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Paper Abstract:
In the present paper, I set out to investigate a crucial episode in the history of the relationship of science and religion, namely the mechanical philosophers' use of the design argument in seventeenth-century science.

Galileo's *Assayer* introduced the famous distinction between primary and secondary qualities, which paved the way to the mechanical philosophy. Following Gassendi and Descartes, most natural philosophers adopted the mechanical view of nature, namely the view that everything was to be explained in terms of the 'two catholic principles', *matter* and *motion*. Particles of matter are endowed with shape, size, and motion. In Descartes' mechanism, matter is inert and devoid of sources of activity of its own. Aristotelianism and Renaissance Naturalism did not consider mind and matter, spirit and body, as separate entities. The effect of the Cartesian dualism, in contrast, was to excise every trace of the psychic from material, leaving it a lifeless field. Excluding the psychic from physical nature brought about the denial that matter on its own had any power to originate change. The origin of motion was God: He created matter and set it in motion. Once started, the movement was shuffled round but it did not diminish it. For Descartes, God is the author of the eternal truths and is also essential to sustain the material world, which lacked any capacity to maintain itself in existence from one instant to the next. Establishing an opposition between the spiritual and the material world, most mechanical philosophers opposed the materialistic view that matter is endowed with sense perception and with the power of thought. Robert Boyle strongly rejected such thoroughgoing materialism, and clung to a soul-body dualism (even while rejecting Descartes' theories). Boyle insisted on the radical distinction between the Creator and the creation and denied activity and purpose to Nature. The argument of design was central to Boyle's natural philosophy and was conceived as a major answer to materialism. The natural world, being the handiwork of God, clearly indicates to Boyle the existence, omnipotence and goodness of God. The more we study the natural world, the more we understand that the universe could not have come about by blind chance. Boyle saw a close association between science and religion, viewing the discovery of facts about the natural world as a simultaneous discovery of its Creator. Although Boyle recognized the limits of human reason, he believed the knowledge of the physical world provided a powerful argument to support the Christian religion against atheism.

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The Mechanical Philosophy and the Design Argument

Antonio Clericuzio

1. Introduction

The mechanical philosophy elaborated during the seventeenth century was one of the pillars of modern science. Mechanical philosophers conceived the world as a perfect machine and maintained that natural phenomena were produced by matter and motion directed by the laws of nature. The mechanists' picture of reality differs radically from everyday experience: natural phenomena are produced by the motions of invisible and senseless particles of matter. Nature is lifeless matter in motion; what we call "life" is merely the outcome of matter in motion and is not intrinsic to nature. Anthropomorphism is banished from the description of the physical world, which appears to be bound to mechanical necessity. Whereas Laplace adopted a determinsitic view of the mechanical world world, stressing its independence from the Creator, seventeenth-century mechanists (with some exceptions) stressed the dependence of the physical world from God.[1] Modern mechanists shared with ancient atomists the view that change comes about through matter and motion, but their view of the world as a clock-work entailed that of a maker, since the mechanism was conceived as the product of design - the reasons of a machine being in the plans of its maker. The order to be found in the mechanical world is grounded in the intentions of the unlimited Judeo-Christian God. God is the craetor and the architect who fabricated the world mechanism. The mechanization of the world picture brought about the de-deification of nature. Whereas Aristotelians maintained that natural bodies act according to purpose, as attested by the oft-repeated sentence "Nature does nothing in vain", mechanical philosophers stressed the dependence of creatures from God as the first cause.

Though mechanical philosophers disagreed on what was God's relationship to the world He created, most mechanical philosophers recognized the final causes, but at a higher level than the physical theory. Whereas the conception of the world as living organism suggested the idea of an immanent final cause, the mechanical philosophers (with some important exceptions) maintained the view that the end to which the mechanism had been made did not explain its behaviour. God had designed the world in the most economic manner. As we shall see, some mechanists kept both the design argument and teleology in the study of nature - though in a mitigated version.

In the present paper I investigate the different ways the argument of design was adopted by mechanists and their views of the role of final causes in the study of nature.

2. Galileo

In 1623 Galileo Galilei (1564-1642) (*Il Saggiatore*) paved the way to the mechanization of the world picture by introducing the distinction between primary and secondary qualities, which was subsequently adopted (and reinterpreted) by most mechanical philosophers, including Descartes, Hobbes, Boyle and John Locke. Primary qualities are properties of the objects, secondary qualities are purely in us, and have nothing to do with the object at all. Primary qualities are the geometrico-mechanical ones, i.e., the size, shape, weight and relative motions of bodies; secondary qualities, such as color, taste and smell, reside only in the consciousness of individuals sensing them. As he put it:

> I believe that a few examples will make my conception clearer. I move one of my hands, first over a marble statue, and then over a living person. As far as concerns the action which comes from the hand to each subject, it is one and the same, and it consists of those primary accidents, namely motion and touch; and these are the only names we have given them. But the animate body which is subject to these actions, feels different affections depending on which parts are touched. For example, when touched under the soles of the feet, on the knees, or under the armpits, in addition to the ordinary sensation of touch, there is another sensation to which we have given a special name, by calling it 'tickling'. This affection belongs wholly to us, and not a whit of it belongs to the hand. And it seems to me that it would be a serious error if one wanted to say that, in addition to the motion and the touching, the hand had in itself this distinct capacity of tickling, as if tickling were an accident which inhered in it. A little piece of paper or a feather drawn lightly over any part of our body performs intrinsically the same action throughout, namely moving and touching us; but on touching us around the eyes, the nose, or under the nostrils, it gives rise to an almost intolerable itching, whereas in other parts we scarcely feel it. This itching belongs entirely to us, and not to the feather. Remove the animate and sentient body, and it is nothing other than a mere name. I believe that many other qualities which have been attributed to natural bodies (such as tastes, smells, colours, and others) have no greater an existence. When a body which is solid (or very 'material' as it is called) is in motion, and comes into contact with any part of my person, it produces in me the sensation which we call 'touch'. Although it is present over the whole of the body, nevertheless, it seems to reside mainly in the palms of the hands, and especially in the tips of the fingers, with which we sense the tiniest differences in roughness, smoothness, softness, and hardness, which we cannot distinguish so easily with other parts of the body. Some of these sensations are more pleasant than others, and others less pleasant, depending on the different shapes of the bodies which are touched — smooth or scaly, sharp or blunt, hard or yielding.[2]

Galilei established the foundations of a new conception of nature, a mechanistic one, in opposition to both the Peripatetic and the magic ones. Aristotelian philosophy of nature was based on the four qualities (hot, cold, dry, wet); Renaissance magic was based on occult qualities, hidden correspondences, sympathies and antipathies, spirits and astral influences. For the Renaissance magician nature is a living organism, endowed with perception, powers, and the soul. As Tommaso Campanella put it (*De sensu rerum et magia*, 1620), "the world is a feeling animal... whose parts partake in one and the same kind of life". Like any higher organism, the living cosmos posses a "spirit, both active and passive in nature, capable of suffering everything and of acting with everything."

For Galileo, the physical world exists without color, smell, taste, warmth or sound, and may be described solely in terms of its primary qualities. The secondary qualities exist only in our minds as the result of sensory interpretation of the primary qualities of matter, and therefore in no way resemble the objects that we normally attribute them to. For Galileo, the real world is a succession of atomic motions in mathematical continuity; causality is placed in the motions of particles of matter. Whereas Peripatetic philosophers explained change and movement in teleological terms, focusing on the *why* of motion, Galilei introduced the mathematical study of the *how* of motions. Where for Aristotle motion was a process, involving the very nature of the body, Galileo separated motion from the nature of the body – the latter being indifferent to the state of motion and of rest. As Alexander Koyré pointed out, Galileo's study of motion postulated idealized conditions that experience can never know.[3] Galileo applied geometry to terrestrial motions, giving the initial impulse to the mathematical science of motion. As we read in *Il Saggiatore*, the book of nature is written in "the language of mathematics, and the letters are triangles, circles and other geometric figures. Without these means it is impossible for men to understand a single word; without these means there is only vain stumbling in a dark labyrinth." In his view, nature is not animated, and there is no place for the world soul of the Neoplatonic philosophers. As he put it in the Letter to the Grand Duchess, Nature is inexorable and immutable, ad never passes the bounds of the laws assigned her.

But what is God's role in Galileo's universe? According to the Italian scientist, from the Divine Word the Sacred Scripture and Nature did both alike proceed; God discovers himself to us both in Nature and in the Scripture. Galileo's God is a geometrician who made the world according to mathematical laws. This view of God as geometrician becomes apparent if we consider Galileo's cosmogony (also known as the Platonic myth) as contained in the *Dialogo sopra i due massimi sistemi del mondo* (1632). The Divine Architect created the Sun, and, at some distance from it, the planets. The planets, according to their "assigned tendencies", began to fall towards the Sun in naturally accelerated motion. When the planets reached their orbits, their linear motions were diverted into circular motions by the "divine Mind" thereby retaining their acquired velocities.[4] Galileo's God followed precise mathematical rules when he dropped the planets at a given distance from the Sun and their accelerated motion follows the law of fall. In addition, their uniform orbital motion can be inferred from the double distance rule.[5]

Galileo unambiguously abolished final causes from natural philosophy, but he kept the design argument, which he introduced in his mathematical view of nature.

3. Gassendi and Descartes

Pierre Gassendi (1592-1655) and René Descartes (1596-1650) published two systematic and influential versions of the mechanical philosophy. Gassendi produced an influential christianized version of Epicurus' atomism. He rejected the infinitude and eternity of atoms and universe, the plurality of worlds, and the materialistic cosmogony. For Gassendi, atoms and the void are the ultimate components of the physical world. Atoms possess only a few primary qualities: shape, size, solidity and heaviness. Atoms colliding in empty space bring about all the natural phenomena. Gassendi maintained that a wise and omnipotent God had created a finite number of indivisible atoms and endowed them with motions. He also insisted on God's continuing providential relationship to the physical world. The argument from design was central to Gassendi's natural philosophy. The harmony and order to be found in the natural world show that the it was not produced by chance, but was created by an intelligent architect: "The paths of stars – wrote Gassendi-, the vicissitudes of storms, the succession of generations, the order and use of parts, everything that is in the world announces order and declares that the world is a most orderly system".[6] The world cannot have an innate or immanent order. Order derives from reason and planning that are not immanent, but transcendent. Gassendi believed that God's absolute power was not constrained by the creation – God's will is constrained only by the principle of non-contradiction. The order and harmony that God created, as well as the natural laws, are contingent on his absolute power. Three major consequences follow from God's complete freedom: 1. God could have created an entirely different natural order; 2. the laws of nature depend on the divine will; 3. God can interrupt the natural order of causes and effects by producing miracles. Given the contingency of the natural world, there is no guarantee that the course of nature will be constant, so our knowledge of nature fallible and has only observation as its source. Gassendi's voluntarist theology and the contingency of the physical world ruled out the possibility of a mathematical science of nature. Therefore Gassendi maintained an empiricist view of knowledge which had two epistemic consequences: probabilism and anti-essentialist view of nature.

Gassendi rejected the Aristotelian teleology, namely immanent finality in nature. But he did not rule out final causes from natural philosophy, he reinterpreted them as divine intentions reflected in the creation.

In his effort to replace Aristotelian natural philosophy with a new system of philosophy, Descartes was seeking the security of absolute certainty. In order to show that science rested on firm foundations, Descartes began by bringing into doubt all the beliefs that come to us from the senses. He argued that, if our knowledge came to us through the senses, we could not even be sure that anything outside of us existed. Therefore, because senses deceive, they cannot provide the basis to scientific knowledge. The consequence was that for Descartes the physical reality was by no means similar to the one our senses depict. Descartes claimed that a system of knowledge should start from first principles and proceed mathematically to a series of deductions, reducing physics to mathematics. The first principles are a priori, namely, clear and distinct ideas, that are the starting point of Descartes' science. When he defined matter, he maintained that the only clear and distinct idea we have of a material body is its geometrical extension. So he concluded that geometrical extension is what matter in itself is. According to Descartes, the essence of material substance is simply extension, the property of filling up space. We know the nature of bodies by means of solid geometry, which describes the possibility of dividing an otherwise uniform space into distinct parts.

Descartes' distinction between mind and body (*res extensa* and *res cogitans*) underlies his mechanical view of nature. The activity of thinking constitutes the essential nature of mind, while extension is the quality of material bodies. Descartes' dichotomy brings about the exclusion of psychic activity from the material world. Matter is identified with geometrical extension and is divisible to infinity – so atoms cannot exist. Since matter is identical with extension, space and matter are the same thing, and for this reason there is no void in the universe. Descartes' mechanism is grounded on the denial that matter on its own has any power to originate change, which is produced by impact. The origin of motion was God: He created undifferentiated and limitless extended matter and set it in motion. Once started, the movement was shuffled round but did not diminish. From the Divine immutability Descartes deduced that God always conserved the same quantity of motion in the universe. It is by virtue of motion that a body can act on another by impact, since action at a distance is rejected by Descartes - as well as by most mechanical philosophers. All natural phenomena are produced by matter and motion; all the qualities, including weight, heat, hardness and color are mere appearances, produced by the motions of particles of matter on our senses. Like Galileo, Descartes turned the familiar world of sensory experience to be a mere illusion. Descartes saw the world as a machine composed of the insensible parts of matter moved by physical necessity.[7] The universe is to be conceived as a plenum, and motions of its parts are communicated to each other by impact.

The idea of God is the foundation of Descartes' science: he held that God created the eternal truths (i.e., the mathematical truths) and the laws of nature. Like Gassendi, Descartes believed that God is entirely free in his creation, but he was no voluntarist. The Cartesian God cannot change what he once created freely. Indeed, Descartes accepted the existence of some necessity in the world. The eternal truths are inborn in our mind, and we are assured that He will not change them and deceive us. They are eternal and unchangeable because God's will is immutable, as His understanding is. God's knowledge is - for Descartes- identical to His power, and, as a consequence, any change in His understanding would entail some imperfection in God. In other words, mathematical truths depend on God and for this very reason they provide the foundation of our knowledge.

From the infinite perfection of God Descartes derived the metaphysical and epistemological foundations to his science, and from God's omnipotence, he derived the laws of nature. Descartes began with an assumption about how God created the world, and then deduced, on the basis of the laws of motion, the way the world came about. By His absolute power, God created matter and set the parts of matter in motion in the beginning, and by his ordinary concourse, He preserves the same quantity of motion in the universe. (*Principles of Philosophy*, Part II, art. 36). Like the eternal truths, the laws of nature follow from God's immutability. Since God always acts in a manner that is constant and immutable, the amount of motion in the world always remains constant. In other words, Descartes derived a law of conservation of motion from God's nature. The laws of nature are not properties of body but, rather, laws set up by God, and for this reason, they cannot be deduced from the property of matter-extension. Instead, they are to be deduced from the immutability of God. The first law of nature is that, in the absence of friction or collision, an object in motion remains in motion, and an object at rest remains at rest. According to the second law, bodies tend to move in rectilinear paths, with the result that for an object's trajectory to curve, some further force is needed to change its path. The third, and final, law is that, when two bodies collide, the weaker body gains some motion, and the stronger body loses the corresponding amount of motion (e.g. when a projectile hits a hard body it rebounds in the opposite direction, but when it hits a soft body it stops). The belief in the stability of the natural order is a necessary pre-

condition of Descartes' laws of nature. According to Descartes, God always maintains the different parts of matter in the same way and with the same laws which he made them obey at their creation (*Principles of Philosophy*, Part II, art. 36). As a consequence of the emphasis on the regularity of the created world, Descartes denied of the possibility of divine intervention in the natural world.

In the third part of the *Principles* Descartes attempted to give a physical account of the origin of the universe that is entirely based on matter and motion. In article 45 of part IV he maintained that his mechanical cosmogony was not true, since (as we learn from the Scripture) God created the world as perfect as it is. Yet, he claims that the outcome of the mechanical agents does not differ from what God fabricated. His account is presented as hypothetical, but the reader cannot avoid considering it a very plausible explanation of the origin of the world. Descartes claimed that at the beginning all parts of matter were equal among themselves, both in size and in movement. Then the laws of nature established by God produced the universe:

> It matters very little how I suppose matter to have been disposed at the beginning, since its disposition must afterwards be changed, according to the laws of nature; and one can scarcely imagine any disposition from which one could not prove that by these laws it must continually change, until finally it composes a world entirely similar to this one [...] For since these laws cause matter to take on successively all the forms it is capable of, if one considers all those forms in order, one will be able finally to arrive at the form that exists at present in the world. (*Principles of Philosophy*, 3, art. 47).[8]

Descartes did not reject final causes, but he rejected the claim that we can know the final causes of natural things, because it is impossible for us to know God's purposes: "we ought not be so arrogant as to think that we are participant in his plans." Though he did not rule out finalism, Descartes made no use of final causes in the mechanical explanations of natural phenomena. Gassendi reaffirmed the role of final causes in order to recognize God as creator and governor of the universe. He linked the final causes to the argument of design – an argument that Descartes did not adopt. According to Gassendi, the rejection of final causes might bring about the view that the universe is the product of chance. But Gassendi's view of the final causes differed from the Aristotelian one: teleology, for Gassendi, was not immanent to nature, but was imposed by a providential God.

4. Boyle

Robert Boyle (1627-1691) maintained that matter and motion are the two universal principles of mechanical philosophy.[9] Explanations based on the shape, size and motion of corpuscles are the primary, simplest and most comprehensive a naturalist can adopt. Like other mechanical philosophers, he described the universe as a clockwork made of one universal matter, whose parts were set in motion by God. "Local motion is the principal amongst second causes, and the grand agent of all that happens in nature" (*The Origin of Forms and Qualities*). Following Descartes, Boyle maintained that motion was no inherent quality of matter, which is extended, divisible and impenetrable. Matter is passive and can in no ways move itself. Boyle's view is that motion is accidental to matter, since it can only be ascribed to some external cause. According to Boyle, God created a mass of inert matter and guided the motion of the particles. Not only did the origin of motion depend on God, but

also did the velocities of corpuscles. Boyle's opposition to the view of active matter was based on his concern to reduce the power of matter, and consequently to stress the role of spiritual agents in nature. God created the universe and set it in motion, in such a way that the orderly system now revealed in it should result:

> The most wise and powerful Author of Nature, whose piercing sight is able to penetrate the whole universe and survey all parts of it at once, did, at the beginning of things, frame things corporeal into such a system, and settled among them such laws of motion, as he judged suitable to the ends he proposed to himself in making the world...(*A Disquisition about the Final Causes of Natural Things*, in *Works*, 6 vols, V, p. 413)

For Boyle, God created the universe and the laws of nature and maintains the world with His concourse. For Boyle, the mechanical world is not a self-contained and law-governed system, he maintained that the universe would inevitably fly apart if God does not intervene with his general concourse:

> This most potent Author, and Opificer of the world hath not abandoned a masterpiece so worthy of Him, but does still maintain and preserve it, so regulating the stupendously swift motions of the great globes, and other vast masses of the mundane matter, that they do not, by any notable irregularity, disorder the grand system of the universe, and reduce it to a kind of chaos, or confused state of shuffled and depraved things. (*The Christian Virtuoso*, in *Works*, V, p. 419).

Boyle's view of nature's laws radically differs from Descartes'. Descartes claimed that the laws of nature can produce our universe and are sufficient to maintain the harmonious system of the world.

Boyle put severe restriction on their role. Besides stressing the dependence of the physical world on God's concourse, Boyle stated that 'laws of nature' is an improper locution; as he put it, law of nature is "a notional thing", because a law is a rule of action according to which an intelligent and free agent is bound to regulate his actions. But inanimate bodies are utterly incapable of understanding what a law is.

Like Gassendi, Boyle adopted a voluntarist view of God, stressing the contingency of the physical world. He maintained that God is 'a most free agent', who did not create the world of necessity; He created it when there was no substance besides Himself, and no creature to which He owed any obligation or by which He could be restricted. As He is the most free and powerful Author of nature, "He is able, whenever He thinks fit, to suspend, alter, or contradict those laws of motion, which He alone at first established and which need His perpetual concourse to be upheld."(*A Disquisition about the Final Causes of Natural Things*, in *Works*, IV, p. 414) God might thus at any time, "by withholding his concourse, or changing these laws of motion, that depend perfectly upon his will..., invalidate most, if not all, the axioms and theorems of natural philosophy."(*Some Considerations about the Reconcileableness of Reason and Religion*, in *Works*, IV, p. 161). When he stated that God, by withholding his concourse "can invalidate most of the axioms of natural philosophy", Boyle evidently referred to miracles recorded in the Scripture. But he also counted a miracle

the union of the rational, immortal soul with a physical body at birth. It is important to point out that Boyle did not overstate the importance of miracles; in his view, the main argument for God and Providence is the harmony and order of the universe.

Boyle did not hold an occasionalist view of God: he maintained that God and natural entities each play a causal role in the world. But natural bodies are incapable to sustain the lawful order of the universe without the continued assistance of God. In *A Free Inquiry into the Vulgarly Received Notion of Nature* Boyle set out to discuss whether nature be that "almost divine thing whose works, among others, we are, or a notional thing, that in some sense is rather to be reckoned among our works, as owing its being to human intellects."(*Works*, V, p. 161) The received notion of nature - he claimed - was both useless to natural philosophy and dangerous to Christian religion. The view of nature as God's lieutenant, i.e., an agent intermediate between God and the creation, would inevitably limit God's power. He rejected both the Aristotelian nature and Henry More's Spirit of Nature that would interfere with God's action in the world. Nature is no distinct and separate being. God has created the world and maintains it with His general concourse without the assistance of a "vice-gerent". We can use the term "Nature", provided that we mean a 'notional entity', in order to denote the universe as a whole.

Boyle produced a defense of teleological explanation in natural philosophy. This would seem at odds with his mechanical philosophy and with his insistence on local motion as the principal amongst second causes. In order to understand Boyle's view of final causes we have to consider that in his tract on final causes he criticized both the Epicureans and the Cartesians. The followers of Epicurus think that the world was the production of atoms and chance and rule out the very existence of final causes. Descartes and his followers accept the reality of final causes in nature, but claim that God "being an omniscient agent, it is rash and presumptuous for men to think that they know, or can investigate, what ends He proposed to Himself in his actings about his creatures" (*A Disquisition about the Final Causes of Natural Things*, in *Works*, IV, p. 395).

Against the Epicureans, Boyle maintains that final causes can be legitimately employed in natural philosophy; in several cases final causes are useful for our understanding of natural phenomena. Against the Cartesians, he claims it is possible to know with some degree of probability the final causes of natural things. Boyle rejected the Aristotelian view that nature acts according to an immanent finality. Yet he maintained that final causes are allowable. First, physico-thological conclusions from the order of the universe to its creator are often permissible. Second, final causes are both permissible and useful in the study of plants and animals. The uses and the structures of the parts of animals reveal God's ends: "There is no part of nature known to us, wherein the consideration of final causes may so justly take place, as in the structure of the bodies of animals (Ibid., IV, p. 424). Boyle did not rule out Descartes' ontological proof, but he considered the argument of design the strongest argument for the existence of God:

It is true, that, in the idea of a Being infinitely perfect, boundless wisdom is one of the attributes that is included: but, for my part, I shall take leave to think, that this general and indefinite idea of the divine wisdom, will not give us so great a wonder and veneration for it, as may be produced in our minds, by knowing and considering the admirable contrivance of the particular productions of that immense wisdom, and their exquisite fitness for those ends and uses, to which they appear to be destined." (Ibid., p. 439).

5. Conclusions

In ridding matter of Aristotelian forms and qualities, the mechanical philosophers rejected sympathies, antipathies and attractions from the physical world. The scholastic substances and causes were swept away in favor of the view that bodies are composed of material corpuscles, equipped with none but mechanical properties. All immediate causality is placed in particles of inert matter and in local motions, described in geometrico-mechanical terms. Yet, its adherents saw the mechanical philosophy as being more conductive to religion and a better antidote against atheism than Aristotelianism and Renaissance naturalism. If matter is inert, it would be necessary to assume that the order and complexity to be found in the world are the outcome of an intelligent Architect. Whereas for Descartes God set matter in motion, established and kept the laws of motion, Gassendi and Boyle made God the creator and the governor of the physical world. With the exception of Descartes, the argument of design played a prominent part in seventeenth-century mechanical philosophy: mechanical philosophers like Boyle preserved and reinforced with theories and observations the doctrine of God's providential control of the universe.

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[1] "We ought to regard the present state of the universe as the effect of its antecedent state and as the cause of the state that is to follow. An intelligence knowing all the forces acting in nature at a given instant, as well as the momentary positions of all things in the universe, would be able to comprehend in one single formula the motions of the largest bodies as well as the lightest atoms in the world, provided that its intellect were sufficiently powerful to subject all data to analysis; to it nothing would be uncertain, the future as well as the past would be present to its eyes. "Laplace, *Essai Philosophique sur les Probabilités* forming the introduction to his *Théorie Analytique des Probabilités*. (Paris: 1820); repr. F.W. Truscott and F.L. Emory (trans.), *A Philosophical Essay on Probabilities*. (New York, 1951) .

[2] Galileo Galilei*, Il Saggiatore*, in *Le Opere di Galileo Galilei*. Ed. Antonio Favaro, 20 vols. (Florence, 1890-1909): 6, pp. 347-8.

[3] A. Koyré, *Galileo Studies*, (Highlands, NJ, 1978)

[4] I.B. Cohen, "Galileo, Newton, and the Divine Oder of the Solar System", in Ernan MacMullin (ed.), *Galileo, Man of Science* (New York, 1967).

[5] "The double distance rule states that a body, whose motion is diverted into a uniform motion after fall through a certain distance, will in the time it took to fall, traverse in uniform motion twice the distance fallen". I. Büttner, "Galileo's Cosmogony", in J. Montesinos-C. Solís (eds), *Largo campo di filosofare. Eurosymposium Galileo 2001*. (La Orotava, 2001), pp. 391-401: 393.

[6] Gassendi, *Syntagma Philosophicum*, in *Opera omnia*, 6 vols (Lyon, 1658) 1, p. 294. Cf. M. Osler, *Divine will and the mechanical philosophy: Gassendi and Descartes on contingency and necessity in the Created world* (Cambridge,1994); S. Fisher, *Pierre Gassendi's Philosophy and Science* (Leiden, 2005).

[7] "I have hitherto described this earth and generally the whole visible world, as if it were merely a machine in which there was nothing at all to consider except the shapes and motions of its parts..." (*Principles of Philosophy*)

[8] See D. Garber, *Descartes' Metaphysical Physics.* (Chicago, 1992); S. Gaukroger, *Descartes' System of Natural Philosophy* (Cambridge, 2002).

[9] M. Hunter (ed.), *Robert Boyle Reconsidered (Cambridge, 1994)* R-M. Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment* (Chicago, 1995).