OBSERVATIONS TOUCHING THE PRINCIPLES OF NATURAL MOTIONS pdf

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Observations touching the principles of natural motions, and especially touching rarefaction & condensation together with a reply to certain remarks / by the author of Difficiles nugae.

Contemporaries of Aristotle like Aristarchus rejected these principles in favor of heliocentrism , but their ideas were not widely accepted. Indeed, the Physics is largely concerned with an analysis of motion, particularly local motion, and the other concepts that Aristotle believes are requisite to that analysis. White, "Aristotle on the Infinite, Space, and Time" in Blackwell Companion to Aristotle There are clear differences between modern and Aristotelian physics, the main being the use of mathematics , largely absent in Aristotle. The terrestrial spheres of water and earth shown in the form of continents and oceans are at the center of the universe, immediately surrounded by the spheres of air, and then fire, where meteorites and comets were believed to originate. The surrounding celestial spheres from inner to outer are those of the Moon, Mercury, Venus, Sun, Mars, Jupiter, and Saturn, each indicated by a planet symbol. The eighth sphere is the firmament of fixed stars , which include the visible constellations. The precession of the equinoxes caused a gap between the visible and notional divisions of the zodiac, so medieval Christian astronomers created a ninth sphere, the Crystallinum which holds an unchanging version of the zodiac. Above that, Christian theology placed the "Empire of God". What this diagram does not show is how Aristotle explained the complicated curves that the planets make in the sky. To preserve the principle of perfect circular motion, he proposed that each planet was moved by several nested spheres, with the poles of each connected to the next outermost, but with axes of rotation offset from each other. Though Aristotle left the number of spheres open to empirical determination, he proposed adding to the many-sphere models of previous astronomers, resulting in a total of 44 or 55 celestial spheres. Elements and spheres[edit] Main article: Classical element Aristotle divided his universe into "terrestrial spheres" which were "corruptible" and where humans lived, and moving but otherwise unchanging celestial spheres. Aristotle believed that four classical elements make up everything in the terrestrial spheres: Other, lighter objects, he believed, have less earth, relative to the other three elements in their composition. During the Scientific Revolution , the ancient theory of classical elements was found to be incorrect, and was replaced by the empirically tested concept of chemical elements. Because the celestial spheres are incapable of any change except rotation, the terrestrial sphere of fire must account for the heat, starlight and occasional meteorites. The celestial spheres are composed of the special element aether, eternal and unchanging, the sole capability of which is a uniform circular motion at a given rate relative to the diurnal motion of the outermost sphere of fixed stars. The concentric, aetherial, cheek-by-jowl " crystal spheres " that carry the Sun, Moon and stars move eternally with unchanging circular motion. Spheres are embedded within spheres to account for the "wandering stars" i. Mercury, Venus, Mars, Jupiter, and Saturn are the only planets including minor planets which were visible before the invention of the telescope, which is why Neptune and Uranus are not included, nor are any asteroids. Aristotle submits to the calculations of astronomers regarding the total number of spheres and various accounts give a number in the neighborhood of fifty spheres. An unmoved mover is assumed for each sphere, including a "prime mover" for the sphere of fixed stars. Terrestrial change[edit] The four terrestrial elements Unlike the eternal and unchanging celestial aether , each of the four terrestrial elements are capable of changing into either of the two elements they share a property with: These properties are predicated of an actual substance relative to the work it is able to do; that of heating or chilling and of desiccating or moistening. The four elements exist only with regard to this capacity and relative to some potential work. Natural place[edit] The Aristotelian explanation of gravity is that all bodies move toward their natural place. For the elements earth and water, that place is the center of the geocentric universe; [11] the natural place of water is a concentric shell around the earth because earth is heavier; it sinks in water. The natural place of air is likewise a concentric shell surrounding that of water; bubbles rise in water. Finally, the natural place of fire is higher than that of air but below the innermost celestial sphere carrying the

Moon. This definition remained dominant until the beginning of the 17th century, even though it had been questioned and debated by philosophers since antiquity. For example, earth, the heaviest element, and water, fall toward the center of the cosmos; hence the Earth and for the most part its oceans, will have already come to rest there. At the opposite extreme, the lightest elements, air and especially fire, rise up and away from the center. Instead, they are abstractions used to explain the varying natures and behaviors of actual materials in terms of ratios between them. Motion and change are closely related in Aristotelian physics. Motion, according to Aristotle, involved a change from potentiality to actuality. In Physics he states that objects fall at a speed proportional to their weight and inversely proportional to the density of the fluid they are immersed in. Now however it is understood that at any time prior to achieving terminal velocity in a relatively resistance-free medium like air, two such objects are expected to have nearly identical speeds because both are experiencing a force of gravity proportional to their masses and have thus been accelerating at nearly the same rate. This became especially apparent from the eighteenth century when partial vacuum experiments began to be made, but some two hundred years earlier Galileo had already demonstrated that objects of different weights reach the ground in similar times. It is obvious that there are principles and causes which are generable and destructible apart from the actual processes of generation and destruction; for if this is not true, everything will be of necessity: Will this be, or not? Yes, if this happens; otherwise not Metaphysics VI, a Continuum and vacuum[edit] Aristotle argues against the indivisibles of Democritus which differ considerably from the historical and the modern use of the term " atom ". As a place without anything existing at or within it, Aristotle argued against the possibility of a vacuum or void. The void, therefore, could never form. Four causes and Teleology According to Aristotle, there are four ways to explain the aitia or causes of change. He writes that "we do not have knowledge of a thing until we have grasped its why, that is to say, its cause. For a table, that might be wood; for a statue, that might be bronze or marble. A little later on. Aristotle re-iterates this claim, in slightly different terms, in An. He says for example that the ratio 2: Form is not just shape We are asking and this is the connection with essence, particularly in its canonical Aristotelian formulation what it is to be some thing. And it is a feature of musical harmonics first noted and wondered at by the Pythagoreans that intervals of this type do indeed exhibit this ratio in some form in the instruments used to create them the length of pipes, of strings, etc. In some sense, the ratio explains what all the intervals have in common, why they turn out the same. For example, the efficient cause of a baby is a parent of the same species and that of a table is a carpenter, who knows the form of the table. In his Physics II, b29â€”32, Aristotle writes: For Aristotle, any process requires a constantly operative efficient cause as long as it continues. Similarly, in every case of animal generation, there is always some thing responsible for the continuity of that generation, although it may do so by way of some intervening instrument Phys II. Goals have an explanatory function: Less of a commonplace is the view espoused by Aristotle, that finality and purpose are to be found throughout nature, which is for him the realm of those things which contain within themselves principles of movement and rest i. Thus a man may exercise for the sake of his health: But the eyelids are for the sake of the eye to protect it:

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Observations touching the principles of natural motions, and especially touching rarefaction & condensation: together with a reply to certain remarks touching the gravitation of fluids.

The same thing is to be understood of snow, and fine dust or powders, that are condensed by compression or liquefaction, and of all bodies that are by any causes whatever differently condensed. I have no regard in this place to a medium, if any such there is, that freely pervades the interstices between the parts of bodies. It is this quantity that I mean hereafter everywhere under the name of body or mass. And the same is known by the weight of each body, for it is proportional to the weight, as I have found by experiments on pendulums, very accurately made, which shall be shown hereafter. The motion of the whole is the sum of the motions of all the parts; and therefore in a body double in quantity, with equal velocity, the motion is double; with twice the velocity, it is quadruple. This force is always proportional to the body whose force it is and differs nothing from the inactivity of the mass, but in our manner of conceiving it. A body, from the inert nature of matter, is not without difficulty put out of its state of rest or motion. Upon which account, this vis insita may, by a most significant name, be called inertia vis inertiae or force of inactivity. But a body only exerts this force when another force, impressed upon it, endeavours to change its condition; and the exercise of this force may be considered as both resistance and impulse; it is resistance so far as the body for maintaining its present state, opposes the force impressed; it is impulse so far as the body, by not easily giving way to the impressed force of another endeavours to change the state of that other. Resistance is usually ascribed to bodies at rest, and impulse to those in motion; but motion and rest, as commonly conceived, are only relatively distinguished; nor are those bodies always truly at rest, which commonly are taken to be so. This force consists in the action only, and remains no longer in the body when the action is over. For a body maintains every new state it acquires by its inertia only. But impressed forces are of different origins, as from percussion, from pressure, from centripetal force. Of this sort is gravity, by which bodies tend to the centre of the earth; magnetism, by which iron tends to the loadstone; and that force, whatever it is, by which the planets are continually drawn aside from the rectilinear motions, which otherwise they would pursue, and made to revolve in curvilinear orbits. A stone, whirled about in a sling, endeavours to recede from the hand that turns it; and by that endeavour, distends the sling, and that with so much the greater force, as it is revolved with the greater velocity, and as it is let go, flies away. That force which opposes itself to this endeavour, and by which the sling continually draws back the stone towards the hand, and retains it in its orbit, because it is directed to the hand as the centre of the orbit, I call the centripetal force. And the same thing is to be understood of all bodies, revolved in any orbits. They all endeavour to recede from the centres of their orbits; and were it not for the opposition of a contrary force which restrains them to, and detains them in their orbits, which I therefore call centripetal, would fly off in right lines, with an uniform motion. A projectile, if it was not for the force of gravity, would not deviate towards the earth, but would go off from it in a right line, and that with an uniform motion, if the resistance of the air was taken away. It is by its gravity, that it is drawn aside continually from its rectilinear course, and made to deviate towards the earth, more or less, according to the force of its gravity, and the velocity of its motion. The less its gravity is, or the quantity of its matter, or the greater the velocity with which it is projected, the less will it from a rectilinear course, and the farther it will go. If a leaden ball, projected from the top of a mountain by the force of gunpowder, with a given velocity, and in a direction parallel to the horizon, is carried in a curved line to the distance of two miles before it falls to the ground; the same, if the resistance of the air were taken away, with a double or decuple velocity, fly twice or ten times as far. And by increasing the velocity, we may at pleasure increase the distance to which it might be projected, and diminish the curvature of the line which it might describe, till at last it should fall at the distance of 10, 30, or 90 degrees, or even might go quite round the whole earth before it falls; or lastly, so that it might never fall to the earth, but go forwards into the celestial spaces, and proceed in its motion in infinitum. And after the same manner that a projectile, by the force of gravity, may be made to revolve in an orbit, and go round the whole earth, the moon also, either by the force of gravity, if it is endued with gravity, or by any other force, that impels it towards the earth, may be continually drawn aside towards the earth, out of the rectilinear way which by its innate force it would pursue; and would be made to revolve in the orbit which it now describes; nor could the moon without some such force be retained in its orbit. If this force was too small, it would not sufficiently turn the moon out of a rectilinear course; if it was too great, it would turn it too much, and draw down the moon from its orbit towards the earth. It is necessary that the force be of a just quantity, and it belongs to the mathematicians to find the force that may serve exactly to retain a body in a given orbit with a given velocity; and vice versa, to determine the curvilinear way into which a body projected from a given place, with a given velocity, may be made to deviate from its natural rectilinear way, by means of a given force. The quantity of any centripetal force may be considered as of three kinds: Thus the magnetic force is greater in one loadstone and less in another, according to their sizes and strength of intensity. Thus the force of the same loadstone is greater at a less distance, and less at a greater: Thus the weight is greater in a greater body, less in a less body; and, in the same body, it is greater near to the earth, and less at remoter distances. This sort of quantity is the centripetency, or propension of the whole body towards the centre, or, as I may say, its weight; and it is always known by the quantity of an equal and contrary force just sufficient to hinder the descent of the body. These quantities of forces, we may, for the sake of brevity, call by the names of motive, accelerative, and absolute forces; and, for the sake of distinction, consider them with respect to the bodies that tend to the centre, to the places of those bodies, and to the centre of force towards which they tend; that is to say, I refer the motive force to the body as an endeavour and propensity of the whole towards a centre, arising from the propensities of the several parts taken together; the accelerative force to the place of the body, as a certain power diffused from the centre to all places around to move the bodies that are in them; and the absolute force to the centre, as endued with some cause, without which those motive forces would not be propagated through the spaces round about; whether that cause be some central body such as is the magnet in the centre of the magnetic force, or the earth in the centre of the gravitating force , or anything else that does not yet appear. For I here design only to give a mathematical notion of those forces, without considering their physical causes and seats. Wherefore the accelerative force will stand in the same relation to the motive, as celerity does to motion. For the quantity of motion arises from the celerity multiplied by the quantity of matter; and the motive force arises from the accelerative force multiplied by the same quantity of matter. For the sum of the actions of the accelerative force, upon the several particles of the body, is the motive force of the whole. Hence it is, that near the suffice of the earth, where the accelerative gravity, or force productive of gravity, in all bodies is the same, the motive gravity or the weight is as the body; but if we should ascend to higher regions, where the accelerative gravity is less, the weight would be equally diminished, and would always be as the product of the body, by the accelerative gravity. So in those regions, where the accelerative gravity is diminished into one-half, the weight of a body two or three times less, will be four or six times less. I likewise call attractions and impulses, in the same sense, accelerative, and motive; and use the words attraction, impulse, or propensity of any sort towards a centre, promiscuously, and indifferently, one for another; considering those forces not physically, but mathematically: I do not define time, space, place, and motion, as being well known to all. Only I must observe, that the common people conceive those quantities under no other notions but from the relation they bear to sensible objects. And thence arise certain prejudices, for the removing of which it will be convenient to distinguish them into absolute and relative, true and apparent, mathematical and common. Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration: Absolute space, in its own nature, without relation to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute spaces; which our senses determine by its position to bodies; and which is commonly taken for immovable space; such is the dimension of a subterraneous, an aerial, or celestial space, determined by its position in respect of the earth. Absolute and relative space are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air, which relatively and in respect of the earth remains always the same, will at one time be one part of the absolute space into which the air passes; at another time it will be another part of the same, and so, absolutely understood, it will be continually changed. Place is a part of space which a body takes up, and is according to the space, either absolute or relative. I say, a part of space; not the situation, nor the external surface of the body. For the places of equal solids are always equal; but their suffices, by reason of their dissimilar figures, are often unequal. Positions properly have no quantity, nor are they so much the places themselves, as the properties of places. The motion of the whole is the same with the sum of the motions of the parts; that is, the translation of the whole, out of its place, is the same thing with the sum of the translations of the parts out of their places; and therefore the place of the whole is the same as the sum of the places of the parts, and for that reason, it is internal, and in the whole body. Absolute motion is the translation of a body from one absolute place into another; and relative motion, the translation from one relative place into another. Thus in a ship under sail, the relative place of a body is that part of the ship which the body possesses; or that part of the cavity which the body fills, and which therefore moves together with the ship: But real, absolute rest, is the continuance of the body in the same part of that immovable space, in which the ship itself, its cavity, and all that it contains, is moved. Wherefore, if the earth is really at rest, the body, which relatively rests in the ship, will really and absolutely move with the same velocity which the ship has on the earth. But if the earth also moves, the true and absolute motion of the body will arise, partly from the true motion of the earth, in immovable space, partly from the relative motion of the ship on the earth; and if the body moves also relatively in the ship, its true motion will arise, partly from the true motion of the earth, in immovable space, and partly from the relative motions as well of the ship on the earth, as of the body in the ship; and from these relative motions will arise the relative motion of the body on the earth. As if that part of the earth, where the ship is, was truly moved towards the east, with a velocity of 10, parts; while the ship itself, with a fresh gale, and full sails, is carried towards the west, with a velocity expressed by 10 of those parts; but a sailor walks in the ship towards the east, with I part of the said velocity; then the sailor will be moved truly in immovable space towards the east, with a velocity of 10, parts, and relatively on the earth towards the west, with a velocity of g of those parts. Absolute time, in astronomy, is distinguished from relative, by the equation or correction of the apparent time. For the natural days are truly unequal, though they are commonly considered as equal, and used for a measure of time; astronomers correct this inequality that they may measure the celestial motions by a more accurate time. It may be, that there is no such thing as an equable motion, whereby time may be accurately measured. All motions may be accelerated and retarded, but the flowing of absolute time is not liable to any change. The duration or perseverance of the existence of things remains the same, whether the motions are swift or slow, or none at all: The necessity of this equation, for determining the times of a phenomenon, is evinced as well from the experiments of the pendulum clock, as by eclipses of the satellites of Jupiter. As the order of the parts of time is immutable, so also is the order of the parts of space. Suppose those parts to be moved out of their places, and they will be moved if the expression may be allowed out of themselves. For times and spaces are, as it were, the places as well of themselves as of all other things. All things are placed in time as to order of succession; and in space as to order of situation. It is from their essence or nature that they are places; and that the primary places of things should be movable, is absurd. These are therefore the absolute places; and translations out of those places, are the only absolute motions. But because the parts of space cannot be seen, or distinguished from one another by our senses, therefore in their stead we use sensible measures of them. For from the positions and distances of things from any body considered as immovable, we define all places; and then with respect to such places, we estimate all motions, considering bodies as transferred from some of those places into others. And so, instead of absolute places and motions, we use relative ones; and that without any inconvenience in common affairs; but in philosophical disquisitions, we ought to abstract from our senses, and consider things themselves, distinct from what are only sensible measures of them. For it may be that there is no body really at rest, to which the places and motions of others may be referred. But we may distinguish rest and motion, absolute and relative, one from the other by their properties, causes, and effects. It is a property of rest, that bodies really at rest do rest in respect to one another. And therefore as it is possible, that in the remote regions of the fixed stars, or perhaps far beyond them, there may be some body absolutely at rest; but impossible to know, from the position of bodies to one another in our regions, whether any of these do keep the same position to that remote body, it follows that absolute rest cannot be determined from the position of bodies in our regions. It is a property of motion, that the parts, which retain given positions to their wholes, do partake of the motions of those wholes. For all the parts of revolving bodies endeavour to recede from the axis of motion; and the impetus of bodies moving forwards arises from the joint impetus of all the parts. Therefore, if surrounding bodies are moved, those that are relatively at rest within them will partake of their motion. Upon which account, the true and absolute motion of a body cannot be determined by the translation of it from those which only seem to rest; for the external bodies ought not only to appear at rest, but to be really at rest. For otherwise, all included bodies, besides their translation from near the surrounding ones, partake likewise of their true motions; and though that translation were not made, they would not be really at rest, but only seem to be so. For the surrounding bodies stand in the like relation to the surrounded as the exterior part of a whole does to the interior, or as the shell does to the kernel; but if the shell moves, the kernel will also move, as being part of the whole, without any removal from near the shell. A property, near akin to the preceding, is this, that if a place is moved, whatever is placed therein moves along with it; and therefore a body, which is moved from a place in motion, partakes also of the motion of its place. Upon which account, all motions, from places in motion, are no other than parts of entire and absolute motions; and every entire motion is composed of the motion of the body out of its first place, and the motion of this place out of its place; and so on, until we come to some immovable place, as in the before-mentioned example of the sailor. Wherefore, entire and absolute motions can be no otherwise determined than by immovable places; and for that reason I did before refer those absolute motions to immovable places, but relative ones to movable places. Now no other places are immovable but those that, from infinity to infinity, do all retain the same given position one to another; and upon this account must ever remain unmoved; and do thereby constitute immovable space. The causes by which true and relative motions are distinguished, one from the other, are the forces impressed upon bodies to generate motion. True motion is neither generated nor altered, but by some force impressed upon the body moved; but relative motion may be generated or altered without any force impressed upon the body. For it is sufficient only to impress some force on other bodies with which the former is compared, that by their giving way, that relation may be changed, in which the relative rest or motion of this other body did consist. Again, true motion suffers always some change from any force impressed upon the moving body; but relative motion does not necessarily undergo any change by such forces. For if the same forces are likewise impressed on those other bodies, with which the comparison is made, that the relative position may be preserved, then that condition will be preserved in which the relative motion consists. And therefore any relative motion may be changed when the true motion remains unaltered, and the relative may be preserved when the true suffers some change. Thus, true motion by no means consists in such relations. The effects which distinguish absolute from relative motion are, the forces of receding from the axis of circular motion. For there are no such forces in a circular motion purely relative, but in a true and absolute circular motion, they are greater or less, according to the quantity of the motion. If a vessel, hung by a long cord, is so often turned about that the cord is strongly twisted, then filled with water, and held at rest together with the water; thereupon, by the sudden action of another force, it is whirled about the contrary way, and while the cord is untwisting itself, the vessel continues for some time in this motion; the surface of the water will at first be plain, as before the vessel began to move; but after that, the vessel, by gradually communicating its motion to the water, will make it begin sensibly to revolve, and recede by little and little from the middle, and ascend to the sides of the vessel, forming itself into a concave figure as I have experienced , and the swifter the motion becomes, the higher will the water rise, till at last, performing its revolutions in the same times with the vessel, it becomes relatively at rest in it. This ascent of the water shows its endeavour to recede from the axis of its motion; and the true and absolute circular motion of the water, which is here directly contrary to the relative, becomes known, and may be measured by this endeavour. At first, when the relative motion of the water in the vessel was greatest, it produced no endeavour to recede from the axis; the water showed no tendency to the circumference, nor any ascent towards the sides of the vessel, but remained of a plain surface, and therefore its true circular motion had not yet begun.

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Newton did not have any subsidies, grants, funds, Secret Service money. But he had the moon. I cannot throw a ball round the world, but let me picture the moon as if it were a ball which has been flung around the world How long will it take to go round the world? He said, "Let us suppose that it is given by an inverse square law. Now, how long will it take the moon to go around? As Newton said, "They agreed pretty nearly. The gloriously romantic universe of Dante and Milton , that set no bounds to the imagination of man as it played over space and time, had now been swept away. Space was identified with the realm of geometry, time with the continuity of number. The world that people had thought themselves living inâ€”a world rich with colour and sound, redolent with fragrance, filled with gladness, love and beauty, speaking everywhere of purposive harmony and creative idealsâ€”was crowded now into minute corners in the brains of scattered organic beings. The really important world outside was a world hard, cold, colourless, silent, and dead; a world of quantity, a world of mathematically computable motions in mechanical regularity. The world of qualities as immediately received by man became just a curious and quite minor effect of that infinite machine beyond. Edwin Arthur Burtt , The Metaphysical Foundations of Modern Physical Science; a Historical and Critical Essay William Gilbert published a famous book on the magnet in and laid himself open to the gibes of Sir Francis Bacon for being one of those people so taken by their pet subject of research that they could only see the whole universe transposed into terms of it. Having made a spherical magnet called a terrella , and having found that it revolved when placed in a magnetic field, he decided that the whole earth was a magnet, that gravity was a form of magnetic attraction, and that the principles of the magnet accounted for the workings of the Copernican system as a whole. Kepler and Galileo were both influenced by this view, and with Kepler, it became an integral part of his system, a basis for the doctrine of almost universal gravitation. The latter had overthrown the ideas of Aristotle on this subject and Descartes simply "threw himself upon the enemy" that had already been "put to the rout. The motions of bodies in their direct impact was imperfectly understood by Galileo erroneously given by Descartes and first correctly stated by C. Wallis , and C. Florian Cajori , A History of Mathematics , [[1]] In the sixteenth and seventeenth centuries the medieval world view, based on Aristotelian philosophy and Christian theology, changed radically. The notion of an organic, living, and spiritual universe was replaced by that of a world as a machine, and the world machine became the dominant metaphor of the modern era. This radical change was brought about by the new discoveries in physics, astronomy, and mathematics known as the Scientific Revolution and associated with the names of Copernicus , Galileo , Descartes , Bacon , and Newton. Andrew Motte In the century from Copernicus to Newton , the understanding of the universe had been transformed. The Earth had been firmly dislodged from its position of celestial preeminence at the center of the Ptolemaic universe. The nature of the orbits of the planets had been revealed by the masterful observations of Tycho and their ingenious interpretation by Kepler. The failure to detect parallax in stars was accepted as an indication that they must be at vast distances beyond the solar system, such that any parallax would be too small to be measurable with current instruments. Galileo introduced the telescope and produced observations that provided validations of the new ideas. And the genius of Newton brought forth the reflecting telescope, new laws of motion, and an understanding of the fundamentals of optics. It also delivered the theory of universal gravitation , which explained the motions of the planets and identified the primary force in shaping the universe. Real science now had its firm foundation. Clark, Measuring the Cosmos: There follows an array of fascinating accounts of, and quotations from, works by contemporary authors who were compelled to face as facts numerous phenomena the ancients had been quite sure could not possibly be observed because they were bound not to exist. The narrow world of sense-data to which the ancient natural philosophers had confined their all-too-rational speculations was now being blown to pieces. And this was not being done by fellow natural philosophers, but rather at the urging of scarcely literate sailors! Floris Cohen , The Scientific Revolution: A Historiographical Inquiry Galileo had the experience of beholding the heavens as they actually are for perhaps the first time, and wherever he looked he found evidence to support the Copernican system against the Ptolemaic , or at least weaken the authority of the ancients. This shattering experienceâ€”of observing the depths of the universe, of being the first mortal to know what the heavens are actually likeâ€”made so deep a an impression There was for him no path of compromise, no way to have separate secular and theological cosmologies. If the Copernican system was true as he believed, what else could Galileo do but fight with every weapon he had in his arsenal Bernard Cohen , The Birth of a New Physics The seventeenth century witnessed the birth of modern science as we know it today. The science was something new, based on a direct confrontation of nature by experiment and observation. But there was another feature of the new scienceâ€”a dependence on numbers, on real numbers of actual experience. The ancients knew a few numerical laws But prior to the Scientific Revolution, the goal of science or the study of nature was not to seek laws of nature expressed in terms of numbers or number relations. Bernard Cohen , The Triumph of Numbers: How Counting Shaped Modern Life The pioneering practitioners of the new science knew that they were producing a new kind of knowledge and so they declared this newness in the titles of their books and articles. When Ben Jonson presented a masque entitled "News from the New World," his new world was not the newly found continent of North America, but the new world of science, the world revealed by the telescope of Galileo. How Counting Shaped Modern Life Although the authority of the ancient authors as the arbiters of all scientific knowledge had obviously been severely weakened, it did not immediately crumble. Too many professional, medical, ecclesiastical, and legal careers were founded on that authority for it to simply disappear without a struggle. The scientific elite resisted the infusion of new natural knowledge with all its might, but in the long run, its rearguard efforts were futile. The common sense of the working people prevailed and brought about the changes in worldview that have come to be known as the Scientific Revolution. D[edit] Growing skill in the working of metals is Brass, ivory, and closed-grained woods, such as box and pear, were the principal materials of the instrument-makers, with brass becoming increasingly favoured because of its rigidity and permanence. For the shaping of metal the lathe was a valuable tool, and the clock-makers in particular developed it greatly for precision work. The engraving of scales was, of course, a most important part of the work: The earliest products of the instrument-makers were made mainly for astronomical purposes or to apply astronomical methods in navigation: From the seventeenth century, however, a variety of new instruments, or much improved versions of old ones, began to appear. The needs of surveyors led to the elaboration of the hodometer The invention of the telescope and microscope introduced new problems both in the making of lenses and of the instruments in which they were mounted: From the revolution in science was making still further demands on the craft, and air-pumps, thermometers, barometers, electrical machines, and other instruments were called for in constantly increasing quantities. Williams, A Short History of Technology: From the Earliest Times to A. That is still a good prayer for all of us as we begin the twenty-first century. Freeman Dyson , Progress In Religion The great question for our time is, how to make sure that the continuing scientific revolution brings benefits to everybody rather than widening the gap between rich and poor. To lift up poor countries, and poor people in rich countries, from poverty, to give them a chance of a decent life, technology is not enough. Technology must be guided and driven by ethics if it is to do more than provide new toys for the rich. Davis and Sakharov belong to an old tradition in science that goes all the way back to the rebels Benjamin Franklin and Joseph Priestley in the eighteenth century, to Galileo and Giordano Bruno in the seventeenth and sixteenth. If science ceases to be a rebellion against authority, then it does not deserve the talents of our brightest children. We should try to introduce our children to science today as a rebellion against poverty and ugliness and militarism and economic injustice. Freeman Dyson , The Scientist As Rebel E-F[edit] I want now to glance for a moment at the development of the theoretical method, and while doing so especially to observe the relation of pure theory to the totality of the data of experience. Here is the eternal antithesis of the two inseparable constituents of human knowledge, Experience and Reason, within the sphere of physics. We honour ancient Greece as the cradle of western science. This marvellous accomplishment of reason gave to the human spirit the confidence it needed for its future achievements. But yet the time was not ripe for a science that could comprehend reality, was not ripe until a second elementary truth had been realized, which only became the common property of philosophers after Kepler and Galileo. Pure logical thinking can give us no knowledge whatsoever of the world of experience; all knowledge about reality begins with experience and terminates in it. John Freely , Before Galileo: The Birth of Modern Science in Medieval Europe G[edit] I mentally conceive of some moveable [sphere] projected on a horizontal plane, all impediments being put aside. Now it is evident Thus, there emerges a certain motion, compounded And he added that these having been made to gain that degree [of speed] which it pleased God that they should maintain forever, He turned their straight motion into circulation, the only kind [of motion] that is suitable to be conserved equably, turning always without retreat from or approach toward any pre-established goal desired by them. The conception is truly worthy of Plato, and it is to be more esteemed to the extent that its foundations, of which Plato remained silent, but which were discovered by our Author in removing their poetical mask or semblance, show it the guise of a true story. Galileo believed only circular not straight line motion is conserved perpetual , see The New Birth of Physics On the authority of Aristotle Gonzalo, The Intelligible Universe: Yet the metaphor of uniform circular motion as the divine key Studies in the Art of the Renaissance p. The Portuguese had undertaken their voyages towards the southern hemisphere in spite of the science of their day Reijer Hooykaas , "The Portuguese Discoveries and the Rise of Modern Science" in Selected Studies in History of Science Our thesis now is that the Portuguese seafarers and scientists of the 15th and 16th centuries made an important contribution to the rise of modern science by unintentionally undermining the belief in scientific authorities and by strengthening the confidence in an empirical, natural, historical method. Reijer Hooykaas , "The Portuguese Discoveries and the Rise of Modern Science" in Selected Studies in History of Science Perhaps there is no literature in Europe that mirrors so clearly as the Portuguese, the painful conflict in the minds of people who, on the one hand, by their humanistic education, not only knew better but also more uncritically admired, ancient learning than their medieval predecessors, and, who, on the other hand, in the same epoch, were confronted with abundant proofs of the insufficiency and fallibility of that same Antiquity. Reijer Hooykaas , "The Portuguese Discoveries and the Rise of Modern Science" in Selected Studies in History of Science In the early decades of the seventeenth century, the men of the Renaissance could show that they had already put out to good interest the treasure bequeathed to them by the Greeks. In Italy, which had succeeded Greece in the hegemony of the scientific world, the Accademia dei Lyncei and sundry other such associations for the investigation of nature, the models of all subsequent academies and scientific societies, had been founded; while the literary skill and biting wit of Galileo had made the great scientific questions of the day not only intelligible, but attractive to the general public. Metals were worked from their ores by immemorial rule of thumb, and the centre of the iron trade of these islands was still among the oak forests of Sussex. The utmost skill of our mechanicians did not get beyond the production of a coarse watch. I-J[edit] Science She catalogues her elements and records her laws indifferent as to what purpose may be shown forth by them, and constructs her theories quite careless of their bearing on human anxieties and fates. Though the scientist may individually nourish a religion, and be a theist in his irresponsible hours, the days are over when it could be said that for Science herself the heavens declare the glory of God and the firmament showeth his handiwork. Our solar system, with its harmonies, is seen now as but one passing case of a certain sort of moving equilibrium in the heavens, realized by a local accident in an appalling wilderness of worlds where no life can exist. In a span of time which as a cosmic interval will count but as an hour, it will have ceased to be. The Darwinian notion of chance production, and subsequent destruction, speedy or deferred, applies to the largest as well as to the smallest facts. It is impossible, in the present temper of the scientific imagination, to find in the driftings of the cosmic atoms, whether they work on the universal or on the particular scale, anything but a kind of aimless weather, doing and undoing, achieving no proper history, and leaving no result. Nature has no one distinguishable ultimate tendency with which it is possible to feel a sympathy.

OBSERVATIONS TOUCHING THE PRINCIPLES OF NATURAL MOTIONS pdf

4: Aristotelian physics - Wikipedia

Observations touching the principles of natural motions, and especially touching rarefaction & condensation together with a reply to certain remarks touching the gravitation of fluids / by the author of Difficiles nugae.

Life and Works Margaret Lucas was born in in Colchester into a family of aristocrats and staunch royalists. She received little formal education, being tutored at home with her seven siblings, of which she was the youngest. She reports having spent much time in conversation with one of her brothers, John, who considered himself a scholar and who would become a founding member of the Royal Society. They were married in Margaret herself reports having attended several dinners, at which these philosophers were present, though she denies having spoken to them about any, but the most superficial of matters. While her husband remained in exile, she returned in and again in to England. This was during the reign of Commonwealth, during which her husband, were he to have returned, would have had to renounce his royalism and swear fealty to the Commonwealth, as was required by the republican parliament of the time. The parliament did not extend that requirement to women, claiming that women were not capable of such political acts. Thus Margaret was allowed to return to England without swearing fealty to the Commonwealth. During her visit, she arranged for the publication of her first collection of writings, Poems and Fancies and Philosophical Fancies. She reports having delivered the second philosophical treatise a few days too late to have it included with the first in a single publication, which had been her original intention. The publisher was Martin and Allestyre, at the Bell in St. It is truly remarkable that she was able to secure their publication, as few women published philosophy in England in the seventeenth century, much less under their own name and while in exile. The second work of , Philosophical and Physical Opinions, contained five parts and chapters, the first part of which, consisting of 58 chapters, was in fact a reprinting of her earlier Philosophical Fancies. With the Restoration of Charles II to the throne, she returned to England with her husband and continued to write. There may have been some controversy over a woman publishing works on natural philosophy, as she felt the need to include several epistles, both from herself and from her husband and brother-in-law, attesting to the fact that she had written these works herself. Indeed, she returns to defend herself as an author and natural philosopher at a number of different places in her work, often in epistles to the reader. She also defends the propriety of her being so bold as to write in her own name and to think her thoughts worthy of publication. Her several discussions of fame are worth noting in this context. She continued to write on natural philosophy, among other topics, to growing attention. She sent her works to many of the well-known philosophers then operating in England, as well as to the faculties at Cambridge and Oxford. Indeed, after she had published her most famous work of natural philosophy, Observations Upon Experimental Philosophy in , she was invited to attend a meeting of the Royal Society, a privilege rarely granted to women at the time. In all, she may be the most prolific woman writer of early modern Europe and certainly the most prolific woman philosopher. Depending on how one counts, she published over a dozen and perhaps as many as twenty works, at least five of which are works on natural philosophy and many more contain essays with substantive philosophical content. Natural Philosophy Cavendish wrote half a dozen of works on natural philosophy. Indeed, natural philosophy constituted the largest part of her philosophical output and a large part of her writing as a whole. Her philosophical commitments can be described as materialist, vitalist and panpsychist. In what follows, her philosophical discussions will be grouped around several recurring themes and arguments. She explains that her intent is to provide a philosophical system accessible to all, without special training. From her earliest work, Philosophical Fancies, published in , Cavendish argued for materialism in nature. This infinite material substance is composed of an infinite number of material parts, with infinite degrees of motion. Similarly, this motion is all of the same kind, differing from instance to instance only in swiftness or direction. In other words, the natural world is entirely constituted by a single type of stuff, which she calls matter and a single force, which she calls motion. She distinguishes the objects and events in nature from one another by the varying parts of matter, bearing different motions, within that one infinite material substance. Thus we see from the very beginning of her first work that she is a materialist. The exact nature of her materialism develops over time, however. Later, in her Observations from , she provides at least two arguments against atomism. She also argues that composite bodies, each with their own motions, could not account for the unity of the complex body, but would instead be like a swarm of bees or a school of fish. Atomism, she argues, cannot explain organic unity. Instead of atomism, Cavendish proposes that matter is both infinite in extension and always further divisible. Furthermore, for Cavendish, complex beings such as animals are composed of distinctive matter in motion, which she takes to provide them with their unity. Even so, her primary targets are not atomist materialism, as much as both the occultism of the Schools and the mechanism of some of her contemporaries. She also applies her materialism to the human mind. In her early works, she suggests that there is nothing of the human being that is not material. For example, in her first work, she wrote a brief dialogue between body and mind, in which she claims that the only way the mind can attain any sort of life after the death of the body is by fame, that is, by being thought well of by others. Indeed, she elsewhere claims that "all the actions of sense and reason Cavendish seems to qualify her materialism with regard to the human soul later in her career, when she clarifies that her previously strong and consistent commitment to materialism only applies to the natural world. For example, in Observations, she claims that humans have both a material mind and, in addition, a supernatural, immaterial soul. She argues that the way, in which this supernatural soul is related to the material mind and body is itself supernatural. After all, she suggests, place is a property belonging only to bodies and thus, could not belong to an immaterial soul. Therefore, the way, in which the immaterial soul is related to the material person is itself a supernatural, that is, miraculous phenomenon. Unfortunately, she offers little explanation for this immaterial soul and refrains from explaining whether or how the immortal soul might interact at all with anything in nature, instead implying that it does not. To make matters even more confusing, she seems to amend her view in when claiming that only God is immaterial and all other things are material. It may be that she had changed her mind as to whether or not human beings have immaterial, supernatural souls, but the texts themselves do not seem to speak definitively. Throughout her work, however, Cavendish did claim that human beings possess a material soul. She explains the material, natural soul in the same way, in which she explains the mind, through her distinction among the different degrees of motion in matter, as mentioned above. In contrast, there is also a finer and more rare matter, which possesses more motion. This faster and lighter matter infuses dull matter. The natural, material, human soul or mind, she explains, is the finer, rarer matter within our grosser, cruder material bodies. Scholars have noted the similarity this view bears to Stoic doctrine, in that the rarer, more quickly moving matter resembles the Stoic pneuma. Just like the Stoics, she also explicitly states in her later worksâ€”and suggests at times in her earlier worksâ€”that all bodies are completely infused with varying degrees of this active matter. Indeed, it is this matter that accounts for the regularity of natural phenomena across all of nature. She claims, for example, that animals possess motions visible externally, such as jumping or running, whereas vegetables and minerals possess and exhibit motions only detectable internally, such as contracting or dilating. Ultimately, though, these motions and the matter they infuse are of the same fundamental kind, differing only in their degree of motion. In other words, if a bit of matter has a certain degree of motion, according to Cavendish, it cannot lose that degree of motion nor communicate it to another piece of matter. We might say that, for Cavendish, the particular degree of motion that a part of matter bears is essential to that part. Thus, the cruder and grosser matter that bears a lesser degree of matter does so by its nature and cannot lose or gain a degree of motion. Similarly, the more quickly moving, finer parts of matter also bear their greater degree of motion by nature and cannot gain, lose or communicate the motion either. Vitalism and the Variability Argument In addition to her commitment to materialism, Cavendish took pains to reject a position that was often associated with materialism in the seventeenth century, namely that of mechanism. Mechanism can be understood as the view that the natural world, as well as human beings, are made up of uniform material components that interact according to laws of motion and collision. Cavendish argued that mechanism could not be an accurate account of the natural world, because it could not properly explain the world that we observe. She claimed that two notable features of the natural world are variety and orderliness. The world around us is full of a vast array of different sorts of creatures and things, each performing distinctive activities or bearing distinct properties. If we understand the nature of a particular creature or substance, we could predict successfully how it might behave or react to certain stimuli. Cavendish reasoned that if the world was ultimately constituted by uniform matter, passively receiving and transferring motion, according to mathematical laws of collision, then the universe should be either entirely homogenous or entirely chaotic. In other words, if passive, uniform matter communicating motion was really all we had to explain nature, we would not be able to account for its variety and orderlinessâ€”it would lack one or the other. Instead, she claimed, different parts of the infinite material substance bear different degrees of motion by nature. They cannot directly transfer motion from one body to another, since motion is a property of the body that possesses it and not as something that can exist apart from its body. Thus individual bodies cannot give or receive their motions. Hence, the phenomena we observe are not to be explained by reference to uniform pieces of matter exchanging motion via collision. Rather, she explains, what we see is like a dance, in which each body moves according to its own, distinctive, internal principle, such that a pattern might be created by the dancers on the dance floor. She explicitly offers this dance metaphor in her first work of and again in For example, when she explains perception, she claims that the rational spirits flow in and out of the body through the eyes and touch upon the object being perceived, intermixing with the rational spirits found therein. The object, possessing its own distinctive spirits and motions, dances a pattern before the rational spirits, which flow back into the eyes. Note that, throughout this account of perception, motion is never transferred from one body to another. The matter moves itself according to its own nature and initiates changes in its own motion via natural sympathy. Even so, the account is largely the same. Her argument from the Observations could be reconstructed as follows: Bodies move in orderly and infinitely variable ways. Either they are moved by spirits or they are moved by bodies. But not spirits because that is mysterious, so bodies. If bodily motion issues from the body, then, it must issue from either inanimate matter mechanism or animate matter vitalism. But not inanimate matter mechanism , for the mechanistic account of bodily motion, such as animals spirits and inanimate fine particles that transmit force , cannot account for the infinite variety and orderliness of the activity in nature. This is what might be called the argument from the variability and regularity of nature for self-moving matter. Premise 5 implies the argument that if the world was ultimately constituted by uniform matter, passively receiving and transferring motion, according to mathematical laws of collision, then the universe should be either entirely homogenous or entirely chaotic. Another significant feature of her natural philosophy, and one that appears especially clearly when she critiques mechanism, is her refusal to take mathematical physics as an exemplar. Whereas Cartesian and Hobbesian natural philosophy could be described as attempts to understand nature with metaphors and modes of explanation taken from the new, mathematical physics, Cavendish instead draws from other sources, especially her personal experiences with country life and, less directly, the life sciences. When explaining natural phenomena, she often makes reference to the behaviors of animals and humans, as well as her awareness of botanical phenomena. By the s, at least, we know that she had read and engaged the work of other vitalist and anti-mechanists, such as the alchemist Johannes Baptista Van Helmont.

OBSERVATIONS TOUCHING THE PRINCIPLES OF NATURAL MOTIONS pdf

5: åŽšç©•è–„ç™¼: Sir Matthew Hale, Law, Religion and Natural Philosophy

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The first transformation was accomplished by ignoring the implications of a long standing distinction between observing and experimenting. To experiment is to isolate, prepare, and manipulate things in hopes of producing epistemically useful evidence. It had been customary to think of observing as noticing and attending to interesting details of things perceived under more or less natural conditions, or by extension, things perceived during the course of an experiment. To look at a berry on a vine and attend to its color and shape would be to observe it. To extract its juice and apply reagents to test for the presence of copper compounds would be to perform an experiment. Contrivance and manipulation influence epistemically significant features of observable experimental results to such an extent that epistemologists ignore them at their peril. The logical empiricists tended to ignore it. A second transformation, characteristic of the linguistic turn in philosophy, was to shift attention away from things observed in natural or experimental settings and concentrate instead on the logic of observation reports. The shift developed from the assumption that a scientific theory is a system of sentences or sentence like structures propositions, statements, claims, and so on to be tested by comparison to observational evidence. Secondly it was assumed that the comparisons must be understood in terms of inferential relations. If inferential relations hold only between sentence like structures, it follows that theories must be tested, not against observations or things observed, but against sentences, propositions, etc. Schlick Friends of this line of thought theorized about the syntax, semantics, and pragmatics of observation sentences, and inferential connections between observation and theoretical sentences. In doing so they hoped to articulate and explain the authoritativeness widely conceded to the best natural, social and behavioral scientific theories. Some pronouncements from astrologers, medical quacks, and other pseudo scientists gain wide acceptance, as do those of religious leaders who rest their cases on faith or personal revelation, and rulers and governmental officials who use their political power to secure assent. But such claims do not enjoy the kind of credibility that scientific theories can attain. The logical empiricists tried to account for this by appeal to the objectivity and accessibility of observation reports, and the logic of theory testing. Part of what they meant by calling observational evidence objective was that cultural and ethnic factors have no bearing on what can validly be inferred about the merits of a theory from observation reports. In response to this rationale for ethnic and cultural purging of the German educational system the logical empiricists argued that because of its objectivity, observational evidence, rather than ethnic and cultual factors should be used to evaluate scientific theories. Less dramatically, the efforts working scientists put into producing objective evidence attest to the importance they attach to objectivity. Furthermore it is possible, in principle at least, to make observation reports and the reasoning used to draw conclusions from them available for public scrutiny. If observational evidence is objective in this sense , it can provide people with what they need to decide for themselves which theories to accept without having to rely unquestioningly on authorities. Francis Bacon argued long ago that the best way to discover things about nature is to use experiences his term for observations as well as experimental results to develop and improve scientific theories Bacon 49ff. The role of observational evidence in scientific discovery was an important topic for Whewell and Mill among others in the 19th century. Recently, Judaea Pearl, Clark Glymour, and their students and associates addressed it rigorously in the course of developing techniques for inferring claims about causal structures from statistical features of the data they give rise to Pearl, ; Spirtes, Glymour, and Scheines But such work is exceptional. Popper , 31 Drawing a sharp distinction between discovery and justification, the standard philosophical literature devotes most of its attention to the latter. Although theory testing dominates much of the standard philosophical literature on observation, much of what this entry says about the role of observation in theory testing applies also to its role in inventing, and modifying theories, and applying them to tasks in engineering, medicine, and other practical enterprises. Theories are customarily represented as collections of sentences, propositions, statements or beliefs, etc. Observations are used in testing generalizations of both kinds. Suppe , So conceived, a theory can be adequately represented by more than one linguistic formulation because it is not a system of sentences or propositions. Instead, it is a non-linguistic structure which can function as a semantic model of its sentential or propositional representations. Suppe , â€" This entry treats theories as collections of sentences or sentential structures with or without deductive closure. But the questions it takes up arise in pretty much the same way when theories are represented in accordance with this semantic account. What do observation reports describe? One answer to this question assumes that observation is a perceptual process so that to observe is to look at, listen to, touch, taste, or smell something, attending to details of the resulting perceptual experience. In either case, observation sentences describe perceptions or things perceived. Observers use magnifying glasses, microscopes, or telescopes to see things that are too small or far away to be seen, or seen clearly enough, without them. Similarly, amplification devices are used to hear faint sounds. But if to observe something is to perceive it, not every use of instruments to augment the senses qualifies as observational. Philosophers agree that you can observe the moons of Jupiter with a telescope, or a heart beat with a stethoscope. But minimalist empiricists like Bas Van Fraassen , 16â€"17 deny that one can observe things that can be visualized only by using electron and perhaps even light microscopes. Their intuitions come from the plausible assumption that one can observe only what one can see by looking, hear by listening, feel by touching, and so on. Investigators can neither look at direct their gazes toward and attend to nor visually experience charged particles moving through a bubble chamber. Instead they can look at and see tracks in the chamber, or in bubble chamber photographs. The identification of observation and perceptual experience persisted well into the 20th centuryâ€"so much so that Carl Hempel could characterize the scientific enterprise as an attempt to predict and explain the deliverances of the senses Hempel , This was to be accomplished by using laws or lawlike generalizations along with descriptions of initial conditions, correspondence rules, and auxiliary hypotheses to derive observation sentences describing the sensory deliverances of interest. Theory testing was treated as a matter of comparing observation sentences describing observations made in natural or laboratory settings to observation sentences that should be true according to the theory to be tested. This makes it imperative to ask what observation sentences report. Even though scientists often record their evidence non-sententially, e. Hempel , This view is motivated by the assumption that the epistemic value of an observation report depends upon its truth or accuracy, and that with regard to perception, the only thing observers can know with certainty to be true or accurate is how things appear to them. For the phenomenalist it follows that reports of subjective experience can provide better reasons to believe claims they support than reports of other kinds of evidence. Worse yet, if experiences are directly available only to those who have them, there is room to doubt whether different people can understand the same observation sentence in the same way. How could you decide whether her visual experience was the same as the one you would use her words to report? Observers do sometmes have trouble making fine pointer position and color discriminations but such things are more susceptible to precise, intersubjectively understandable descriptions than subjective experiences. How much precision and what degree of intersubjective agreement are required in any given case depends on what is being tested and how the observation sentence is used to evaluate it. And similarly for non-sentential records; a drawing of what the observer takes to be the position of a pointer can be more reliable and easier to assess than a drawing that purports to capture her subjective visual experience of the pointer. The fact that science is seldom a solitary pursuit suggests that one might be able to use pragmatic considerations to finesse questions about what observation reports express. Scientific claimsâ€"especially those with practical and policy applicationsâ€"are typically used for purposes that are best served by public evaluation. Furthermore the development and application of a scientific theory typically requires collaboration and in many cases is promoted by competition. This, together with the fact that investigators must agree to accept putative evidence before they use it to test a theoretical claim, imposes a pragmatic condition on observation reports: Feyerabend took this requirement seriously enough to characterize observation sentences pragmatically in terms of widespread decidability. In order to be an observation sentence, he said, a sentence must be contingently true or false, and such that competent speakers of the relevant language can quickly and unanimously decide whether to accept or reject it on the basis what happens when they look, listen, etc. If epistemic trustworthiness requires certainty, this requirement favors the phenomenalists. Philosophers need to address the question of how these two requirements can be mutually satisfied. Is observation an exclusively perceptual process? Many of the things scientists investigate do not interact with human perceptual systems as required to produce perceptual experiences of them. The methods investigators use to study such things argue against the ideaâ€”however plausible it may once have seemedâ€”that scientists do or should rely exclusively on their perceptual systems to obtain the evidence they need. Thus Feyerabend proposed as a thought experiment that if measuring equipment was rigged up to register the magnitude of a quantity of interest, a theory could be tested just as well against its outputs as against records of human perceptions Feyerabend , â€" Feyerabend could have made his point with historical examples instead of thought experiments. A century earlier Helmholtz estimated the speed of excitatory impulses traveling through a motor nerve. To initiate impulses whose speed could be estimated, he implanted an electrode into one end of a nerve fiber and ran a current into it from a coil. The other end was attached to a bit of muscle whose contraction signaled the arrival of the impulse. To find out how long it took the impulse to reach the muscle he had to know when the stimulating current reached the nerve. This meant arranging things so that current from the coil could deflect a galvanometer needle. Assuming that the magnitude of the deflection is proportional to the duration of current passing from the coil, Helmholtz could use the deflection to estimate the duration he could not see ibid. Such devices enable the observer to scrutinize visible objects. The miniscule duration of the current flow is not a visible object. Helmholtz studied it by looking at and seeing something else. Hooke , 16â€"17 argued for and designed instruments to execute the same kind of strategy in the 17th century. Consider functional magnetic resonance images fMRI of the brain decorated with colors to indicate magnitudes of electrical activity in different regions during the performance of a cognitive task. The magnetic force coordinates the precessions of protons in hemoglobin and other bodily stuffs to make them emit radio signals strong enough for the equipment to respond to. When the magnetic force is relaxed, the signals from protons in highly oxygenated hemoglobin deteriorate at a detectably different rate than signals from blood that carries less oxygen. Elaborate algorithms are applied to radio signal records to estimate blood oxygen levels at the places from which the signals are calculated to have originated. There is good reason to believe that blood flowing just downstream from spiking neurons carries appreciably more oxygen than blood in the vicinity of resting neurons. Assumptions about the relevant spatial and temporal relations are used to estimate levels of electrical activity in small regions of the brain corresponding to pixels in the finished image. The results of all of these computations are used to assign the appropriate colors to pixels in a computer generated image of the brain. The role of the senses in fMRI data production is limited to such things as monitoring the equipment and keeping an eye on the subject. Their epistemic role is limited to discriminating the colors in the finished image, reading tables of numbers the computer used to assign them, and so on. If anything is observed, the radio signals that interact directly with the equipment would seem to be better candidates than blood oxygen levels or neuronal activity. The production of fMRI images requires extensive statistical manipulation based on theories about the radio signals, and a variety of factors having to do with their detection along with beliefs about relations between blood oxygen levels and neuronal activity, sources of systematic error, and so on. In view of all of this, functional brain imaging differs, e. And similarly for many other methods scientists use to produce non-perceptual evidence. In their place, working scientists tend to talk about data. Philosophers who adopt this usage are free to think about standard examples of observation as members of a large, diverse, and growing family of data production methods. Instead of trying to decide which methods to classify as observational and which things qualify as observables, philosophers can then concentrate on the epistemic influence of the factors that differentiate members of the family. In particular, they can focus their attention on what questions data produced by a given method can be used to answer, what must be done to use that data fruitfully, and the credibility of the answers they afford. Bogen It is of interest that records of perceptual observation are not always epistemically superior to data from experimental equipment. Indeed it is not unusual for investigators to use non-perceptual evidence to evaluate perceptual data and correct for its errors. For example, Rutherford and Pettersson conducted similar experiments to find out if certain elements disintegrated to emit charged particles under radioactive bombardment.

6: Newton's Mathematical Principles of Natural Philosophy

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God said, "Let Newton be! As is often the case in science, however, this explanation immediately lead to additional, more basic questions: Why are the orbits elliptical? Why is the Sun at one focus? Why do the planets move faster at perihelion? These questions were addressed by the English scientist and mathematician Isaac Newton - Newton had a fundamental belief that guided his work: In other words, by understanding why objects move the way they do here on Earth, we should also be able to understand the motions of the planets. Newton therefore studied motion in detail, making many new observations. Newton formulated his new observations as well as those of others in three fundamental Laws of Motion which govern all objects, including the planets. When Newton talked about the motion of an object, he was referring to two general characteristics: Together, these are also known as the linear momentum of the object. An object at rest is simply a special case of motion, with zero speed. The motion of an object will remain unchanged unless a force acts on it. In other words, an object will never change its speed or direction unless something comes along and forces it to do so. This is an example of the principle of Conservation of Linear Momentum. However, the First Law was in direct contradiction to the still-dominant teachings of Aristotle, who thought that all objects in motion will eventually come to rest of their own accord. Newton therefore felt it necessary to make a forceful contradiction. Like motion, force has both a value or "strength", and a direction in which it acts. We commonly think of "acceleration" as a speeding up, but in physics it can also include a slowing down "deceleration" as well as a change in direction. In the metric system, the unit of force is called a Newton, whose abbreviation is "N". In the English system, the unit of force is the pound; it is equal to 4. For example, the larger the force is, the larger the acceleration: Second, the Second Law actually includes the First Law within it. Third, for an equal force, a larger mass must have a smaller acceleration, and vice versa: In other words, a larger mass has greater inertia than a smaller mass. The force on an object is always due to another object, and that other object always feels an equal and opposite force. You are familiar with this law from striking an object with your hand: Gravity holds the Sun and planets together in the solar system, and holds stars together in galaxies. You should be personally familiar with the effects of gravity, which holds you to the Earth and in general makes things "fall down". We will discuss the gravitational force in more detail below. Electromagnetism holds atoms together, makes compasses point north, and is the source of starlight and auroras. You should also be personally familiar with electromagnetism, via common devices such as electric appliances, refrigerator magnets, and the innumerable sources of light surrounding you. We will discuss electromagnetism in more detail later on, in the contexts of electricity , magnetism , and light. The strong nuclear force holds atomic nuclei together, and we will talk about it more in that context. The strong nuclear force is involved in the generation of energy in stars and in their explosive destruction known as type I supernovae. Although this is probably not a force with which you have personal familiarity, it has been harnessed in nuclear power plants to provide electricity, and in various medical applications. The weak nuclear force can change one type of subatomic particle into another in some situations such as radioactive decay , the generation of energy in stars , and in type II supernovae. The weak nuclear force shows up in the same sorts of technologies described above for the strong nuclear force. We will consider the weak nuclear force in more detail in our discussion of radioactive decay. You are also personally familiar with contact forces, the result of electromagnetic forces acting within solids, liquids, and gasses: The normal force prevents planets and stars from collapsing down to zero size under the force of their own gravity though not always! Cohesion prevents moons and planets from being torn apart by tidal forces though not always! Friction between molecules in a gas falling into a black hole will cause it to heat up and emit radiation. Here, G is a constant, M and m are two masses, and r is the separation between them. Therefore, large masses are required to provide an appreciable force, e. In the process Newton also had to invent the mathematics of calculus! Because the Sun is so much more massive than any of the planets, it has a very small gravitational acceleration, and can be taken as essentially motionless. Objects with circular and elliptical orbits move around the Sun with a definite period, always between their perihelion and aphelion distances, and sweeping out equal areas in equal times. As before, a is measured in AU and P is measured in years. But now the mass M appears, and here is measured as multiples of the mass of the Sun. This result provides a powerful tool for determining the mass of the Sun, as well any planet being orbited by a moon, simply by measuring a and P. Newton could immediately calculate the mass of which planets? Circular and elliptical orbits describe objects which are bound to the Sun. Newton also demonstrated that there could be parabolic and hyperbolic orbits! A parabolic orbit describes an object which is marginally bound. An object in a hyperbolic orbit travels in a straight line until it nears the Sun and has its path deflected by gravity. Such an object is not part of our solar system, but is instead simply passing through, and can be infinitely far from the Sun while still moving at high speed. An object with a hyperbolic orbit is therefore said to be unbound. We all have an intuitive idea of what this means. For example, when something moves very fast we say it "has a lot of energy". We might also recognize that heat, electricity, and light have energy as well. Energy of motion is called kinetic energy. For example, a car travelling at 90 mph has much more energy than a baseball travelling at 90 mph. In the metric system, the unit of energy is the Joule, whose abbreviation is "J". A unit of energy you may be more familiar with is the food calorie, which is equal to J. You are probably more familiar with power, the rate of energy production or use energy per unit time. The metric unit of power is called a Watt, whose abbreviation is "W". If the object is thrown upward, it will have some initial speed but it will immediately begin to slow down and eventually stop, i. The object will then begin to move back downward, rapidly gaining speed as it is accelerated by gravity, and its kinetic energy increases. We intuitively think of an object with greater height as having, "potentially", more energy, because it will be moving faster when it reaches us. If kinetic energy increases, potential energy must decrease by an equal amount, and vice versa, so that E remains a constant value. We can think of this as one kind of energy being converted into another. The potential energy described above is basically another way to characterize the force of gravity. We can define potential energy for all of the fundamental forces, in such a way that energy is, in general, conserved. As a result, energy conservation and conversion from one form to another are extremely important concepts in physics and astronomy, and we will see many applications, such as planet formation and solar thermal equilibrium. Note that the potential energy is always a negative number, and reaches its maximum value of zero when the two masses are an infinite distance r apart. For planetary orbits, we can take the Sun to be fixed at position zero, and a planet to be a distance r away from it. With each orbit around the Sun, the planet will move between its perihelion and its aphelion , and as it does so its energy will convert back and forth between potential and kinetic. At perihelion, kinetic energy is a maximum and potential energy is a minimum; at aphelion, kinetic energy is a minimum and potential energy is a maximum. This is true for all bound objects those in circular or elliptical orbits. You can further explore planetary motion and energy using this Java applet. We can get an intuitive feel for potential energy by "revolving" the potential energy curve into three dimensions. Potential energy then forms a two-dimensional surface called a gravity well, with the Sun at the bottom and planetary orbits forming curves along it. Imagine walking around the edge of a valley: This means that the object must be marginally bound or unbound, and so have at least zero total energy: Newton knew about escape velocity, and used the idea in his Mathematical Principles to illustrate how gravity works; you can explore this yourself with this Java applet from the University of Virginia. Much like linear momentum , objects have a tendency to keep rotating in the absence of external forces. This "rotational inertia " is characterized by angular momentum, which can be loosely defined as: The "direction" of angular momentum is also important; two rotating objects with the same mass and speed, but different axes of rotation, have different angular momenta. For many forces, including gravity, the angular momentum of a rotating or revolving object will be conserved, i. Conservation of angular momentum is why the Earth always rotates once every 24 hours, and why its rotation axis remains relatively fixed in space as it orbits the Sun. Halley noticed that the comets of , , and had similar characteristics, and were separated by the same period of 76 years. In , Halley visited Newton in Cambridge, and told him about his suspicion that they were the same comet moving in a periodic orbit around the Sun. In , an amateur astronomer named William Herschel , who had built one of the most powerful telescopes of the time, noticed "a curious either nebulous star or perhaps a comet". Subsequent observations revealed that this object moved relative to the stars, although more slowly than a comet. Herschel soon realized that he had discovered a seventh planet, Uranus and the first in recorded history! At its brightest, Uranus is barely visible to the naked eye in a dark sky. Because of its slow motion, however, Uranus was always mistaken for a star by earlier observers. Neptune moves even more slowly than Uranus, and it has an orbital period of years.

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7: Scientific Revolution - Wikiquote

Observations touching the principles of natural motions; and especially touching rarefaction and condensation: Together with a reply to certain remarks touching the gravitation of fluids".

Themes, Arguments, and Ideas The Materialist View of Human Nature Hobbes believed that all phenomena in the universe, without exception, can be explained in terms of the motions and interactions of material bodies. He did not believe in the soul, or in the mind as separate from the body, or in any of the other incorporeal and metaphysical entities in which other writers have believed. Instead, he saw human beings as essentially machines, with even their thoughts and emotions operating according to physical laws and chains of cause and effect, action and reaction. As machines, human beings pursue their own self-interest relentlessly, mechanically avoiding pain and pursuing pleasure. Hobbes saw the commonwealth, or society, as a similar machine, larger than the human body and artificial but nevertheless operating according to the laws governing motion and collision. In putting together this materialist view of the world, Hobbes was influenced by his contemporaries Galileo and Kepler, who had discovered laws governing planetary motion, thereby discrediting much of the Aristotelian worldview. Hobbes hoped to arrive at his laws of motion deductively, in the manner of geometrical proofs. It is important to note that Hobbes was not in any position to prove that all of human experience can be explained in terms of physical and mechanical processes. That task would have required scientific knowledge far beyond that possessed by the seventeenth century. Even today, science is nowhere near being able to fully explain human experience in physical terms, even though most people tend to believe that science will one day be able to do just that. The Inadequacy of Observation as a Foundation of Knowledge Hobbes rejected what we now know as the scientific method because he believed that the observation of nature itself is too subjective a basis on which to ground philosophy and science. Hobbes contested the scientific systems of the natural philosophers Francis Bacon and Robert Boyle. These major figures in the Scientific Revolution in England base their natural philosophy on a process of inductive reasoning, making inferences and conclusions based on the observation of nature and the manipulation of nature through experimentation. For Hobbes, the chief aim of philosophy is to create a totalizing system of truth that bases all its claims on a set of foundational principles and is universally demonstrable through the logic of language. He rejects the observation of nature as a means of ascertaining truth because individual humans are capable of seeing the world in vastly different ways. He rejects inductive reasoning, arguing that the results of contrived experiments carried out by a few scientists can never be universally demonstrable outside of the laboratory. Accordingly, Hobbes holds that geometry is the branch of knowledge that best approximates the reasoning that should form the basis of a true philosophy. He calls for a philosophy based on universally agreed-upon first principles that form the foundation for subsequent assertions. Fear as the Determining Factor in Human Life Hobbes maintained that the constant back-and-forth mediation between the emotion of fear and the emotion of hope is the defining principle of all human actions. Either fear or hope is present at all times in all people. Thus, the state of nature is a state of constant war, wherein humans live in perpetual fear of one another. This fear, in combination with their faculties of reason, impels men to follow the fundamental law of nature and seek peace among each other. Peace is attained only by coming together to forge a social contract, whereby men consent to being ruled in a commonwealth governed by one supreme authority. Fear creates the chaos endemic to the state of nature, and fear upholds the peaceful order of the civil commonwealth. Thus, in speaking of human nature, he defines good simply as that which people desire and evil as that which they avoid, at least in the state of nature. Hobbes uses these definitions as bases for explaining a variety of emotions and behaviors. For example, hope is the prospect of attaining some apparent good, whereas fear is the recognition that some apparent good may not be attainable. Hobbes admits, however, that this definition is only tenable as long as we consider men outside of the constraints of law and society. Absolute Monarchy as the Best Form of Government Hobbes promoted that monarchy is the best form of government and the only one that can guarantee peace. In some of his early works, he only says that there must be a supreme sovereign power of some kind in society, without stating definitively which sort of sovereign power is best. In Leviathan,however, Hobbes unequivocally argues that absolutist monarchy is the only right form of government. In general, Hobbes seeks to define the rational bases upon which a civil society could be constructed that would not be subject to destruction from within. Accordingly, he delineates how best to minimize discord, disagreement, and factionalism within societyâ€"whether between state and church, between rival governments, or between different contending philosophies. Hobbes believes that any such conflict leads to civil war. He holds that any form of ordered government is preferable to civil war. Thus he advocates that all members of society submit to one absolute, central authority for the sake of maintaining the common peace. The sovereign is empowered to run the government, to determine all laws, to be in charge of the church, to determine first principles, and to adjudicate in philosophical disputes. For Hobbes, this is the only sure means of maintaining a civil, peaceful polity and preventing the dissolution of society into civil war.

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8: Galileo Galilei (Stanford Encyclopedia of Philosophy)

An Essay touching the Gravitation or Non-Gravitation of fluid Bodies, and the Reasons thereof. 8vo. 6. Observations touching the Principles of Natural Motions, and especially touching Rarefaction and Condensation ; together with a Reply to.

See Article History Principles of physical science, the procedures and concepts employed by those who study the inorganic world. Physical science , like all the natural sciences, is concerned with describing and relating to one another those experiences of the surrounding world that are shared by different observers and whose description can be agreed upon. One of its principal fields, physics , deals with the most general properties of matter, such as the behaviour of bodies under the influence of forces, and with the origins of those forces. In the discussion of this question, the mass and shape of a body are the only properties that play a significant role, its composition often being irrelevant. Physics, however, does not focus solely on the gross mechanical behaviour of bodies but shares with chemistry the goal of understanding how the arrangement of individual atoms into molecules and larger assemblies confers particular properties. Moreover, the atom itself may be analyzed into its more basic constituents and their interactions. The present opinion, rather generally held by physicists, is that these fundamental particles and forces, treated quantitatively by the methods of quantum mechanics , can reveal in detail the behaviour of all material objects. This is not to say that everything can be deduced mathematically from a small number of fundamental principles, since the complexity of real things defeats the power of mathematics or of the largest computers. Nevertheless, whenever it has been found possible to calculate the relationship between an observed property of a body and its deeper structure, no evidence has ever emerged to suggest that the more complex objects, even living organisms, require that special new principles be invoked , at least so long as only matter, and not mind, is in question. The physical scientist thus has two very different roles to play: This modern view of a unified science , embracing fundamental particles, everyday phenomena, and the vastness of the Cosmos , is a synthesis of originally independent disciplines , many of which grew out of useful arts. The extraction and refining of metals, the occult manipulations of alchemists, and the astrological interests of priests and politicians all played a part in initiating systematic studies that expanded in scope until their mutual relationships became clear, giving rise to what is customarily recognized as modern physical science. For a survey of the major fields of physical science and their development, see the articles physical science and Earth sciences. The development of quantitative science Modern physical science is characteristically concerned with numbers â€”the measurement of quantities and the discovery of the exact relationship between different measurements. Yet this activity would be no more than the compiling of a catalog of facts unless an underlying recognition of uniformities and correlations enabled the investigator to choose what to measure out of an infinite range of choices available. Proverbs purporting to predict weather are relics of science prehistory and constitute evidence of a general belief that the weather is, to a certain degree, subject to rules of behaviour. Modern scientific weather forecasting attempts to refine these rules and relate them to more fundamental physical laws so that measurements of temperature , pressure, and wind velocity at a large number of stations can be assembled into a detailed model of the atmosphere whose subsequent evolution can be predictedâ€"not by any means perfectly but almost always more reliably than was previously possible. Between proverbial weather lore and scientific meteorology lies a wealth of observations that have been classified and roughly systematized into the natural history of the subjectâ€"for example, prevailing winds at certain seasons, more or less predictable warm spells such as Indian summer , and correlation between Himalayan snowfall and intensity of monsoon. In every branch of science this preliminary search for regularities is an almost essential background to serious quantitative work, and in what follows it will be taken for granted as having been carried out. Compared with the caprices of weather, the movements of the stars and planets exhibit almost perfect regularity, and so the study of the heavens became quantitative at a very early date, as evidenced by the

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oldest records from China and Babylon. Objective recording and analysis of these motions, when stripped of the astrological interpretations that may have motivated them, represent the beginning of scientific astronomy. The heliocentric planetary model c. A distinction may be drawn between an observational science like astronomy, where the phenomena studied lie entirely outside the control of the observer, and an experimental science such as mechanics or optics, where the investigator sets up the arrangement to his own taste. Before proceeding as far as this, however, attention must be paid to the mechanical studies of Galileo Galilei , the most important of the founding fathers of modern physics, insofar as the central procedure of his work involved the application of mathematical deduction to the results of measurement. Page 1 of 7.

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9: Sir Matthew Hale | Open Library

Observations touching the principles of natural motions by Matthew Hale, Sir 1 edition - first published in A letter of advice to his grand-children, Matthew, Gabriel, Anne, Mary, and Francis Hale.

Brief Biography Galileo was born on February 15, in Pisa. By the time he died on January 8, but see problems with the date, Machamer , pp. Galileo and his family moved to Florence in He started to study for the priesthood, but left and enrolled for a medical degree at the University of Pisa. He never completed this degree, but instead studied mathematics notably with Ostilio Ricci, the mathematician of the Tuscan court. Later he visited the mathematician Christopher Clavius in Rome and started a correspondence with Guildobaldo del Monte. He applied and was turned down for a position in Bologna, but a few years later in , with the help of Clavius and del Monte, he was appointed to the chair of mathematics in Pisa. In he was appointed, at a much higher salary, to the position of mathematician at the University of Padua. While in Padua he met Marina Gamba, and in their daughter Virginia was born. In they had another daughter Livia, and in a son Vincenzo. It was during his Paduan period that Galileo worked out much of his mechanics and began his work with the telescope. Galileo had lobbied hard for this position at the Medici court and even named the moons of Jupiter, which he discovered, after the Medici. There were many reasons hewanted move, but he says he did not like the wine in the Venice area and he had to teach too many students. In he became a member of what is perhaps the first scientific society, the Academia dei Lincei. In this latter work he first expressed his position in favor of Copernicus. In both his daughters entered the Franciscan convent of Saint Mathew, near Florence. Marina Gamba, their mother, had been left behind in Padua when Galileo moved to Florence. In â€”4 Galileo entered into discussions of Copernicanism through his student Benedetto Castelli, and wrote a Letter to Castelli. In he transformed this into the Letter to the Grand Duchess Christina. Galileo then was called to an audience with Cardinal Robert Bellarmine and advised not to teach or defend Copernican theory. In Galileo published The Assayer dealing with the comets and arguing they were sublunary phenomena. In this book, he made some of his most famous methodological pronouncements including the claim the book of nature is written in the language of mathematics. It was published with an imprimatur from Florence and not Rome in Shortly afterwards the Inquisition banned its sale, and Galileo was ordered to Rome for trial. In he was condemned. There is more about these events and their implications in the final section of this article, Galileo and the Church. In , while Galileo was under house arrest, his daughter, Maria Celeste died cf. This book was smuggled out of Italy and published in Holland. Galileo died early in Due to his conviction, he was buried obscurely until Galileo discovered many things: This is no small set of accomplishments for one 17th-century Italian, who was the son of a court musician and who left the University of Pisa without a degree. One of the good things about dealing with such momentous times and people is that they are full of interpretive fecundity. Galileo and his work provide one such occasion. Since his death in , Galileo has been the subject of manifold interpretations and much controversy. Philosophically, Galileo has been used to exemplify many different themes, usually as a side bar to what the particular writer wished to make the hallmark of the scientific revolution or the nature of good science. Whatever was good about the new science or science in general, it was Galileo who started it. More philosophically, many would ask how his mathematics relates to his natural philosophy? How did he produce a telescope and use his telescopic observations to provide evidence in favor of Copernicanism Reeves ? Or did he have no method and just fly like an eagle in the way that geniuses do Feyerabend ? Behind each of these claims there was some attempt to place Galileo in an intellectual context that brought out the background to his achievements. Yet most everyone in this tradition seemed to think the three areasâ€”physics, astronomy and methodologyâ€"were somewhat distinct and represented different Galilean endeavors. More recent historical research has followed contemporary intellectual fashion and shifted foci bringing new dimensions to our understanding of Galileo by studying his rhetoric Moss , Feldhay , Spranzi , the power structures of his social milieu Biagioli , , his personal quest for acknowledgment Shea and Artigas and more generally has emphasized the larger social and cultural history, specifically the court and papal culture, in which Galileo functioned Redondi , Biagioli , , Heilbron In an intellectualist recidivist mode, this entry will outline his investigations in physics and astronomy and exhibit, in a new way, how these all cohered in a unified inquiry. In setting this path out I shall show why, at the end of his life, Galileo felt compelled in some sense of necessity to write the Discourses Concerning the Two New Sciences, which stands as a true completion of his overall project and is not just a reworking of his earlier research that he reverted to after his trial, when he was blind and under house arrest. Particularly, we shall try to show why both of the two new sciences, especially the first, were so important a topic not much treated except recently by Biener and Raphael In passing, we shall touch on his methodology and his mathematics and here refer you to some of the recent work by Palmieri , At the end we shall have some words about Galileo, the Catholic Church and his trial. Galileo signals this goal clearly when he leaves Padua in to return to Florence and the court of the Medici and asks for the title Philosopher as well as Mathematician. This was not just a status-affirming request, but also a reflection of his large-scale goal. What Galileo accomplished by the end of his life in was a reasonably articulated replacement for the traditional set of analytical concepts connected with the Aristotelian tradition of natural philosophy. Some scholars might wish to describe what Galileo achieved in psychological terms as an introduction of new mental models Palmieri or a new model of intelligibility Machamer , Adams et al. In their place he left only one element, corporeal matter, and a different way of describing the properties and motions of matter in terms of the mathematics of the equilibria of proportional relations Palmieri that were typified by the Archimedian simple machinesâ€"the balance, the inclined plane, the lever, and, he includes, the pendulum Machamer , Machamer and Hepburn , Palmieri In doing so Galileo changed the acceptable way of talking about matter and its motion, and so ushered in the mechanical tradition that characterizes so much of modern science, even today. But this would take more explaining Dijksterhuis , Machamer et al. Despite working on problems of the nature of matter from onwards, he could not have written his final work much earlier than , certainly not before The Starry Messenger of , and actually not before the Dialogues on the Two Chief World Systems of Before , he did not have the theory and evidence he needed to support his claim about unified, singular matter. And this he did not do until the Dialogues. Galileo began his critique of Aristotle in the manuscript, De Motu. For Aristotle, sublunary or terrestrial matter is of four kinds [earth, air, water, and fire] and has two forms, heavy and light, which by nature are different principles of natural motion, down and up. Galileo, using an Archimedian model of floating bodies and later the balance, argues that there is only one principle of motion, the heavy gravitas , and that lightness or levitas is to be explained by the heavy bodies moving so as to displace or extrude other bits of matter in such a direction that explains why the other bits rise. So on his view heaviness or gravity is the cause of all natural terrestrial motion. But this left him with a problem as to the nature of the heavy, the nature of gravitas? In De Motu, he argued that the moving arms of a balance could be used as a model for treating all problems of motion. In this model heaviness is the proportionality of weight of one object on one arm of a balance to that of the weight of another body on the other arm of the balance. Galileo realized quickly these characterizations were insufficient, and so began to explore how heaviness was relative to the different specific gravities of bodies having the same volume. He was trying to figure out what is the concept of heaviness that is characteristic of all matter. What he failed to work out, and this was probably the reason why he never published De Motu, was this positive characterization of heaviness. There seemed to be no way to find standard measures of heaviness that would work across different substances. So at this point he did not have useful replacement categories. Still, he has no good way to measure or compare specific gravities of bodies of different kinds and his notebooks during this early 17th-century period reflect his trying again and again to find a way to bring all matter under a single proportional measuring scale. He tries to study acceleration along an inclined plane and to find a way to think of what changes acceleration brings. In this regard and during this period he attempts to examine the properties of percussive effect of bodies of different specific gravities, or how they have differential impacts. Yet the details and categories of how to properly treat weight and movement elude him. Except for the inclined plane, time is not a property of the action of simple machines that one would normally attend to. In discussing a balance, one does not normally think about how fast an arm of the balance descends nor how fast a body on the opposite arm is rising though Galileo in his Postils to Rocco ca. The converse is also true. In the Fifth Day of the Discouses, he presciently explores the concept of the force of percussion. This concept will become, after his death, one of the most fecund ways to think about matter. In â€”9, Galileo worked long at doing experiments on inclined planes and most importantly with pendula. The pendulum again exhibited to Galileo that acceleration and, therefore, time is a crucial variable. Moreover, isochronyâ€”equal times for equal lengths of string, despite different weightsâ€”goes someway towards showing that time is a possible form for describing the equilibrium or ratio that needs to be made explicit in representing motion. It also shows that in at least one case time can displace weight as a crucial variable. Work on the force of percussion and inclined planes also emphasized acceleration and time, and during this time ca. Galileo accepts, probably as early as the draft of Le Mecaniche, that natural motions might be accelerated. But that accelerated motion is properly measured against time is an idea enabled only later, chiefly through his failure to find any satisfactory dependence on place and specific gravity. Galileo must have observed that the speeds of bodies increase as they move downwards and, perhaps, do so naturally, particularly in the cases of the pendulum, the inclined plane, in free fall, and during projectile motion. Also at this time he begins to think about percussive force, the force that a body acquires during its motion that shows upon impact. For many years he thinks that the correct science of these changes should describe how bodies change according to where they are on their paths. Specifically, it seems that height is crucial. The law of free fall, expressed as time squared, was discovered by Galileo through the inclined plane experiments Drake , v. But let us return to the main matter. In Galileo begins his work with the telescope. Many interpreters have taken this to be an interlude irrelevant to his physics. The Starry Messenger, which describes his early telescopic discoveries, was published in Perhaps the most unequivocal case of this is when he analogizes the mountains on the moon to mountains in Bohemia. Further, if there is only one kind of matter there can be only one kind of natural motion, one kind of motion that this matter has by nature. So it has to be that one law of motion will hold for earth, fire and the heavens. This is a far stronger claim than he had made back in

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