems concerning the action of fluids on hard but flexible bodies, and by bringing the aid of the geometry of the interior itself, moreover they have brought out into the light the elegant curves of linen sails filled with still water, as many other matters I may pass over in silence.

Moreover, because with these matters selected, found in various journals and dispersed in other books and often with the principles elicited from diverse sources : I have considered it to be a pleasant task for me, from these put together, and for those who take a delight in these things, if everything were collected together in a natural order into one, and from these a few simple principles deduced, and that I might make available to the public. Truly scarcely had I entered this field I understood at once, I would never be happy to be led away from that proposal, unless I might return to everything at a higher level, and more might be borrowed from the mechanics of solid bodies, according to that so that novices would be able to run through the little book without stumbling, nor for the understanding of that would they have a need to seek help from elsewhere. Truly with these matters and with these subsidiaries requiring to be explained the material in it has grown so much, so that it could not be considered to constitute part of a small work, and finally the present treatise has arisen; which to be more general with the title *Phoronomiae,* or *De Viribus & Motibus Corporum solidorum & fluidodrum,* [*i.e. Concerning the Forces and Motions of Bodies and Fluids*.] requiring to be separated and I have been led to dividing it into two books, of which the first sets out the forces and motions of solid bodies, and the latter truly of fluids.

The first book contains two sections subdivided into chapters, of which the first is about simple weights of solid figures, or about the laws of equilibrium of the forces of machines, connected together, and of their average directions, whether these forces shall

be applied to rigid or flexible bodies ; which two exceedingly general cases have been provided by us and perhaps with elegant theorems, from which henceforth the laws of equilibrium of solids and fluids are defined easily and the solutions of problems of the catenary, of sails, shapes of clothes, and others are derived as corollaries for examples. The second section vindicates the science of motion, in as much as these motions arise from the continuous action of gravity or continually by doing work, or which arise from the collision of bodies between each other. Hence this second section contains the particulars of all these questions whichever concerning the accelerated or retarded motion by uniform gravity, or to be different in some way, able to be shown, while also it defines an isochrone generally whatever system of weights may be able to be assumed, and in that case, in which the direction of gravity may be agreed upon at one and the same point. And because curves of projections are unable to be algebraic in all dissimilar forms of gravity or with a variable hypothesis, a general canon is treated, against which it requires gravity to be varied, so that according to that the curves of thrown objects are described algebraically, and for almost circular orbits for moving masses the rule is treated for the centripetal forces to be readily reckoned in the curve required of some moving body, and hence it is shown how from a given centripetal force of this kind, or from the influence of gravity, the motion of a circular curve can be found. After this a new theory of the centre of oscillation follows, which will not displease, I suppose, on account of its simplicity : there the whole to be established from that, because certain excitations are assumed and at the particles the oscillations act in directions perpendicular to the distances of the particles from the axis of oscillation, pulled down by equivalent forces of gravity ; with the help of which the principles of the compound pendulum can be compared with the simple pendulum isochronous to that, once the length of this simple pendulum may be found, and that by a single and simple calculation. When first I happened upon this theory, as it was completed within three years, it happened that I had applied it only to the case of uniform gravitation, according to that of Huygens and James Bernoulli, but later, from what appeared in the Acta Leipzig of Feb. 1713, where the Cel. Joh. Bernoulli in §. 23 set out in his outstanding paper about a new theory of the centre of oscillation, which itself he could extend both to pendulums oscillating within various liquids, as well as outside the same, of which he makes a mention with the same method extended ; and also from these circumstances I began to have hopes for the best success of my method, for there at once from his paper, which Bernoulli was than promising and afterwards published in the following year in January, as these papers besides have offered to me at once after reading the first example of the previous year 1713, no more than what I had given easily by demonstration showing that effect, just as the postulate of Huygens had itself postulated to concede: evidently the common centre of gravity of all the particles, of each composite pendulum with the chains shattered by which they were joined together, would be able to reach the same height with their motion turned into height, as from which the same centre would fall, with the particles still connected to each other. I have derived by the method new rules for the motion of elastic bodies striking each other from a remarkable law of this kind of nature, lest I am mistaken.

The second book includes the resolution of many problems concerning fluid bodies. For it is concerned with the weights of liquids of any kind while lying in planes, as well

as on the sides of vessels, and thence rules are derived about the forces on vessels, so that they are able to be carried through before the being fractured by the pressure of the liquid. Concerned with the equilibrium of liquids both between themselves as well as with solid bodies themselves sent in. About figures, which fluids induce in flexible bodies in which they are at rest. Concerned with the weight and elasticity of the air and with the density of the atmosphere at all distances from the earth, and according to whatever law of elasticity. With regard to the motion and measurement of water flowing out from some vessel, or of water flowing in channels; with the effects of striking fluids, which pertain to resistance, which wide shapes of fluid may undergo, and the mean directions of these resistances, likewise problems related to sails and others of that kind. Regarding both linear as well as curved motions of bodies in resisting mediums. With regard to the motion of ships from the forces of the wind. The circular motion of fluids. The motion of air in the production of sound ; and finally the internal motion of fluids, depending on heat. And from these a summary of all the recent small works is completed.

Since I had desired brevity in everything, I had given that the main need, so that however great the work should become, everything could be understood from the general theorems ; from which then small particulars were able to be deduced as Corollaries. Therefore at first just as I had observed heterogeneous liquids, and investigated the laws of their pressures and equilibriums, from which then I elucidated easily the laws of homogeneous fluids. Thus also I myself proposed a rectilinear or a curved sail to be incident in all its points by forces with variable impulses of some kind, in which I might investigate direction of the forces, and this according to the way of the significant property of the centre of gravity, as I was thinking first to be found by me; but when also the Cel. Johann Bernoulli had proposed in the book now published (*Essay d'une Nouvelle Theorie de Manoeuvre des Vaisseaux).Cap.* XII. §VI. But it will be recorded here the most celebrated geometer without doubt had himself seen my manuscript, in which the theorems here being set out were contained, before his published book might be praised, just as equally I had seen my own proposition then hitherto unpublished, in his book. Thus also the problems of catenaries, sails, etc., I have reduced to this form in general, of which the simplest solution as it seemed to me anyhow: I have shown how to find the figure remaining of a flexible line acted on at individual points by forces along any directions. And in this manner I have tried to proceed to other problems. I have received favorable responses for the clarity, as far as I have been able ; therefore many propositions will be seen to be perhaps extremely prolix by advanced geometers, but they know I wish the novice also to be taken into account by me, from which that is not always in my power to be supplied, which immediately by necessity are gratefully cut back by the mind with the shortest and most elegant demonstrations. Meanwhile also I am unwilling for me to disavow, how much I have tried, to be pursuing elegance, and therefore to have brought forwards algebraic lines of demonstrations, taught well by much experience, the consideration of figures to supply most often more simple and elegant solutions and constructions, than showy analysis. I say ornate, for repeatedly I use geometrical analysis, or with a line without preceding algebraic symbols, of which a much more elegant benefit is obtained than from the analytical calculus, even if not always. I value the geometrical analysis of this kind used by the ancients, such as given

by Euclid and Apollonius that may be gathered at once from the little book *de Sectione Rationis* published by the most celebrated Edmund Halley; similar also to the analysis used by the great Newton to a state of numbness in his *Principia.* Truly in the application of theorems, as in a more suitable place, I use the algebraic calculus often.

In these books a number of curves has been used for representing forces, times, speed, and for the purposes of other proportions of this kind, which I am accustomed therefore to indicate as *scalars* [i.e. ladders], just as Cavalleri and Viviani the most celebrated of geometers indicated a long time before me concerning [increasing] steps of weight and of motions, to imitate architects, who call a right line divided up into several equal parts a geometrical *scale* (according to that, so that ideas of the preconceived work may be able to be set out from that in proportional). Therefore it is apparent consideration of a curved line not only to be useful, but completely necessary for an accurate representation of the phenomena and of the nature of the forces.

So much concerning the form of the notation adopted, when two or more lines with equally spaced points are put together, from this lines are indicated to be drawn between themselves, so that AB.CD indicates the rectangle from AB by CD, which by others thus is accustomed to be assigned AB + CD. Thus also §. 472. *num.* 11. *t*BE = N.$\sqrt{\text{A}}$. ang. ICD indicates the time by the exponent BE, by the factor from N and with the root of A itself at the angle ICD; and thus in the rest of this Proposition and with the demonstrations in place, and in the two following Propositions. The fractions or ratios according to the type setting may be expressed conveniently by a colon. Thus AB : CD is the same and commonly $\frac{\text{AB}}{\text{CD}}$, and $\text{AB} : \text{CD} = \text{EF} : \text{MN}$ the same as by the common $\text{AB.CD} :: \text{EF.MN}$. With several fractions themselves to be added in turn, these either with a comma, or by a semi-colon, or they may be distinguished also by brackets : thus $f = a : b, + c : d$. or $f = a : b; + c : d$ which likewise ordinarily is $f = \frac{a}{b} + \frac{c}{d}$. For quantities with other quantities enclosed in brackets immediately after without any sign interposed attached, which indicates quantities to be equal; thus, if A(*a*) may be had that indicates the magnitudes A and *a* to be equal or equivalent, but if truly with a point in between so that it may be distinguished as A.(*a*) this denotes the product from A by a; and thus with others. Indeed the expressions : $\sqrt{(aa + bb)}$; $(aa + bc)^m$ denote $\sqrt{aa + bb}$; $\overline{aa + bc}^m$ respectively. The remaining signs are used in the common sense.

THE FORCES AND MOTIONS OF BODIES

PRELIMINARY NOTES.

1. Bodies are said to be moving absolutely, when the contiguous parts of these continually change with infinite and immoveable parts of space on all sides ; and thus the motion itself consists of a continuous change of this kind.

2. These parts of infinite and immobile space are contiguous with a body which are in immediate contact and encircle it; and space is said to be immoveable, because its parts are separated constantly by the same distance, and thus are understood to remain at the same mutual position with respect to each other, and the whole of space running beyond to infinity on all sides cannot itself be understood to wander and change the position between these.

3. Because the change of the contiguity cannot happen except from the passage of time, indeed it implies that one and the same body likewise and at the same time may be contiguous at different parts of space, that is, it may be present at different places; thus all motion involves time.

4. Time can be considered as the equal flow of the one indivisible sign, which we will call a moment or instant ; with that nearly in the same manner by which geometrical lines are understood to be generated by the motion of a point, yet with this difference; as the motion of the point describing the line can only be accomplished more quickly or more slowly, as on the contrary from our equable flow of the moments of time, just as I have said, it happens with an equal passage of moments, thus so that the distances between the parts in equal moments of time flowing, or the intervals from the station in which they started, may vindicate themselves.

5. Hence, because the flow of our moments or time is understood to be perceptible only from the periodic motions of the heavenly bodies, or from the use of clocks or with the aid of some other instruments, and may be rendered perceptible in some manner, and may be recalled according to some kind of measure. But such measures of time and representations are not exactly rigorous in the end, since neither the annual motion of the sun, nor which may be compared from that daily, nor perhaps from that each day, as some astronomers suppose, are perfectly equal, and therefore only supposed to be apparent measures of the time. Therefore astronomers also, who have investigated the true and equal measures of the time, thereupon reduce the apparent time to the true time, which they call the mean time, and which by necessity they have reduced to be uniform. And although with pendulum clocks, just as according to the mark of the level of perfection which have been produced by Huygens, the measurement may be seen to have true accuracy, yet the motion of these cannot be with mathematical and uniform accuracy, indeed not because of defects of the principles, in which the construction of these is founded, but on account of the defect in the performance of these ; for it is agreed

at no time can machines be prepared with such ultimate rigor, such as theory demands to be constructed, because in theory it is not accustomed to be freed so much always from these impediments and circumstances, which yet in practise are not accustomed to be absent in practise from themselves, eluding a succession of more accurate machines.

6. If our point flowing, or even some body, advances by uniform steps, and likewise the moments of time are understood to flow uniformly, then the motion of a point or of a body may be called equable [*i.e.* equal in all regards]. And the journey or length, which is accustomed to be called the interval described by the body, is to the passage of time meanwhile drawn together from the moment flowing, that is, to the time of rendering applied, or the division, is called the *speed* or *velocity*.

7. This [quantity], which stirs the body into motion, or from which the motion of the body results, that is by which the motion of the body is established, is called the *motive force*, which can be divided into *Living* and *Dead Forces.* [The idea of the *vis viva* originated from Leibniz, and was an early idea about kinetic energy; the continued impact of bodies in creating a force was also due to Leibniz]

8. It is the living force which is connected with the actual motion. Thus a body, which is be sent along a given line in a given time, is said to be endowed with a living force.

9. Truly it is the *dead force*, from which no actual motion results, unless it were continued and repeated within a body for some time. Such a force would be only from the impulse of a weight with no others succeeding that, and indeed not, unless finally after infinitely many blows of a weight repeated incessantly or one continually following others, a perceptible motion is acquired by the weight. Thus also the centrifugal attempt arising from circular motion, and likewise the impulses of gravity establish an example of the dead force.

10. The charm of the greater distinction, the living force, we will call the solisitation hereafter simply the force, truly the dead force at last could be of whatever kind. The preceding definitions of forces indicate clearly enough the actions of living forces of bodies.

11. But also a certain *passive force* is present in bodies, from which no motion nor a tendency for motion results ; but consists of that holding back, that is the state of change of motion or of rest by which bodies may be reluctant to try to be induced to move according to some external force. Which resistance has been called by the most significant name the *force of inertia* by the most eminent astronomer Johan Kepler. This force of inertia appears to be satisfied in bodies at rest ; and indeed some body A striking into another B, moreover at rest, will lose some of its force and motion, and B receiving some of the forces and it will acquire motion by striking A. From which it is clear, the resting body B in truth has some passivity being broken up and overcome from that force due to colliding with the body A ; otherwise the striking body A would be losing none of

its motion, since the resting body B, if it might be without the facility of resisting, would be able to offer no hinderance to the other motion, thus so that both the striking body A and the struck body B, with that speed itself, by which the body A was being brought forwards before the collision, also ought to advance after making contact, which contrary phenomenon no one observes.

12. A law of nature is based on the force of inertia, from which *for any action there is an equal and opposite reaction.* For in every action it is a struggle between the body acting and the body acted on, and without a struggle of this kind no action, thus said properly, can be considered to be acting on the passive body, otherwise no stable foundations of mechanics may be had, and moreover any effect may arise from any cause.

13. The *active forces*, of whatever kind they might be, are able to be varied between themselves in two ways. For these other forces are more intensive [than these inactive ones], and take no account of the receiving subject matter ; [on the one hand,] when two bodies are acted on by unequal forces, as long as they have equal amounts of matter. Again [on the one hand], some bodies can have unequal amounts of matter than others, when equally intense forces are applied to the bodies. For in general the force on any body is that, which results from all the partial forces, by which they act on the individual elements or the smallest parts of the body. Thus if the forces, by which the individual elements of a body may be affected, are acting together, the total force will be the inclusion or sum of all the partial forces.

14. The amount of matter of each body, which henceforth we will call the mass, is the entire sum of all the particles, from which the body has been composed. Truly these are the constituent particles of the body, more briefly they may be called the *elements* of the body. Therefore the fluid matter, which can be present in the lateral motions of a body, is not considered to pertain to the substance of the body, and therefore the water lurking in the pores of a sponge does not refer to the substance of the sponge.

15. The *volume* of any body is the space, which the matter of the body with its interspersed pores occupies. From the combination of the mass or quantity of matter with the volume, there results…..

16. The *Density*, which is the ratio which the quantity of matter in any body has to the volume of the body. So that, if the body may be understood to be a mass with pores without liquid present, also a mass of this kind is understood easily occupying a space less the space of the pores, which it occupied with the pores interspersed : the ratio of such a mass without the pores: to the volume of the body according to us is the density of the body. With other bodies, the density stands either more or less in accordance with a greater or smaller amount of pores present, so that it satisfies our definition; for by how much greater is the ratio of the mass to the volume of the body with the pores missing, from that the sizes of the movements will be less, and thus the greater the density of the body.

17. *The rareness* of bodies is the quality reciprocal to density, consisting in the ratio of the volume to the mass or the quantity of the matter, for it is known these two always signify one and the same thing.

And from these consequences a steady stream of following consequences flow which, because in the following they shall be of the maximum use, they are being indicated here briefly. Bodies C, c may be said to be prepared together ; the masses of which are M, m; volumines V, v; densities D, d; rarities R, r; and , from these names in place, there will be ….

18. *Quantites of Matter or Masses* (M, m) *in the combined ratio of the densities* (D, d) *and Volumes* (V, v). That is, $M : m = D.V : d.v$.

For (§.16.) $D = M : V$ & $d = m : v$, therefore $M : m = D.V : d.v$.

19. *Volumes* (V, v) *will be in combined ratio from the direct proportion of the masses and the inverse proportions of the densities.* That is, $V : v = (M : D) : (m : d)$. It is clear from §.17.

Volumes are also in the combined ratio from the direct ratio of the masses and in the direct ratio of the rareness'. That is $V : v = M.R : m.r$. For by (§.16.) :
$R = V : M$, & $r = v : m$ therefore $V : v = M.R : m.r$.

20. *The densities are inversely proportional to the rareness', or*
$D : d = r : R$. For, by (§.l6,17.) there is $D = M : V$, & $R = V : M$, there will be
$r : R = M : V = D$ and therefore $D.R = 1$, & $d.r = 1 = D.R$; hence $D : d = r : R$.

21. *The direction* of any motive force is linear, near which this force acts on a body, and that is the right line which the moving body will describe or perhaps is attempting to describe, set in motion by this force.

22. Forces and motions *are acting together,* the directions of which agree, or at any rate are parallel, and act in the same directions.

23. Truly forces and motions *are contrary*, that is directly opposite, the directions of which indeed are in agreement or perhaps are equidistant, but are inclined in opposite directions.

Hitherto it has been the general affectations of bodies, by which they have been assessed : now we touch upon briefly the kinds of forces to be applied. The account of the order above requires that the kinds of forces, by which these various forces can be applied, may be distinguished from each other in turn; for the bodies are either solid or fluid ; and from these diverse kinds of phenomina result.

24. These bodies may be said to be *solid* or *consistent*, the elements of which perhaps up to a point cohere, so that no part of the body may be said to be moving sensibly, without the whole mass participating in the same motion. Yet otherwise, from the observations of the Celeb. Dominico Cassini, it is agreed for a metal to contract exposed to the cold, & vice versa, provided the volume be stretched out in cold places ; and the extensions and contractions of metals of this kind, which, without doubt for the hardest and applicable also to other bodies more or less, cannot be accounted for without the internal motion of the parts: but because these motions are required to be deduced by reasoning alone from the phenomina, they do not at once meet the senses, and are unable to offer any obstruction to that definition ; since in these cases the elements of hard bodies, or of solids, are said not be cohering completely, but as it were up to that point, so that I may say they cannot be torn apart or moved appreciably from that, unless the whole body may be forced away by the same motion.

25. Truly *fluids* are bodies, of which the most agile particles may be considered to cohere to some extent, but they can move easily without the motion of the whole mass of fluid. In viscid fluids the particles not only may be considered to cohere, but the wonderful adhesion of such of these between themselves does not destroy the mobility, and therefore such fluids considered are not excluded from this definition.

AD BENEVOLUM LECTEREM.

Cum ante hoc quinquennium circiter in Illustri Lyceo Patavino Hydrostaticam publicis meis Lectionibus exponendam eligerem, tam ob argumenti jucunditatem, quam ob utilitatem non contemnendam in Philosophia Naturali, cogitatio simul animum subiit , forte non ab re futurum , si , quae auditoribus meis explicuissem, in publicum mitterem. In hoc deinceps proposito eo magis confirmatus fui firmiusque perstiti , quo id magis amicis harum rerum intelligentibus probari cognovi.

Archimedes primus , quod constet, Hydrostaticae rudimenta tradidit in suis *De lnsidentibut Humido* Libris, sed optima ab ipso in Philosophiam Naturalem sparsa semina magno temporis tractu sterilia jacuere, usque dum sagaci Galilaei ingenio foecundata germinare inciperent. Etenim magnum hoc Philosophiae lumen Archimedea principia non solum luculentius exposuit, explanavit, nonnullisque novis speculationibus auxit, sed etiam singulare phaenomenon, ab aquilege tamen acceptum, Philosophos docuit, non posse aquam in antliis suctoriis ultra octodecim cubitorum altitudinem attolli , & , quanquam veram ejus rationem non assequutus esse videtur, de elegantissimo tamen invento optime est meritus ,cum hoc ejus phaenomenon, seu observatio, non tantum tubi Torricelliani experimentum pepererit, sed etiam occasio fuerit, qua Hydrostaticae principia ad aerem ipsum traducerentur. Nam Euangelista Torricellius Magni Ducis Hetruriae FERDINAND III. Mathematicus, & Galilaei in hoc munere successor, observationem illam attenta mente revolvens pro ea, qua erat ingenii sagacitate, limitatam illam duodeviginti cubitorum altitudinem in antliis a determinata atmosphaerae pressione provenire posse demum suspicari coepit, qua de re ut certior fieret , cum hydrargyro experimentum tentavit, &, ut praesagiebat, respondit eventus. Tam nobile inventum diu delitescere non poterat , nam paulo post ejus ortum statim in Gallia aliisque regionibus percrebuit, & curiosorum animos in se convertit. Hinc Blasus Pascalius sagacissimi ingenii juvenis, quae fama ex ltalia attulerat experiundi cupidus, non sine insigni voluptatis sensu ea omnia iteratis experimentis veritati consentanea invenit, & experimenti processum atque eventum in peculiari libello De Gravitate Atmosphaerae (*De la Pesanteur de la Masso de l'Air*) exposuit, cui alium ingeniosum tractatum De Aequilibrio Liquorum praemisit. Pascalii conatus deinceps Anglorum ingenia excitavit, atque inter ea Celeberrimum Philosophiae experimentalis cultorem Robertum Boylium, qui in Paradoxis suis Hydrostaticis experimenta captu facillima, atque ab innumeris cum successu repetita, memoriae prodidit; haec vero omnia latius pertractata multisque aucta fuere a Borello & Mariotto, quorum opera notiora sunt, quam ut ulla recensione indigeant, ambo enim hi Autores, praeter Hydrostatica, etiam plura ad hydraulicam pertinentia attigerunt, de motibus aquarum aliisque, in quibus, quem antea laudavi, Torricellius , & Benedictus Castellus ipsis facem praetulerunt ; Gulielminus vero doctrinam de motu aquarum magis deinceps auxit, atque flumintibus feliciter applicuit; verum laudatis hisce viris ulterius longe processit Celeberrimus Petrus Varignon, qui eam hydraulicae partem, quae mensuram liquorum fluentium respicit, plurimum protendit in duobus praeclaris specimintibus Actis Academiae Regiae Parisiensis insertis, quorum

prius circa constructionem omnis generis Clepsydrarum versatur; alterum vero argumentum de liquoribus effluentibus eorumque mensuris ex professo excolit. Ante hosce duos postremos laudatissimos viros Summus Geometra Isaacus Newtonus in aureo opere, quod *Philosophiae Naturalis Principia Mathematica* inscripsit, plura tradidit corporum fluidorum vires & affectiones concernentia, quo referenda sunt ea, quae circa vim elasticam aeris, densitates atmosphaerae , quae circa resistentias figurarum in fluidis incedentium , circa motus corporum in mediis resistentibus, circa agitationem aeris in productione soni, atque alia demonstrata exhibuit: ejusque exemplo permoti Illustris Leibnitius atque Nobilissimus Hugenius meditationes suas circa motus corporum in medio resistenti publico diutius invidere noluerunt; quod argumentum postea generaliter pertractavit supra laudatus Varignonius. Celeberrimi vero deque reconditiori Geometria optime meriti Bernoullii Fratres diversa Problemata circa fluidorum actiones in corpora dura, sed flexibilia, contemplati sunt, atque interiori Geometria ipsis opem ferente, elegantes curvas velariae at lintei intus stagnantem liquorem continente, in apricum produxerunt, ut alia multa taceam.

Sed, quia eximia haec inventa in variis Diariis aliisque libris dispersa & ex diversis saepe principiis elicita sunt, gratum me iis facturum, qui hisce rebus delectantur, existimavi, si omnia juxta genuinum ordinem in unum collecta, ex paucis iisque simplicibus principiis deducta & aucta publicae luci sisterem. Verum hunc vix ingressus campum illico perspexi, propositum istud me nunquam feliciter ad exitum deducturum, nisi omnia altius repeterem, pluraque ex Mechanica corporum solidorum mutuarer, ad id ut tyrones opusculium citra offensionem percurrere possent, nec ad ejus intelligentiam auxilia aliunde conquirere necessum haberent. Cum vero in rebus hisce subsidiariis explicandis materia in.tantum excreverit, ut non contemnendam opusculi partem constitueret, natus demum est praesens tractatus; quem generaliori titulo *Phoronomiae*, seu *De Viribus & Motibus Corporum solidorum & fluidodrum*, insigniendum & in duos libros dividendum duxi, quorum prior vires & motus corporum solidorum, fluidorum vero alter, evolveret.

Liber primus duas continet Sectiones in sua Capita, subdivisas, quarum prior versatur circa simplices gravitationes solidorum, seu circa leges aequilibrii potentiarum mechanicarum, inter se commissarum, earumque medias directiones, sive hae potentiae corporibus inflexibilibus & rigidis, sive flexibilibus applicatae sint; qui duo casus nobis praebuerunt admodum generalia & forte non inelegantia theoremata, ex quibus deinceps leges aequilibrii solidorum & fluidorum facile definiuntur & solutiones Problematae catenariae, velariae, figurae lintei, alterumque non nisi Corollarionum ad instar derivantur. Secundae Sectio, motus doctrinam sibi vendicat, quatenus hi motus a gravitas solicitationibus continuatis seu continue operandibus proveniunt, vel qui ex collisione corporum inter se resultant. Haec proinde secunda Sectio praecipua eorum omnium continet quaecunque circa motus acceleratos vel retardatos a gravitate uniformi, aut quomodocunque difformi, demonstrari possunt, tum etiam generaliter Isochronam definit quodcunque gravitatis systema assumi queat, idque in casu, quo gravium directiones in uno etiam eodemque puncto convenient. Et quia curvae projectorum non in omni gravitatis difformis seu variabilis hypothesi algebraicae esse queunt, canon generalis traditur, juxta quem gravitatem variare oportet, ad id ut missilia curvas algebraicas

describant, & pro orbibus mobilibus propemodum circularibus facili rationi regula pro viribus centripitis, in curva mobile requisitis, traditur, ostenditurque deinceps quomodo ex data ejusmodi vi centripetal, seu solicitatione gravitatis, motus curvae circularis inveniri queat. Post haec sequitur theoria nova centri oscillationis, quae propter simplicitatem suam non displicebit, ut opinor : ea tota fundature in eo, quod solicitationes quaedam assumptae & in particulas oscillantes agentes in directionibus perpendicularibus distantiis particularum ab axe oscillationis aequipollent gravitatis pressionibus ; ope hujus principii & comparationis penduli compositi cum simplice ei isochrono, illico reperitur longitudino huius penduli simplicis, idque per unicum atqae simplicem analogiam. Cum primum in hanc theoriam incidi, quod minimum ante triennium & quod excurrit, accidit, eam tantum gravitati uniformi, ut Hugenius & Jac. Bernoullius, applicueram, sed postea, ex quo in Acta Lipsiensia 1713 M. Febr. incidi, ubi Celeb. Joh. Bernoullius in §. 23. egregii sui Schediasmatis de nova centri oscillationis theoria, quae tam ad pendula intra varios liquores oscillantia, quam extra eosdem, sese extendat , mentionem facit, in hisce etiam circumstantiis methodi meae periculum facere coepi optimo cum successu, nam sponte sua ea, quae Bernoullius de sua tunc pollicebatur, & postmodum anno sequenti Mens. Jan. praestitit, ultro sese mihi obtulerunt statim post lectum specimen prius anni 1713. praeterquam quod demonstratione facili id demonstratum dedi, quod Hugeniae tanquam postulatum sibi concedi postulabat , centrum scilicet commune gravitatis omnium particularum, cujusque penduli compositi diffractis, quibus connexae erant, vinculis ad eandem altitudinem attolli posse motu earum in altum converso, ex qua idem centrum ceciderat, particulis tamen inter se connexis. Ex memorabili ejusmodi naturae lege methodo, ni fallor, nova regulas motus ex percussione corporum elasticorum derivavi.

Liber Secundus corporibus fluidis destinatus perplura complectitur. Agit enim de gravitationibus liquorum quorumlibet tum in plana subjecta, tum in latera vasorum, indeque canones derivantur circa vires vasorum, ut citra fracturam liquoris pressiones perferre queant. De aequilibriis liquorum cum inter se, tum cum corporibus solidis ipsis immissis. De figuris, quas fluida corporibus flexibilibus, in quibus stagnant, inducunt. De gravitate & elasticitate aeris ac densitatibus atmosphaerae in omnia tellure distantia & in quacunque elasticitatis lege. De motu & mensura aquarum fluentium ex vasis quibuscunque erumpentium, aut in canalibus devolutarum. De effectibus fluidorum ex percussione, quo pertinent resistentiae, quae figurae in fluidis latae patiuntur, harumque resistentiarum mediae directiones, item problema velarae & id genus alia. De motibus corporum in mediis resistentibus tam rectilineis quam curvilineis. De motu navium vento impulsarum. De motu circulari fluidorum. De motu aeris in productione soni ; ac denique de motu intestino seu interno fluidorum, a quo calor pendet. Hisce summatim recensitis totum opusculium absolvitur.

Cum brevitati in omnibus studuerim, id cumprimis operam dedi, ut, quantum fieri poterat, cuncta generalibus theorematis comprehenderentur ; ex quibus deinde particularia, tanquam Corollaria , possent deduci. Propterea liquores tanquam heterogeneos statim spectavi, atque eorum leges pressionis atque aequilibrii investigavi, ex quibus deinceps leges aequilibrii fluidorum homogeneorum facillime elicui. Sic etiam vectem rectilineum vel curvilineum in omnibus suis punctis a potentiis quomodocunque

variantibus impulsum mihi proposui, in quo mediam potentiarum directionem investigarem , hocque modo in insignem proprietatem centrorum gravitatis, quam me primum invenisse putabam, incidi; sed quam etiam Celeb. Joh. Bernoulli in Libro nuper edito (*Essay d'une Nouvelle Theorie de Manoeuvre desVaisseaux).Cap.* XII. §VI. proponit. Sed Cl. hic Geometra recordabitur haud dubie se MStum meum vidisse, in quo theoremata huc facientia continebantur, priusquam laudatus suus liber editus esset , quemadmodum ego eius Propositionem propriam in eius libro, tunc adhuc inedito, pariter videram. Sic etiam problemata catenariae, velariae, &c. ad hoc generale reduxi : invenire figuram manentem lineae flexilis in singulis punctis a potentiis secundum directiones quascunque impulsae, cujus solutionem simplicissimam, ut mihi saltem videtur, exhibui. Et hoc modo in aliis procedere conatus sum. Perspicuitati, quantum potui, litavi; propterea multae demonstrationes provectioribus Geometris nimis prolixae fortasse videbuntur, sed sciant velim Tyronum quoque rationem habendam mihi fuisse, quibus non semper in potestate est ea supplendi, quae subinde ex demonstrationibus brevitatiae & elegantiae gratia resecantur mente necessario supplenda. Interim diffiteri nolo me etiam, quantum potui, elegantiam sectatum esse, atque propterea demonstrationes lineares algebraicis praetulisse, experientia multiplici edoctum, meditationem figurarum saepissime simpliciores & elegantiores suppeditare solutiones ac constructiones, quam Analysin speciosam. Speciosam dico, nam subinde utor analysi geometrica, seu lineari absque symbolis algebraicis procedente, cujus beneficio multa elegantius obtinentur quam calculis analyticiae, etsi non semper. Ejusmodi analysi geometrica veteres usos existimo, quaemadmodum ex Euclidis datis & Apollonii libello *de Sectione Rationis* a Celeberrimo Edmundo Hallaeo edito non obscure colligitur; simili etiam analysi summus Newtonus ad stuporem usque usuae est in suis *Principiis.* In applicatione vero theorematum, tanquam loco magis idoneo, calculo algebraico subinde utor.

In his libris frequens curvarum est usus ad repaesentandas virium, temporum, celeritatum, aliarumque ejusmodi affectionum proportiones, quas propterea curvas vocabulo *scalarum* insignire soleo, prout Cavallerius & Vivianus Celeberrimi · Geometrae diu ante me circa varios gravitatis gradus & momentorum corporum, Architectos imitati, qui lineam rectam in plures particulas aequales interstinctam (ad id, ut ex ea praeconceptorum operum ideas, proportionaliter delineare possint) *scalam* Geometricam vocant. Patet ergo curvarum linearum contemplationem non solum non esse inutilem , sed absolute necessariam ad accuratam phaenomenorum atque virium naturae repraesentationem.

Quantum ad notationis formam attinet, cum duae pluresve lineae cum interjectis punctis conjunguntar, hoc significat lineas cum interjectis punctis conjunguntur, hoc significant lineas in se mutuo ductas esse, ut AB. CD significant rectangulum sub AB in CD, quod aliis sic designari solet AB + CD. Sic etiam §. 472. *num.* 11. tBE = N.$\sqrt{\text{A}}$. ang. ICD indicat tempus per BE exponi, facto ex N & radice ipsius A in angulum ICD; & sic in reliquis hujus Propositionis demonstrationisque locis, & in Propositionibus duabus sequentibus. Fractiones seu rationes ad Typothetarum commoditatem exprimuntur per duo puncto. Sic AB : CD idem est ac communiter $\frac{\text{AB}}{\text{CD}}$, $\text{AB} : \text{CD} = \text{EF} : \text{MN}$ & idem ac vulgo $\text{AB.CD} :: \text{EF.MN}$. Cum plures fractiones sibi invicem adduntur, eae vel commate,

aut commate cum puncto, aut etiam parenthesibus distinguuntur : sic $f = a:b,+c:d$. aut $f = a:b;+c:d$ idem est quod ordinarie $f = \frac{a}{b} + \frac{c}{d}$. Subinde quantitatibus aliae parenthesibus inclusae sine ullo interposito signo annectuntur, quod indicat quantitates esse aequales; sic, si haberetur A(*a)* id indicaret aequales esse vel aequivalentes magnitudines A & *a*, sin vero cum puncto interposito distinguantur ut A.*(a)* hoc denotat factum ex A in a; & sic in aliis. Expressiones vero *:* $\sqrt{(aa+bb)}$; $(aa+bc)^m$ denotant $\sqrt{aa+bb}$; $\overline{aa+bc}^m$ respective. Reliqua signa usitato sensu adhibentur.

DE VIRIBUS ET MOTIBUS CORPORUM

PRAENOTANDA.

1. Corpora absolute *moveri* dicuntur, cum contiguitas eorum cum partibus spatii undequaque infiniti & immobilis continue mutatur; atque adeo *Motus* ipse consistit in illiusmodi contiguitatis mutatione.
2. Partes *illae* spatii infiniti & immobilis corpori contiguae sunt, quae ipsum immediate contingunt & ambiunt; spatiumque immobile dicitur, quia singulae ejus partes eandem constanter distantiam, atque adeo eundem mutuo respectu situm servare intelliguntur, totumque spatium utpote undique in infinitum excurrens extra se ipsum vagari atque situm mutare, intelligi non potest.
3. Quia contiguitatis mutatio non nisi tractu temporis fieri potest, implicat enim ut unum idemque corpus simul & eodem tempore diversis spatii partibus contiguum sit, id est, in diversis locis existat; ideo omnis motus tempus involvit.
4. Tempus considerari potest tanquam aequabilis fluxus unius ejus signi indivisibilis, quod Momentum vel instans nominabimus; eodem ferme modo quo Geometrae lineas motu puncti generari intelligunt, hoc tamen cum discrimine ; quod puncti lineam describentis motus modo concitatior modo remissior fingi possit, cum e contrario fluxus momenti nostri aequabili, ut ita dicam, passu fiat, ita ut aequalis temporis partes aequales fluentis momenti distantias, seu intervalla a prima statione in qua ea incipiunt, sibi vindicent.
5. Hinc est, quod fluxus momenti nostri seu tempus soli intellectui hoc modo perceptibile, periodicis Corporum caelestium motibus vel Horologiorum usu aliorumve instrumentorum ope, & sensibile quodammodo reddatur, atque ad mensuram qualemcunque revocetur. Sed tales temporis mensurae & repraesentationes non sunt exactae in ultimo rigore, quandoquidem nec motus annuus solis, A nec qui ex eo atque diurno componitur, nec forte ipse diurnus, ut nonnulli Astronomi suspicantur, perfecte aequabiles sunt, ac propterea non nisi temporis apparentis mensurae esse possunt. Ideo etiam Astronomi, qui temporis veri & aequabilis mensuram exquirunt, subinde apparens tempus ad tempus, quod vocant medium, quodque pro uniformi habent, reducere necessum habent. Et quanquam Horologiis oscillatoriis, prout ad insignem perfectionis gradum ab Hugenio perducta sunt, accurata veri seu aequabilis temporis mensura haberi posse videtur, eorum tamen motus Mathematice accurati & uniformes esse nequeunt, non

quidem ob principiorum defectum, in quibus constructio eorum fundata est, sed ob defectum executionis ; constat enim machinas nunquam in ultimo rigore tales parari posse, quales theoria construendas jubet, quia in theoria ab illis impedimentis atque circumstantiis tantum non semper abstrahi solet, quae tamen in ipsa praxi nunquam abesse solitae sunt, successum machinae accuratissimum eludentes.

6. Si fluens nostrum punctum, aut etiam corpus quodvis, uniformi passu incedit, perinde ac momentum temporis uniformiter fluere intelligitur, tunc motus puncti vel corporis a*equabilis* vocatur. Et iter seu longitudo, quae etiam spatium vocari solet motu corporis descriptum, ad tractum temporis a fluente momento interea comfectum, hoc est, ad tempus lationis applicatum seu divisum *Celeritas* vel *Velocitas*, appellatur.

7. Id, quod corpus ad motum concitat, seu ex quo motus corporis resultat, id est quo posito ponitur motus corporis, vocatur *Vis motrix*, quae dividi potest, in *Vivam* & *Mortuam.*

8. *Vis viva* est, quae cum motu actuali conjuncta est. Sic corpus, quod dato tempore datam lineam transmittit, *vi* viva praeditum dicitur.

9. *Vis Mortua* vero est, ex qua nullus motus actualis resultat, nisi aliquandiu in corpore continuata vel replicata fuerit. Talis vis foret unicus tantum gravitatis impulsus nullis aliis ei succedentibus, etenim non, nisi post infinitos demum gravitatis ictus indesinenter replicatos seu unos aliis continuc succedentes, motus sensibilis gravi acquiritur. Sic etiam conatus centrifugi ex circulari motu oriundi, perinde ac gravitatis impulsus, sistunt exemplum vis mortuae.

10. Majoris distinctionis gratia Vim Vivam simpliciter Vim, Mortuam vero cujuscunque demum generis fuerit, *Solicitationem* posthac vocabimus. Praecedentes virium definitiones satis aperte indicant in iis agi de *Vi activa* corporum.

11. Sed inest etiam corporibus *Vis* quaedam *passiva*, ex qua nulus motus nec tendentia ad motum resultat; sed consistit in *Renixu* illo, quo cuilibet vi externae mutationem status, id est motus vel quietis, corporibus inducere conanti reluctatur. Quae resistentiae significantissimo vocabulo a summo Astronomo Joh. Keplero *Vis inertiae* dicta est. Haec Vis inertiae in corporibus quiescentibus se satis prodit; etenim corpus quodcunque A in aliud, sed quiescens, B impactum aliquid de sua vi & motu amittet, excipiensque B aliquid virium & motus ab impellente A acquiret. Ex quo claret, quiesens corpus B reapse vim aliquam passivam habere a vi in id incurrentis corporis A frangendam atque superandam; alioqui impellens A post occursum nihil de suo motu amisisse debuisset, cum corpus quiescens B, si resistendi facultate careret, alterius motui nullam remoram afferre possit, adeo ut ambo, impellens A & impulsum B, ea ipsa celeritate, qua corpus A ante occursum ferebatur, etiam post contactum incedere deberent, quod phaenomenis adversari nemo non videt.

12. In hac Vi inertiae materiae fundata est Naturae lex, qua *Cuilibet actioni aequalis & contrari est reactio.* In omni enim actione est luctatio inter corpus agens & patiens, & sine ejusmodi luctatione nulla actio, proprie sic dicta, agentis in patiens concipi potest, alioqui nulla stabilia haberentur Mechanicae fundamenta, sed quilibet effectus a qualibet caussa oriretur.

13. *Vires activae,* cujuscunque generis fuerint, gemino modo inter fe collatae variare possunt. *Aliae* enim aliis intensivc majores sunt, nulla habita ratione subjecti recipientis ; cum duo corpora, quoad materiam aequalia, viribus inaequalibus pollent. Aliae porro aliis etiam majores esse possunt, cum vires intensive aequales corporibus quoad materiam inaequalibus applicatae sunt. Nam in genere vis cujusque corporis est ea, quae resultat ex omnibus viribus partialibus, quibus singula corporis elementa seu minimae particulae pollent. Sic si vires, quibus singula corporis elementa afficiuntur, conspirantes sunt, *Vis totalis* erit complexus seu aggregatum omnium virum partialium.
14. Quantitas *materiae* cujusque corporis, quam m*assam* deinceps vocabimus, est complexus (aggregatum) omnium particularum, quibus corpus compositum est. Ipsae vero particulae corporis constitutivae, ejus *elementa* brevius dicentur. Idcirco materia fluida, quae in corporum meatibus latere potest, ad corporis substantiam pertinere non censetur, perinde ac aqua in spongiae poris delitescens ad spongiae substantiam non refertur.
15. *Volumen* cujusque corporis est spatium, quod corporis Materiam cum interspersis poris occupat. Ex collatione Massae seu quantitatis materiae cum Volumine resultat
16. *Densitas,* quae est ratio quam materiae quantitas in quolibet corpore habet ad corporis Volumen. Ut, sicorpus in massam poris carentem colliquatum intelligatur, facile etiam intelligitur ejusmodi massam minus spatium occupaturam, quam antea cum intermixtis poris occuparat: Ratio talis Massae poris destitutae: ad corporis Volumen nobis est *Densitas corporis.* Aliis densitas major minorve consistit in majore vel minore pororum amplitudine, quod cum nostra definitione satis convenit; nam quo maior est ratio massae *poris* expertis ad corporis Volumen, eo minor erit meatuum amplitudo, atque adeo major corporis densitas.
17. *Raritas* est corporum qualitas reciproca densitati, consistens in ratione Voluminis ad Massam seu Materiae quantitatem, haec enim duo semper unum idemque significare sciendum est.

Ex hisce definitionibus prono alveo fluunt sequentia consectaria quae, quia in sequentibus maximo usui erunt, breviter hoc loco sunt indicanda. Dicantur Corpora inter se collata C, c; eorum Massae M, m; Volumina *V,* v; Densitates D, d; Raritates R, r; atque, hisce nominibus positis, erunt
18. *Quantitates Materiae seu Massae* (M, m) *in composita ratione Densitatum* (D, d) *& Voluminum* (V, v). Id est, $M : m = D.V : d.v.$
Nam *(§.* 16.) $D = M : V$ & $d = m : v,$ ergo $M : m = D.V : d.v.$
19. *Volumina* (V, v) *erunt in composita ratione ex directa Massarum & inversa Densitatum.* Id est, $V : v = (M : D) : (m : d)$. Liquet ex §.17.

Volumina sunt etiam in composita ratione ex directa Massarum & directa Raritatum. Hoc est V:v=M. R.:m.r. Nam *(§.16.)*
$R = V : M,$ & $r = v : m$ ergo $V : v = M. R : m.r$.
20. *Densitates Raritatibus sunt reciproce proportionales, seu*
$D : d = r : R$. Nam (§.l6.17.) est $D = M : V,$ & $R = V : M$, erit
$r : R = M : V = D$ atque adeo $D.R = 1,$ & $d.r = 1 = D.R;$ hinc $D : d = r : R$.

21. *Directo* cujuslibet vis motricis est linea, juxta quam haec vis in corpus agit, estque illa recta, quam mobile hac vi citatum actu describit aut saltem describere conatur.
22. *Vires* & *Motus conspirantes* sunt, quorum directiones congruunt, aut saltem parallelae sunt, & easdem ad partes tendunt.
23. *Vires* vero & motus *Contrarii* hoc est, *directe* oppositi, quorum directiones quidem congruunt aut saltem aequidistantes sunt, sed in oppositas partes vergunt.

Hactenus generales corporum affectiones, quibus recensitae: virium species applicari possunt, breviter attigimus. Ordinis ratio insuper requirit ut corporum species, quibus vires illae varie possunt applicari, ab invicem distinguantur; corpora enim sunt vel solida vel fluida ; & ex diversis hisce speciebus diversa resultant phaenomena.
24. *Corpora solida* aut *consistentia* dicuntur ea, quorum elementa saltem eousque cohaerent, ut nulla corporis pars sensibiliter moveri possit, quin tota massa eundem motum participet. Caeterum ex observationibus Celeb. Dominici Cassini constat metalla frigori exposita nonnihil contrahi, & vice versa, quoad Volumen, extendi in locis calidis; & ejusmodi metallorum extensiones & contractiones, quibus haud dubie durissima quaeque alia corpora plus minus obnoxia sunt, absque interno partium motu fieri nequeunt: sed quia hi motus, ex solis phaenomenis per ratiocinia colligendi, in sensus immediate non incurrunt, definitioni isti nihil officere possunt; quandoquidem in ea corporum durorum, seu solidorum, elementorum non absolute cohaerere dicuntur, sed tanquam eousque, ut ea ab invocem avelli aut moveri sensibiliter nequeant, quin totum corpus eodem motu abripiatur.
25. *Fluida* vero corpora sunt, quorum particulae agilissimae non cohaerent, sed facile moveri possunt non mota universi fluidi massa. In fluidis viscidis particulae nonnihil cohaerere videntur, sed talis earum adhaesio miram earumdem inter se mobilitatem non tollit, ac propterea talia fluida ex allata hac definitione non excluduntur.