Thomas Hobbes. ELEMENTS OF PHILOSOPHY. THE FIRST SECTION, CONCERNING BODY, WRITTEN IN LATIN BY THOMAS HOBBES OF MALMESBURY, AND TRANSLATED INTO ENGLISH. (1656)

Chapter 8. OF BODY AND ACCIDENT.

1. Body defined.--2. Accident defined.--3. How an accident may be understood to be in its subject.--4. Magnitude, what it is.--5. Place, what it is, and that it is immovable.--6. What is full and empty.--7. Here, there, somewhere, what they signify.--8. Many bodies cannot be in one place, nor one body in many places.--9. Contiguous and continual, what they are.---10. The definition of motion. No motion intelligible but with time.--11. What it is to be at rest, to have been moved, and to be moved. No motion to be conceived, without the conception of past and future.--12. A point, a line, superficies and solid, what they are.--13. Equal, greater, and less in bodies and magnitudes, what they are.--14. One and the same body has always one and the same magnitude. 15. Velocity, what it is.--16. Equal, greater, and less in times, what they are.--17. Equal, greater, and less, in velocity, what. 18. Equal, greater, and less, in motion, what.--19. That which is at rest, will always be at rest, except it be moved by some external thing; and that which is moved, will always be moved, unless it be hindered by some external thing.--20. Accidents are generated and destroyed, but bodies not so. 21. An accident cannot depart from its subject.--22. Nor be moved.--22. Essence, form, and matter, what they are. 24. First matter, what.--25. That the whole is greater than any part thereof, why demonstrated.

1. HAVING understood what imaginary space is, in which we supposed nothing remaining without us, but all those things to be destroyed, that, by existing heretofore, left images of themselves in our minds; let us now suppose some one of those things to be placed again in the world, or created anew. It is necessary, therefore, that this new-created or replaced thing do not only fill some part of the space above mentioned, or be coincident and coextended with it, but also that it have no dependance upon our thought. And this is that which, for the extension of it, we commonly call body; and because it depends not upon our thought, we say is a thing subsisting of itself; as also existing, because without us; and, lastly, it is called the subject, because it is so placed in and subjected to imaginary space, that it may be understood by reason, as well as perceived by sense. The definition, therefore, of body may be this, a body is that, which having no dependance upon our thought, is coincident or coextended with some part of space.

2. But what an accident is cannot so easily be explained by any definition, as by examples. Let us imagine, therefore, that a body fills any space, or is coextended with it; that coextension is not the coextended body: and, in like manner, let us imagine that the same body is removed out of its place; that removing is not the removed body: or let us think the same not removed; that not removing or rest is not the resting body. What, then, are these things? They are accidents of that body. But the thing in question is, what is an accident? which is an enquiry after that which we know already, and not that which we should enquire after. For who does not always and in the same manner understand him that says any thing is extended, or moved, or not moved? But most men will have it be said that an accident is something, namely, some part of a natural thing, when, indeed, it is no part of the same. To satisfy these men, as well as may be, they answer best that define an accident to be the manner by which any body is conceived; which is all one as if they should say, an accident is that faculty of any body, by which it works in us a conception of itself. Which definition, though it be not an answer to the question propounded, yet it is an answer to that question which should have been propounded, namely, whence does it happen that one part of any body appears here, another there? For this is well answered thus: it happens from the extension of that body. Or, how comes it to pass that the whole body, by succession, is seen now here, now there? and the answer will be, by reason of its motion. Or, lastly, whence is it that any body possesseth the same space for sometime? and the answer will be, because it is not moved. For if concerning the name of a body, that is, concerning a concrete name, it be asked, what is it? the answer must be made by definition; for the question is concerning the signification of the name. But if it be asked concerning an abstract name, what is it? the cause is demanded why a thing appears so or so. As if it be asked, what is hard? The answer will be, hard is that, whereof no part gives place, but when the whole gives place. But if it be demanded, what is hardness? a cause must be shewn why a part does not give place, except the whole give place. Wherefore, I define an accident to be the manner of our conception of body.

When an accident is said to be in a body, it is not so to be understood, as if any thing were contained in that body; as if, for example, redness were in blood, in the same manner, as blood is in a bloody cloth, that is, as a part in the whole; for so, an accident would be a body also. But, as magnitude, or rest, or motion, is in that which is great, or which resteth, or which is moved, (which, how it is to be understood, every man understands) so also, it is to be understood, that every other accident is in its subject. And this, also, is explicated by Aristotle no otherwise than negatively, namely, that an accident is in its subject, not as any part thereof, but so as that it may be away, the subject still remaining; which is right, saving that there are certain accidents which can never perish except the body perish also; for no body can be conceived to be without extension, or without figure. All other accidents, which are not common to all bodies, but peculiar to some only, as to be at rest, to be moved, colour, hardness, and the like, do perish continually, and are succeeded by others; yet so, as that the body never perisheth. And as for

the opinion that some may have, that all other accidents are not in their bodies in the same manner that extension, motion, rest, or figure, are in the same; for example, that colour, heat, odour, virtue, vice, and the like, are otherwise in them, and, as they say, inherent, I desire they would suspend their judgment for the present, and expect a little, till it be found out by ratiocination, whether these very accidents are not also certain motions either of the mind of the perceiver, or of the bodies themselves which are perceived; for in the search of this, a great part of natural philosophy consists.

4. The extension of a body, is the same thing with the magnitude of it, or that which some call real space. But this magnitude does not depend upon our cogitation, as imaginary space doth; for this is an effect of our imagination, but magnitude is the cause of it; this is an accident of the mind, that of a body existing out of the mind.

Hobbes: EOP Pt. 2 Ch. 8 p. 105

5. That space, by which word I here understand imaginary space, which is coincident with the magnitude of any body, is called the place of that body; and the body itself is that which we call the thing placed. Now place, and the magnitude of the thing placed, differ. First in this, that a body keeps always the same magnitude, both when it is at rest, and when it is moved; but when it is moved, it does not keep the same place. Secondly in this, that place is a phantasm of any body of such and such quantity and figure; but magnitude is the peculiar accident of every body; for one body may at several times have several places, but has always one and the same magnitude. Thirdly in this, that place is nothing out of the mind, nor magnitude any thing within it. And lastly, place is feigned extension, but magnitude true extension; and a placed body is not extension, but a thing extended. Besides, place is immovable; for, seeing that which is moved, is understood to be carried from place to place, if place were moved, it would also be carried from place to place, so that one place must have another place, and that place another place, and so on infinitely, which is ridiculous. And as for those, that, by making place to be of the same nature with real space, would from thence maintain it to be immovable, they also make place, though they do not perceive they make it so, to be a mere phantasm. For whilst one affirms that place is therefore said to be immovable, because space in general is considered there; if he had remembered that nothing is general or universal besides names or signs, he would easily have seen that that space, which he says is considered in general, is nothing but a phantasm, in the mind or the memory, of a body of such magnitude and such figure. And whilst another says: real space is made immovable by the understanding; as when, under the superficies of running water, we imagine other and other water to come by continual succession, that superficies fixed there by the understanding, is the immovable place of the river: what else does he make it to be but a phantasm, though he do it obscurely and in perplexed words? Lastly, the nature of place does not consist in the superficies

of the ambient, but in solid space; for the whole placed body is coextended with its whole place, and every part of it with every answering part of the same place; but seeing every placed body is a solid thing, it cannot be understood to be coextended with superficies. Besides, how can any whole body be moved, unless all its parts be moved together with it? Or how can the internal parts of it be moved, but by leaving their place? But the internal parts of a body cannot leave the superficies of an external part contiguous to it; and, therefore, it follows, that if place be the superficies of the ambient, then the parts of a body moved, that is, bodies moved, are not moved.

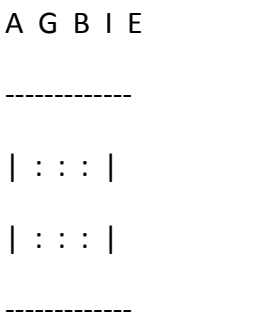
6. Space, or place, that is possessed by a body, is called full, and that which is not so possessed, is called empty.

Here, there, in the country, in the city, and other the like names, by which answer is made to the question where is it? are not properly names of place, nor do they of themselves bring into the mind the place that is sought; for here and there signify nothing, unless the thing be shewn at the same time with the finger or something else; but when the eye of him that seeks, is, by pointing or some other sign, directed to the thing sought, the place of it is not hereby defined by him that answers, but found out by him that asks the question. Now such shewings as are made by words only, as when we say, in the country, or in the city, are some of greater latitude than others, as when we say, in the country, in the city, in such a street, in a house, in the chamber, in bed, &c. For these do, by little and little, direct the seeker nearer to the proper place; and yet they do not determine the same, but only restrain it to a lesser space, and signify no more, than that the place of the thing is within a certain space designed by those words, as a part is in the whole. And all such names, by which answer is made to the question where? have, for their highest genus, the name somewhere. From whence it may be understood, that whatsoever is somewhere, is in some place properly so called, which place is part of that greater space that is signified by some of these names, in the country, in the city, or the like.

8. A body, and the magnitude, and the place thereof, are divided by one and the same act of the mind; for, to divide an extended body, and the extension thereof, and the idea of that extension, which is place, is the same with dividing any one of them; because they are coincident, and it cannot be done but by the mind, that is by the division of space. From whence it is manifest, that neither two bodies can be together in the same place, nor one body be in two places at the same time. Not two bodies in the same place; because when a body that fills its whole place is divided into two, the place itself is divided into two also, so that there will be two places. Not one body in two places; for the place that a body fills being divided into two, the placed body will be also divided into two; for, as I said, a place and the body that fills that place, are divided both together; and so there will be two bodies.

9. Two bodies are said to be contiguous to one another, and continual, in the same manner as spaces are; namely, those are contiguous, between which there is no space. Now, by space I understand, here as formerly, an idea or phantasm of a body. Wherefore, though between two bodies there be put no other body, and consequently no magnitude, or, as they call it, real space, yet if another body may be put between them, that is, if there intercede any imagined space which may receive another body, then those bodies are not contiguous. And this is so easy to be understood, that I should wonder at some men, who being otherwise skilful enough in philosophy, are of a different opinion, but that I find that most of those that affect metaphysical subtleties wander from truth, as if they were led out of their way by an ignis fatuus. For can any man that has his natural senses, think that two bodies must therefore necessarily touch one another, because no other body is between them? Or that there can be no vacuum, because vacuum is nothing, or as they call it, non ens? Which is as childish, as if one should reason thus; no man can fast, because to fast is to eat nothing; but nothing cannot be eaten. Continual, are any two bodies that have a common part; and more than two are continual, when every two, that are next to one another, are continual.

10. MOTION is a continual relinquishing of one place, and acquiring of another; and that place which is relinquished is commonly called the terminus a quo, as that which is acquired is called the terminus ad quem; I say a continual relinquishing, because no body, how little soever, can totally and at once go out of its former place into another, so, but that some part of it will be in a part of a place which is common to both, namely, to the relinquished and the acquired places. For example, let any body be in the place A C B D; the same body cannot come into the place B D E F; but it must first be in G H I K, whose part G H B D is common to both the places A C B D, and G H I K, and whose part B D I K, is common to both the places G H I K, and B D E F.



Now it cannot be conceived that any thing can be moved without time; for time is, by the definition of it, a phantasm, that is, a conception of motion; and, therefore, to conceive

that any thing may be moved without time, were to conceive motion without motion, which is impossible.

11. That is said to be at rest, which, during any time, is in one place; and that to be moved, or to have been moved, which, whether it be now at rest or moved, was formerly in another place than that which it is now in. From which definitions it may be inferred, first, that whatsoever is moved, has been moved; for if it be still in the same place in which it was formerly, it is at rest, that is, it is not moved, by the definition of rest; but if it be in another place, it has been moved, by the definition of moved. Secondly, that what is moved, will yet be moved; for that which is moved, leaveth the place where it is, and therefore will be in another place, and consequently will be moved still. Thirdly, that whatsoever is moved, is not in one place during any time, how little soever that time be; for by the definition of rest, that which is in one place during any time, is at rest.

There is a certain sophism against motion which seems to spring from the not understanding of this last proposition. For they say, that, if any body be moved, it is moved either in the place where it is, or in the place where it is not; both which are false; and therefore nothing is moved. But the falsity lies in the major proposition; for that which is moved, is neither moved in the place where it is, nor in the place where is not; but from the place where it is, to the place where it is not. Indeed it cannot be denied but that whatsoever is moved, is moved somewhere, that is, within some space; but then the place of that body is not that whole space, but a part of it, as is said above in the seventh article. From what is above demonstrated, namely, that whatsoever is moved, has also been moved, and will be moved, this also may be collected, that there can be no conception of motion, without conceiving past and future time.

12. Though there be no body which has not some magnitude, yet if, when any body is moved, the magnitude of it be not at all considered, the way it makes is called a line, or one single dimension; and the space, through which it passeth, is called length; and the body itself, a point; in which sense the earth is called a point, and the way of its yearly revolution, the ecliptic line. But if a body, which is moved, be considered as long, and be supposed to be so moved, as that all the several parts of it be understood to make several lines, then the way of every part of that body is called breadth, and the space which is made is called superficies, consisting of two dimensions, one whereof to every several part of the other is applied whole. Again, if a body be considered as having superficies, and be understood to be so moved, that all the several parts of it describe several lines, then the way of every part of that body is called thickness or depth, and the space which is made is called solid, consisting of three dimensions, any two whereof are applied whole to every several part of the third.

But if a body be considered as solid, then it is not possible that all the several parts of it should describe several lines; for what way soever it be moved, the way of the following part will fall into the way of the part before it, so that the same solid will still be made which the foremost superficies would have made by itself. And therefore there can be no other dimension in any body, as it is a body, than the three which I have now described; though, as it shall be shewed hereafter, velocity, which is motion according to length, may, by being applied to all the parts of a solid, make a magnitude of motion, consisting of four dimensions; as the goodness of gold, computed in all the parts of it, makes the price and value thereof.

13. Bodies, how many soever they be, that can fill every one the place of every one, are said to be equal every one to every other. Now, one body may fill the same place which another body filleth, though it be not of the same figure with that other body, if so be that it may be understood to be reducible to the same figure, either by flexion or transposition of the parts. And one body is greater than another body, when a part of that is equal to all this; and less, when all that is equal to a part of this. Also, magnitudes are equal, or greater, or lesser, than one another, for the same consideration, namely, when the bodies, of which they are the magnitudes, are either equal, or greater, or less, &c.

One and the same body is always of one and the same magnitude. For seeing a body and the magnitude and place thereof cannot be comprehended in the mind otherwise than as they are coincident, if any body be understood to be at rest, that is, to remain in the same place during some time, and the magnitude thereof be in one part of that time greater, and in another part less, that body's place, which is one and the same, will be coincident sometimes with greater, sometimes with less magnitude, that is, the same place will be greater and less than itself, which is impossible. But there would be no need at all of demonstrating a thing that is in itself so manifest, if there were not some, whose opinion concerning bodies and their magnitudes is, that a body may exist separated from its magnitude, and have greater or less magnitude bestowed upon it, making use of this principle for the explication of the nature of rarum and densum.

15. Motion, in as much as a certain length may in a certain time be transmitted by it, is called VELOCITY or swiftness: &c. For though swift be very often understood with relation to slower or less swift, as great is in respect of less, yet nevertheless, as magnitude is by philosophers taken absolutely for extension, so also velocity or swiftness may be put absolutely for motion according to length.

16. Many motions are said to be made in equal times, when every one of them begins and ends together with some other motion, or if it had begun together, would also have ended together with the same. For time, which is a phantasm of motion, cannot be reckoned but by some exposed motion; as in dials by the motion of the sun or of the hand; and if two or more

motions begin and end with this motion, they are said to be made in equal times; from whence also it is easy to understand what it is to be moved in greater or longer time, and in less time or not so long; namely, that that is longer moved, which beginning with another, ends later; or ending together, began sooner.

17. Motions are said to be equally swift, when equal lengths are transmitted in equal times; and greater swiftness is that, wherein greater length is passed in equal time, or equal length in less time. Also that swiftness by which equal lengths are passed in equal parts of time, is called uniform swiftness or motion; and of motions not uniform, such as become swifter or slower by equal increasings or decreasings in equal parts of time, are said to be accelerated or retarded uniformly.

18. But motion is said to be greater, less, and equal, not only in regard of the length which is transmitted in a certain time, that is, in regard of swiftness only, but of swiftness applied to every smallest particle of magnitude; for when any body is moved, every part of it is also moved; and supposing the parts to be halves, the motions of those halves have their swiftness equal to one another, and severally equal to that of the whole; but the motion of the whole is equal to those two motions, either of which is of equal swiftness with it; and therefore it is one thing for two motions to be equal to one another, and another thing for them to be equally swift. And this is manifest in two horses that draw abreast, where the motion of both the horses together is of equal swiftness with the motion of either of them singly; but the motion of both is greater than the motion of one of them, namely, double. Wherefore motions are said to be simply equal to one another, when the swiftness of one, computed in every part of its magnitude, is equal to the swiftness of the other computed also in every part of its magnitude: and greater than one another, when the swiftness of one computed as above, is greater than the swiftness of the other so computed; and less, when less. Besides, the magnitude of motion computed in this manner is that which is commonly called FORCE.

19. Whatsoever is at rest, will always be at rest, unless there be some other body besides it, which, by endeavouring to get into its place by motion, suffers it no longer to remain at rest. For suppose that some finite body exist and be at rest, and that all space besides be empty; if now this body begin to be moved, it will certainly be moved some way; seeing therefore there was nothing in that body which did not dispose it to rest, the reason why it is moved this way is in something out of it; and in like manner, if it had been moved any other way, the reason of motion that way had also been in something out of it; but seeing it was supposed that nothing is out of it, the reason of its motion one way would be the same with the reason of its motion every other way, wherefore it would be moved alike all ways at once; which is impossible.

In like manner, whatsoever is moved, will always be moved, except there be some other body besides it, which causeth it to rest. For if we suppose nothing to be without it, there will be no reason why it should rest now, rather than at another time; wherefore its motion would cease in every particle of time alike; which is not intelligible.

When we say a living creature, a tree, or any other specified body is generated or destroyed, it is not to be so understood as if there were made a body of that which is not-body, or not a body of a body, but of a living creature not a living creature, of a tree not a tree, &c. that is, that those accidents for which we call one thing a living creature, another thing a tree, and another by some other name, are generated and destroyed; and that therefore the same names are not to be given to them now, which were given them before. But that magnitude for which we give to any thing the name of body is neither generated nor destroyed. For though we may feign in our mind that a point may swell to a huge bulk, and that this may again contract itself to a point; that is, though we may imagine something to arise where before was nothing, and nothing to be there where before was something, yet we cannot comprehend in our mind how this may possibly be done in nature. And therefore philosophers, who tie themselves to natural reason, suppose that a body can neither be generated nor destroyed, but only that it may appear otherwise than it did to us, that is, under different species, and consequently be called by other and other names; so that that which is now called man, may at another time have the name of not-man; but that which is once called body, can never be called not-body. But it is manifest, that all other accidents besides magnitude or extension may be generated and destroyed; as when a white thing is made black, the whiteness that was in it perisheth, and the blackness that was not in it is now generated; and therefore bodies, and the accidents under which they appear diversely, have this difference, that bodies are things, and not generated; accidents are generated, and not things.

21. And therefore, when any thing appears otherwise than it did by reason of other and other accidents, it is not to be thought that an accident goes out of one subject into another, (for they are not, as I said above, in their subjects as a part in the whole, or as a contained thing in that which contains it, or as a master of a family in his house,) but that one accident perisheth, and another is generated. For example, when the hand, being moved, moves the pen, motion does not go out of the hand into the pen; for so the writing might be continued though the hand stood still; but a new motion is generated in the pen, and is the pen's motion.

22. And therefore also it is improper to say, an accident is moved; as when, instead of saying, figure is an accident of a body carried away, we say, a body carries away its figure.

23. Now that accident for which we give a certain name to any body, or the accident which denominates its subject, is commonly called the ESSENCE thereof; as rationality is the essence of a man; whiteness, of any white thing, and extension the essence of a body. And the

same essence, in as much as it is generated, is called the FORM. Again, a body, in respect of any accident, is called the SUBJECT, and in respect of the form it is called the MATTER.

Also, the production or perishing of any accident makes its subject be said to be changed; only the production or perishing of form makes it be said it is generated or destroyed; but in all generation and mutation, the name of matter still remains. For a table made of wood is not only wooden, but wood; and a statue of brass is brass as well as brazen; though Aristotle, in his Metaphysics, says, that whatsoever is made of any thing ought not to be called {ekeino}, but {ekeininon}; as that which is made of wood, not {xylon}, but {xylinon}, that is, not wood, but wooden.

24. And as for that matter which is common to all things, and which philosophers, following Aristotle, usually call materia prima, that is, first matter, it is not any body distinct from all other bodies, nor is it one of them. What then is it? A mere name; yet a name which is not of vain use; for it signifies a conception of body without the consideration of any form or other accident except only magnitude or extension, and aptness to receive form and other accident. So that whensoever we have use of the name body in general, if we use that of materia prima, we do well. For as when a man not knowing which was first, water or ice, would find out which of the two were the matter of both, he would be fain to suppose some third matter which were neither of these two; so he that would find out what is the matter of all things, ought to suppose such as is not the matter of anything that exists. Wherefore materia prima is nothing; and therefore they do not attribute to it either form or any other accident besides quantity; whereas all singular things have their forms and accidents certain.

Materia prima, therefore, is body in general, that is, body considered universally, not as having neither form nor any accident, but in which no form nor any other accident but quantity are at all considered, that is, they are not drawn into argumentation.

25. From what has been said, those axioms may be demonstrated, which are assumed by Euclid in the beginning of his first element, about the equality and inequality of magnitudes; of which, omitting the rest, I will here demonstrate only this one, the whole is greater than any part thereof; to the end that the reader may know that those axioms are not indemonstrable, and therefore not principles of demonstration; and from hence learn to be wary how he admits any thing for a principle, which is not at least as evident as these are. Greater is defined to be that, whose part is equal to the whole of another. Now if we suppose any whole to be A, and a part of it to be B; seeing the whole B is equal to itself, and the same B is a part of A; therefore a part of A will be equal to the whole B. Wherefore, by the definition above, A is greater than B; which was to be proved.

Chapter 15. OF THE NATURE, PROPERTIES, AND DIVERS CONSIDERATIONS OF MOTION AND ENDEAVOUR.

1. Repetition of some principles of the doctrine of motion formerly set down.--2. Other principles added to them. 3. Certain theorems concerning the nature of motion.--4. Divers considerations of motion.--5. The way by which the first endeavour of bodies moved tendeth.--6. In motion which is made by concourse, one of the movents ceasing, the endeavour is made by the way by which the rest tend.--7. All endeavour is propagated in infinitum.--8. How much greater the velocity or magnitude is of a movent, so much the greater is the efficacy thereof upon any other body in its way.

1. THE next things in order to be treated of are MOTION and MAGNITUDE, which are the most common accidents of all bodies. This place therefore most properly belongs to the elements of geometry. But because this part of philosophy, having been improved by the best wits of all ages, has afforded greater plenty of matter than can well be thrust together within the narrow limits of this discourse, I thought fit to admonish the reader, that before he proceed further, he take into his hands the works of Euclid, Archimedes, Apollonius, and other as well ancient as modern writers. For to what end is it, to do over again that which is already done? The little therefore that I shall say concerning geometry in some of the following chapters, shall be such only as is new, and conducing to natural philosophy.

I have already delivered some of the principles of this doctrine in the eighth and ninth chapters; which I shall briefly put together here, that the reader in going on may have their light nearer at hand.

First, therefore, in chap. VIII. art. 10, motion is defined to be the continual privation of one place, and acquisition of another.

Secondly, it is there shown, that whatsoever is moved is moved in time.

Thirdly, in the same chapter, art. 11, I have defined rest to be when a body remains for some time in one place.

Fourthly, it is there shown, that whatsoever is moved is not in any determined place; as also that the same has been moved, is still moved, and will yet be moved; so that in every part

of that space, in which motion is made, we may consider three times, namely, the past, the present, and the future time.

Fifthly, in art. 15 of the same chapter, I have defined velocity or swiftness to be motion considered as power, namely, that power by which a body moved may in a certain time transmit a certain length; which also may more briefly be enunciated thus, velocity is the quantity of motion determined by time and line.

Sixthly, in the same chapter, art. 16, I have shown that motion is the measure of time.

Seventhly, in the same chapter, art. 17, I have defined motions to be equally swift, when in equal times equal lengths are transmitted by them.

Eighthly, in art. 18 of the same chapter, motions are defined to be equal, when the swiftness of one moved body, computed in every part of its magnitude, is equal to the swiftness of another, computed also in every part of its magnitude. From whence it is to be noted, that motions equal to one another, and motions equally swift, do not signify the same thing; for when two horses draw abreast, the motion of both is greater than the motion of either of them singly; but the swiftness of both together is but equal to that of either.

Ninthly, in art. 19 of the same chapter, I have shown, that whatsoever is at rest will always be at rest, unless there be some other body besides it, which by getting into its place suffers it no longer to remain at rest. And that whatsoever is moved, will always be moved, unless there be some other body besides it, which hinders its motion.

Tenthly, in chap. IX. art. 7, I have demonstrated, that when any body is moved which was formerly at rest, the immediate efficient cause of that motion is in some other moved and contiguous body.

Eleventhly, I have shown in the same place, that whatsoever is moved, will always be moved in the same way, and with the same swiftness, if it be not hindered by some other moved and contiguous body.

2. To which principles I shall here add those that follow. First, I define ENDEAVOUR to be motion made in less space and time than can be given; that is, less than can be determined or assigned by exposition or number; that is, motion made through the length of a point, and in an instant or point of time. For the explaining of which definition it must be remembered, that by a point is not to be understood that which has no quantity, or which cannot by any means be divided; for there is no such thing in nature; but that, whose quantity is not at all considered, that is, whereof neither quantity nor any part is computed in demonstration; so that a point is

not to be taken for an indivisible, but for an undivided thing; as also an instant is to be taken for an undivided, and not for an indivisible time.

In like manner, endeavour is to be conceived as motion; but so as that neither the quantity of the time in which, nor of the line in which it is made, may in demonstration be at all brought into comparison with the quantity of that time, or of that line of which it is a part. And yet, as a point may be compared with a point, so one endeavour may be compared with another endeavour, and one may be found to be greater or less than another. For if the vertical points of two angles be compared, they will be equal or unequal in the same proportion which the angles themselves have to one another. Or if a strait line cut many circumferences of concentric circles, the inequality of the points of intersection will be in the same proportion which the perimeters have to one another. And in the same manner, if two motions begin and end both together, their endeavours will be equal or unequal, according to the proportion of their velocities; as we see a bullet of lead descend with greater endeavour than a ball of wool.

Secondly, I define IMPETUS, or quickness of motion, to be the swiftness or velocity of the body moved, but considered in the several points of that time in which it is moved. In which sense impetus is nothing else but the quantity or velocity of endeavour. But considered with the whole time, it is the whole velocity of the body moved taken together throughout all the time, and equal to the product of a line representing the time, multiplied into a line representing the arithmetically mean impetus or quickness. Which arithmetical mean, what it is, is defined in the 29th article of chapter XIII.

And because in equal times the ways that are passed are as the velocities, and the impetus is the velocity they go withal, reckoned in all the several points of the times, it followeth that during any time whatsoever, howsoever the impetus be increased or decreased, the length of the way passed over shall be increased or decreased in the same proportion; and the same line shall represent both the way of the body moved, and the several impetus or degrees of swiftness wherewith the way is passed over.

And if the body moved be not a point, but a strait line moved so as that every point thereof make a several strait line, the plane described by its motion, whether uniform, accelerated, or retarded, shall be greater or less, the time being the same, in the same proportion with that of the impetus reckoned in one motion to the impetus reckoned in the other. For the reason is the same in parallelograms and their sides.

For the same cause also, if the body moved be a plane, the solid described shall be still greater or less in the proportions of the several impetus or quicknesses reckoned through one line, to the several impetus reckoned through another.

This understood, let A B C D, (in figure 1, chap. XVII.) be a parallelogram; in which suppose the side A B to be moved parallelly to the opposite side C D, decreasing all the way till it vanish in the point C, and so describing the figure A B E F C; the point B, as A B decreaseth, will therefore describe the line B E F C; and suppose the time of this motion designed by the line C D; and in the same time C D, suppose the side A C to be moved parallel and uniformly to B D. From the point O taken at adventure in the line C D, draw O R parallel to B D, cutting the line B E F C in E, and the side A B in R. And again, from the point Q taken also at adventure in the line C D, draw Q S parallel to B D, cutting the line B E F C in F, and the side A B in S; and draw E G and F H parallel to C D, cutting A C in G and H. Lastly, suppose the same construction done in all the points possible of the line B E F C. I say, that as the proportions of the swiftness wherewith Q F, O E, D B, and all the rest supposed to be drawn parallel to D B and terminated in the line B E F C, are to the proportions of their several times designed by the several parallels H F, G E, A B, and all the rest supposed to be drawn parallel to the line of time C D and terminated in the line B E F C, the aggregate to the aggregate, so is the area or plane D B E F C to the area or plane A C F E B. For as A B decreasing continually by the line B E F C vanisheth in the time C D into the point C, so in the same time the line D C continually decreasing vanisheth by the same line C F E B into the point B; and the point D describeth in that decreasing motion the line D B equal to the line A C described by the point A in the decreasing motion of A B; and their swiftnesses are therefore equal. Again, because in the time G E the point O describeth the line O E, and in the same time the point S describeth the line S E, the line O E shall be to the line S E, as the swiftness wherewith O E is described to the swiftness wherewith S E is described. In like manner, because in the same time H F the point Q describeth the line Q F, and the point R the line R F, it shall be as the swiftness by which Q F is described to the swiftness by which R F is described, so the line itself Q F to the line itself R F; and so in all the lines that can possibly be drawn parallel to B D in the points where they cut the line B E F C. But all the parallels to B D, as S E, R F, A C, and the rest that can possibly be drawn from the line A B to the line B E F C, make the area of the plane A B E F C; and all the parallels to the same B D, as Q F, O E, D B and the rest drawn to the points where they cut the same line B E F C, make the area of the plane B E F C D. As therefore the aggregate of the swiftnesses wherewith the plane B E F C D is described, is to the aggregate of the swiftnesses wherewith the plane A C F E B is described, so is the plane itself B E F C D to the plane itself A C F E B. But the aggregate of the times represented by the parallels A B, G E, H F and the rest, maketh also the area A C F E B. And therefore, as the aggregate of all the lines Q F, O E, D B and all the rest of the lines parallel to B D and terminated in the line B E F C, is to the aggregate of all the lines H F, G E, A B and all the rest of the lines parallel to C D and terminated in the same line B E F C; that is, as the aggregate of the lines of swiftness to the aggregate of the lines of time, or as the whole swiftness in the parallels to D B to the whole time in the parallels to C D, so is the plane B E F C D to the plane A C F E B. And the proportions of Q F to F H, and of O E to E G, and of D B to B A, and so of all the rest taken

together, are the proportions of the plane D B E F C to the plane A B E F C. But the lines Q F, O E, D B and the rest are the lines that design the swiftness; and the lines H F, G E, A B and the rest are the lines that design the times of the motions; and therefore the proportion of the plane D B E F C to the plane A B E F C is the proportion of all the velocities taken together to all the times taken together. Wherefore, as the proportions of the swiftnesses, &c.; which was to be demonstrated.

The same holds also in the diminution of the circles, whereof the lines of time are the semidiameters, as may easily be conceived by imagining the whole plane A B C D turned round upon the axis B D; for the line B E F C will be everywhere in the superficies so made, and the lines H F, G E, A B, which are here parallelograms, will be there cylinders, the diameters of whose bases are the lines H F, G E, A B, &c. and the altitude a point, that is to say, a quantity less than any quantity that can possibly be named; and the lines Q F, O E, D B, &c. small solids whose lengths and breadths are less than any quantity that can be named.

But this is to be noted, that unless the proportion of the sum of the swiftnesses to the proportion of the sum of the times be determined, the proportion of the figure D B E F C to the figure A B E F C cannot be determined.

Thirdly, I define RESISTANCE to be the endeavour of one moved body either wholly or in part contrary to the endeavour of another moved body, which toucheth the same. I say, wholly contrary, when the endeavour of two bodies proceeds in the same strait line from the opposite extremes, and contrary in part, when two bodies have their endeavour in two lines, which, proceeding from the extreme points of a strait line, meet without the same.

Fourthly, that I may define what it is to PRESS, I say, that of two moved bodies one presses the other, when with its endeavour it makes either all or part of the other body to go out of its place.

Fifthly, a body, which is pressed and not wholly removed, is said to RESTORE itself, when, the pressing body being taken away, the parts which were moved do, by reason of the internal constitution of the pressed body, return every one into its own place. And this we may observe in springs, in blown bladders, and in many other bodies, whose parts yield more or less to the endeavour which the pressing body makes at the first arrival; but afterwards, when the pressing body is removed, they do, by some force within them, restore themselves, and give their whole body the same figure it had before.

Sixthly, I define FORCE to be the impetus or quickness of motion multiplied either into itself, or into the magnitude of the movent, by means whereof the said movent works more or less upon the body that resists it.

3. Having premised thus much, I shall now demonstrate, first, that if a point moved come to touch another point which is at rest, how little soever the impetus or quickness of its motion be, it shall move that other point. For if by that impetus it do not at all move it out of its place, neither shall it move it with double the same impetus. For nothing doubled is still nothing; and for the same reason it shall never move it with that impetus, how many times soever it be multiplied, because nothing, however it be multiplied, will for ever be nothing. Wherefore, when a point is at rest, if it do not yield to the least impetus, it will yield to none; and consequently it will be impossible that that, which is at rest, should ever be moved.

Secondly, that when a point moved, how little soever the impetus thereof be, falls upon a point of any body at rest, how hard soever that body be, it will at the first touch make it yield a little. For if it do not yield to the impetus which is in that point, neither will it yield to the impetus of never so many points, which have all their impetus severally equal to the impetus of that point. For seeing all those points together work equally, if any one of them have no effect, the aggregate of them all together shall have no effect as many times told as there are points in the whole body, that is, still no effect at all; and by consequent there would be some bodies so hard that it would be impossible to break them; that is, a finite hardness, or a finite force, would not yield to that which is infinite; which is absurd.

Coroll. It is therefore manifest, that rest does nothing at all, nor is of any efficacy; and that nothing but motion gives motion to such things as be at rest, and takes it from things moved.

Thirdly, that cessation in the movent does not cause cessation in that which was moved by it. For (by number 11 of art. 1 of this chapter) whatsoever is moved perseveres in the same way and with the same swiftness, as long as it is not hindered by something that is moved against it. Now it is manifest, that cessation is not contrary motion; and therefore it follows that the standing still of the movent does not make it necessary that the thing moved should also stand still.

Coroll. They are therefore deceived, that reckon the taking away of the impediment or resistance for one of the causes of motion.

4. Motion is brought into account for divers respects; first, as in a body undivided, that is, considered as a point; or, as in a divided body. In an undivided body, when we suppose the way, by which the motion is made, to be a line; and in a divided body, when we compute the motion of the several parts of that body, as of parts.

Secondly, from the diversity of the regulation of motion, it is in body, considered as undivided, sometimes uniform and sometimes multiform. Uniform is that by which equal lines are always transmitted in equal times; and multiform, when in one time more, in another time

less space is transmitted. Again, of multiform motions, there are some in which the degrees of acceleration and retardation proceed in the same proportions, which the spaces transmitted have, whether duplicate, or triplicate, or by whatsoever number multiplied; and others in which it is otherwise.

Thirdly, from the number of the movents; that is, one motion is made by one movent only, and another by the concourse of many movents.

Fourthly, from the position of that line in which a body is moved, in respect of some other line; and from hence one motion is called perpendicular, another oblique, another parallel.

Fifthly, from the position of the movent in respect of the moved body; from whence one motion is pulsion or driving, another traction or drawing. Pulsion, when the movent makes the moved body go before it; and traction, when it makes it follow. Again, there are two sorts of pulsion; one, when the motions of the movent and moved body begin both together, which may be called trusion or thrusting and vection; the other, when the movent is first moved, and afterwards the moved body, which motion is called percussion or stroke.

Sixthly, motion is considered sometimes from the effect only which the movent works in the moved body, which is usually called moment. Now moment is the excess of motion which the movent has above the motion or endeavour of the resisting body.

Seventhly, it may be considered from the diversity of the medium; as one motion may be made in vacuity or empty place; another in a fluid; another in a consistent medium, that is, a medium whose parts are by some power so consistent and cohering, that no part of the same will yield to the movent, unless the whole yield also.

Eighthly, when a moved body is considered as having parts, there arises another distinction of motion into simple and compound. Simple, when all the several parts describe several equal lines; compounded, when the lines described are unequal.

5. All endeavour tends towards that part, that is to say, in that way which is determined by the motion of the movent, if the movent be but one; or, if there be many movents, in that way which their concourse determines. For example, if a moved body have direct motion, its first endeavour will be in a strait line; if it have circular motion, its first endeavour will be in the circumference of a circle.

6. And whatsoever the line be, in which a body has its motion from the concourse of two movents, as soon as in any point thereof the force of one of the movents ceases, there

immediately the former endeavour of that body will be changed into an endeavour in the line of the other movent.

Wherefore, when any body is carried on by the concourse of two winds, one of those winds ceasing, the endeavour and motion of that body will be in that line, in which it would have been carried by that wind alone which blows still. And in the describing of a circle, where that which is moved has its motion determined by a movent in a tangent, and by the radius which keeps it in a certain distance from the centre, if the retention of the radius cease, that endeavour, which was in the circumference of the circle, will now be in the tangent, that is, in a strait line. For, seeing endeavour is computed in a less part of the circumference than can be given, that is, in a point, the way by which a body is moved in the circumference is compounded of innumerable strait lines, of which every one is less than can be given; which are therefore called points. Wherefore when any body, which is moved in the circumference of a circle, is freed from the retention of the radius, it will proceed in one of those strait lines, that is, in a tangent.

7. All endeavour, whether strong or weak, is propagated to infinite distance; for it is motion. If therefore the first endeavour of a body be made in space which is empty, it will always proceed with the same velocity; for it cannot be supposed that it can receive any resistance at all from empty space; and therefore, (by art. 7, chap. IX) it will always proceed in the same way and with the same swiftness. And if its endeavour be in space which is filled, yet, seeing endeavour is motion, that which stands next in its way shall be removed, and endeavour further, and again remove that which stands next, and so infinitely. Wherefore the propagation of endeavour, from one part of full space to another, proceeds infinitely. Besides, it reaches in any instant to any distance, how great soever. For in the same instant in which the first part of the full medium removes that which is next it, the second also removes that part which is next to it; and therefore all endeavour, whether it be in empty or in full space, proceeds not only to any distance, how great soever, but also in any time, how little soever, that is, in an instant. Nor makes it any matter, that endeavour, by proceeding, grows weaker and weaker, till at last it can no longer be perceived by sense; for motion may be insensible; and I do not here examine things by sense and experience, but by reason.

8. When two movents are of equal magnitude, the swifter of them works with greater force than the slower, upon a body that resists their motion. Also, if two movents have equal velocity, the greater of them works with more force than the less. For where the magnitude is equal, the movent of greater velocity makes the greater impression upon that body upon which it falls; and where the velocity is equal, the movent of greater magnitude falling upon the same point, or an equal part of another body, loses less of its velocity, because the resisting body works only upon that part of the movent which it touches, and therefore abates the impetus of

that part only; whereas in the mean time the parts, which are not touched, proceed, and retain their whole force, till they also come to be touched; and their force has some effect. Wherefore, for example, in batteries a longer than a shorter piece of timber of the same thickness and velocity, and a thicker than a slenderer piece of the same length and velocity, work a greater effect upon the wall.