CHAPTER VI

NEWTON'S VIEW OF MATHEMATICAL KNOWLEDGE

6.1 Introduction

In the preceding chapter, we have addressed Newton's mathematization of nature. There are several related areas that warrant further examination. These areas form the sub-topics of this chapter. They include Newton's concept of mathematical entities, mathematical proof and mathematical truth. What follows is an attempt to delineate his view on the status of mathematical knowledge based on his view of them.

6.2. Mathematical entities

Newton views mathematical entities as having different levels of existence and they owe their existence to the will and ideas of God.[1] God is beyond all distinctions and polarizations and is the cause of existence. "Without all doubt this world, so diversified with that variety of forms and motions we find in it, could arise from nothing but the perfectly free will of God directing and

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[1]See Principia, Motte-Cajori, p.544-5

presiding over all",[2] writes Cotes in his preface to the second edition of the Principia. The preface was approved by Newton before it was added to the second edition.

The external world is part of Newton's phenomena. Since in his philosophy of mathematics the study of nature begins from phenomena, it follows that the inquiry into the arcana of nature in so far as it is connected to the quest for mathematical laws, is first an inquiry concerning the mathematical entities.

In an early discussion about mathematical entities, Newton alludes that there are mathematical entities which exist at the level of sensibles and that the task of the mathematician is to study them beyond the realm of material existence. Says Newton, "It is indeed a matter of great difficulty to discover, and effectually to distinguish, the true motions of particular bodies from the apparent; because the parts of that immovable space, in which those motions are performed, do by no means come under the observation of our senses".[3]

According to Newton, all things are bounded by time, space, place and motion. "Time and Place are common affections of all things without which nothing whatsoever can exist. All things are in time as regards duration of existence, and in place as regards amplitude of presence",[4] says Newton. He believes that time, space,

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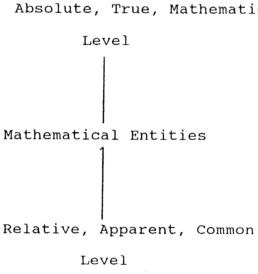
[2] Ibid., p.xxxii.

[3] Ibid., p.12.

[4] See Newton's statement reproduced in J.E. Mc Guire, "Newton on Place, Time and God: An Unpublished Source", British Journal for the History of Science (2)(1978), p.116.

place and motion have different levels of existence: as absolute, true and mathematical as opposed to relative, apparent and common.[5] Consequently, in so far as mathematization is concerned, mathematical entities enclosed by them are perceived as having these characteristics; that at one level, mathematical entities are relative, apparent and common whereas at another level they are said to be absolute, true and mathematical.[6] Now we will examine in greater detail these two levels of existence imbedded in Newton's philosophy of mathematics.



Dia. 6.1 Two levels of existence of mathematical entities.

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[5]See footnote 53 on page 200 in Chapter V. If we take the case of 'time', Newton's "common time" refers to the ordinary concept of time; that is time as a day, a month and so forth.

[6]To say that at a particular level a mathematical entity is mathematical and at another level it is common is not redundant. It is analogous to saying that from one aspect, a red ball is a red ball and from another aspect, it is just another ball.

In what sense are mathematical entities said to be apparent, relative, and common? Taking into account the centrality of God in his philosophy of mathematics, the apparentness of mathematical entities means that there is a need to relate the mathematical properties of any particular mathematical entity to its ontological status. Newton's mathematization which consists partly of experiments and observations, eventually leads to the discovery of some aspects of their external manifestation. It is then part of mathematization to connect these discoveries to their noumenon, their inner aspect, which is their 'center' relating them to God about Whom Newton describes as follows:

> And from his true dominion, it follows that the true God is a living, intelligent, and powerful Being; and, from his other perfections, that he is supreme or most perfect. He is eternal and infinite, omnipotent and omniscient; that his duration reaches from eternity to eternity; his presence from infinity to infinity; he governs all things, and knows all things that are or can be done.[7]

That Newton begins his mathematical study from phenomena indicates that the mathematization of the external world is more than a study of phenomena, searching for more than merely material explanation[8] which is a characteristic of the positivists approach to science. Rather, it is a study of phenomena in connection to

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[7]See Principia, Motte-Cajori, p.545.

[8]By "material explanation" I mean explanation that precludes metaphysical consideration. Examples of such explanations in the foundation of mathematics are those offered by the intuitionists who, following Brouwer, sought to 'purify' mathematics from metaphysics. See for instance, A. Heyting, "Disputation", in R.C. Goodstein, Essays in the Philosophy of Mathematics, (London, 1965), pp. 66-69.

noumena. In other words, Newton sought to discover the relation between the particular to the Universal in order to transcend their "apparentness". As demonstrated in the Principia, his mathematization brings together rational and some metaphysical explanation of phenomena. Thus the scholia in the Principia. Mathematization of external objects does not end up merely by "explaining away" by means of numbers and formulae. Of paramount importance is to relate the particular discovery to the Universal, to Pure Being and to increase one's understanding about Universal Existence itself. Says Newton; "And thus much concerning God, to discourse of whom from the appearances of things does certainly belong to natural philosophy".[9] His discussion on space and time elsewhere leads him to write the following reminder:

> The Reader is desired to observe, that wherever in the following papers through unavoidable narrowneass of language, infinite space or immensity & endless duration or Eternity, are spoken of as Qualities or Properties of the substance which is Immense or Eternal, the terms Quality and Property are not taken in that sense wherein they are vulgarly, by the writers of Logic and Metaphysics applied to matter; but in such a sense as only implies them to be modes of existence in all beings, and unbounded modes and consequences of the existence of a substance which is really and substantially Omnipresent and Eternal; Which existence is neither a substance nor a quality, but the existence of a substance with all its attributes properties and qualities, and yet is so modified by place and duration that those modes cannot be rejected without rejecting the existence.[10]

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[9]See Principia, Motte-Cajori, p.546.

[10]See A. Koyre' and I.B. Cohen, "Newton and the Leibniz-Clarke Correspondence," Archives internationales d'histoire des sciences (15)(1962), p. 96-7. See also I.B. Cohen, The Leibniz-Clarke Correspondence, op. cit., p. xxix.

The existence of mathematical entities is a manifestation of the existence of Pure Being. It is in this sense that the mathematical entities are said to be "apparent". Therefore the mathematization of the external objects again is a mathematical process of finding the relation of these objects to Being which in reality is their origin. Thus in Newton's view, the mathematization of external objects necessarily involves intellectual intuition and metaphysics. Mathematization of external objects is also an application of some metaphysical principles to the external world.

Analysis, observation and experiments performed on the mathematical entities are aids to further one's knowledge of their particular aspects. The fruit of mathematization resulting from the study of these entities finds its higher meaning only in light of the metaphysical principles, which provides wisdom or 'sapientia'. In Newton's view, the fruit of mathematization is also imbedded with metamathematical reasoning. States Newton concerning mathematical entities, "...their inward substances are not to be known either by our senses or by any reflex act of our minds;..."[11] The mathematical properties of the mathematical entities discovered by means of analysis and synthesis are useless and peripheral until through the intelligence they are integrated into the unicity of existence which is the totality of all there is, to the end that they would be meaningful.

Interpolation are carried out on the symbols or measurements by applying formal rules in addition to amalgamating them with

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[11]See Principia, Motte-Cajori, p.546.

God's Names and Attributes. Just to cite an example on how he mathematized space, which is "by way of similitude, as it (space) were the sensory (of God)",[12] his discussion about it leads him to write: "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".[13] In this particular example, the measurements or in other words, quantification, serve as symbols at the elementary level of mathematization.

Newton did not stop upon the arrival or the discoveries of formulae or theorem but he included in the process of mathematization the encompassing integration of the overall results into enlightning discussions of Divine Wisdom and Transcendence, in addition to elucidating God's other Names and Attributes.[14] It is in this sense that mathematics become a ladder between the sensibles and the intelligibles. Newton's overall programme of mathematization is not completed until the arrival in the soul of the mathematician the inner meaning of the discoveries, realising their 'places' with respect to God, so to speak.

There is another aspect of the mathematical entities imbedded in Newton's philosophy of mathematics. In his understanding of mathematics; space, time and all things residing in them are an emanative effect of God. We have stated earlier that Newton was

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[12] See footnote 34 in Chapter V.

[13] See Principia, Motte-Cajori, p.8.

[14] See Newton's description of God in ibid., pp. 544-6 and Opticks, p.400-3.

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[14] See Newton's description of God in ibid., pp. 544-6 and Opticks, p.400-3.

quite apprehensive of the theory of emanation. Interestingly, he clearly states in De Gravitatione that:

> No being exists or can exist which is not related to space in some way. God is everywhere, created minds are somewhere, and body is in the space that it occupies; and what is neither everywhere nor anywhere does not exist. And hence it follows that space is an emanative effect arising from the first existence of being, because when any being is posited, space is posited.[15]

Just what is meant by Newton that space which is also an object of his mathematical study is an "emanative effect"? In order to throw some light onto this question, it is instructive to examine a passage written by a contemporary of Newton and a well known Cambridge Platonist, Henry More.[16]

According to More, an emanative effect necessarily coexists with its cause. It is impossible for the emanative cause to exist and its effect not to. Thus:

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[15]See "De Gravitatione et Aequipondio Fluidorum", in A. Rupert Hall and Marie Boas Hall, Unpublished Scientific Papers of Isaac Newton, (London, 1962), p.136.

[16]In fact, Henry More (1614-87) was one of the leaders of the Cambridge Platonists. Among his numerous writings are An Antidote against Atheism (1653), Philosophical Poems (1647), The Immortality of the Soul (1659) and Divine Dialogues (1668). In the Antidote, he claims that "truth of the existence of God [is] as clearly demonstrable as any theorem in mathematics". For a discussion on the influence of More in Newton's world-view, see for example E.A. Burt, The Metaphysical Foundations of Modern Science, (London, 1932), pp.202-23; L.T. More, Isaac Newton: A Biography, (New York, 1934), pp.552-4, pp. 608-47. cf. B.P. Copenhaver, "Jewish Theologies of Space in the Scientific Revolutions: Henry More, Joseph Raphson, Isaac Newton and Their Predecessor", Annals of Science, (37)(1980), pp. 489-548.

Axiome XVII

An Emanative Effect is coexistent with the very Substance of that which is said to be the Cause thereof.

This must needs to be true, because that very Substance which is said to be the Cause, is the adequate and immediate Cause, and wants nothing to be adjoined to its bare essence for the production of the Effect; and thereof by the same reason the Effect is at any time, it must be at all times, or so long as that Substance does exist.[17]

In view of the above doctrine of emanation, the existence of mathematical entities are totally dependent upon God who is the Substance. From Newton's perspective, emanative effects mean that mathematical entities are not part of the divine essence. In his view, "emanative effects" likewise imply that mathematical entities are immediate causal consequences of God.[18]In other words, mathematical entities have instantaneous causal dependency on God.[19]

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[17]See Henry More, Immortality of the Soul in A Collection of Several Philosophical Writings of Dr. Henry More, (New York, 1978) p.28.

[18]In fact, echoing this position, Clarke writes:

Space is not a substance, but a property; and if it be a property of that which is necessary, it will consequently (as all other properties of that which is necessary must do,) exist more necessarily, (though it be not itself a substance,) than those substances themselves which are not necessary. Space is immense, and immutable, and eternal; and so also is duration. Yet it does not at all hence follow, that anything is eternal hors de Dieu. For space and duration are not hors de Dieu, but are caused by, and are immediate and necessary consequences of his existence. And without them, his eternity and ubiquity (or omnipresence) would be taken away. [I.B. Cohen, Leibniz-Clarke Correspondence, op.cit., p.47.]

[19]Aquinas, for example, cites the dependence of color on light to demonstrate instantaneous causal dependency.

Thus far we have attempted to delineate Newton's conception of mathematical entities with regard to their modes of existence; that in actuality, they are manifestations of the Pure Being. The problem wanting explanation now is the connection between their modes of existence and Newton's position that mathematical objects are apparent, relative and common.

In view of Newton's opinion that mathematical entities with all their properties and qualities are reflections and consequences 'flowing' from God, we posit that they are referred to as apparent, relative and common in accord with that belief.[20] In more specific terms, they are apparent because in actuality they are not what they are thought to be at the first level of mathematization wherein they are construed as constituents of the world of Multiplicity.[21] In actuality they are particularizations of the Pure Being, the perfect Unity upon whom their existence totally depends.

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[20]It is interesting to note that in his preface to the second edition to the Principia, Cotes writes:

> From this fountain it is that those laws which we call the laws of Nature have flowed, in which there appear many traces indeed of the most wise contrivance, but not the least shadow of necessity. [See Principia, Motte-Cajori, p.xxxii]

[21]To this effect, Cotes states in his Preface;

> All sound and true philosophy is founded on the appearances of things; and if these phenomena inevitably draw us, against our wills, to such to such principles as most clearly manifest to us the most excellent counsel and supreme dominion of the All-wise and Almighty Being, they are not therefore to be laid aside because some men may perhaps dislike them.
> [See ibid., p.xxxii]

Mathematical entities are said to be relative because as part of the world of Multiplicity, they are individuations of Absolute Unity who is the ever present God. In other words, the mathematical forms existing in the external world are ultimately bestowed by God. These mathematical forms exist as universals before they descend into the external world which is the world of plurality. At the material level of existence, they are 'relative' because Newton believes that He is the only One who is "absolute"[22] and eternity simpliciter is the prerogative of none other than God. "He is not eternity and infinity, but eternal and infinite; he is not duration or space but he endures and is present",[23] writes Newton.

That mathematical entities are said to be common as opposed to mathematical is because they are identified as such by the vulgar at the elementary level of mathematization. Newton made several comments with regard to the vulgar level of understanding of which we have referred to at an earlier occasion.[24] We only wish to add here that in Newton's philosophy of mathematics, the mathematical experience of Divine Immanence and Divine Wisdom concomittant to mathematical discoveries are not apprehended by the vulgar.

In Newton's philosophy of mathematics, mathematical entities are parts of the conglomerate of symbols[25] used as aids in

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[22] Ibid., p.544.

[23] Ibid., p.545.

[24] See Chapter 4, p. 177-8.

[25] When we say that a mathematical entity is a symbol, we do not mean a symbol in the sense of a notation. For example, ∞ is a conventional notation, not a symbol, for infinity. To say that

mathematization. As a representative of God's initial creative work, nature is in a sense a book of mathematical symbols. There is an inner, metaphysical connection between mathematical entities and the things they symbolized of nature. Newton's acceptance of divine revelation, intellectual intuition (at least from the perspective that God is the source of all knowledge which we have pointed out earlier), and vertical level of existence, provides the premises for the connection between the symbols and the symbolized. In the next section, we will demonstrate that in Newton's philosophy of mathematics, the reality of mathematical entities is not totally exhausted by its quantitative content. There is qualitative aspect of it, although not as much as in the case of al-Bīrūnī. Mathematical entities which have particular symbols are more than mere quantities. A deeper understanding of mathematical entities will lead to a greater understanding of their significance.[26]

6.3 Infinity, Zero, Numbers, Points and Lines

In Newton's philosophy of mathematics, mathematical entities such as infinity, numbers, points and lines are entwined with belief in God and the mathematical structure of the world. In his view, mathematical entities should not be construed solely as

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something is a symbol means that something "is the "reflection", in a lower order of existence, of a reality belonging to a higher ontological status". See O. Bakar, Tawhid and Science, op. cit., p.66-69. Quotation is on page 66. For other example of Newton's notation, see Correspondence of Isaac Newton and Cotes, op. cit., p.172-3.

[26]For a discussion about views on symbols propounded by some Muslims and Christians scholars, see O. Bakar, ibid., pp. 64-68, pp.145-151.

quantitative aids in the process of mathematization. There is also a little qualitative aspect of it whereby mathematical entities are interconnected with metaphysical principles. They serve as the nexus from the world of sensibles to the higher world of archetypes and ultimately to God Himself. There is an intricate and inextricable bond between mathematical entities and the metaphysical principles of the mathematician. In the absence of the qualitative aspects, mathematicians fall into the abyss of 'formal games of symbols', a purely quantitative world void of Divine Wisdom and Transcendence wherein mathematicians are blinded to the sacred connection between their discipline and aspects of Being.

Newton argues that mathematicians should not limit themselves to the view of the common people who concieve time, space, place and motion "under no other notions but from the relation they bear to sensible objects".[27] In the course of mathematization, external objects become extra-sensible things. Mathematical entities are reflections of what there is. Mathematical entities become symbols of the spiritual world. Accordingly in this section, we will explore more closely Newton's view about mathematical entities and their qualitative aspects which is the connection between the symbols and the symbolised.

We will first consider Newton's concept of infinity.[28] Newton

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[27]See Principia, Motte-Cajori, p.6

[28]According to the intuitionists (followers of Brouwer), infinity is basic to the development of mathematics since mathematics from the very beginning deals with the series of natural numbers. Unlike Newton, they contend that metaphysics should not be included in the analysis of mathematics because they

maintains that infinity can be predicated of many different things. He believes that "infinity is not a perfection except when it is attributed to perfections. Infinity of intellect, power, happiness, and so forth, is the height of perfection; but infinity of ignorance, impotence, wretchness, and so on, is the height of imperfection; and infinity of extension is so far perfect as that which is extended".[29]

Newton argues that although infinity itself is beyond imagination, it does not mean that infinity is beyond understanding. To this effect, he writes:

> If anyone now objects that we cannot imagine that there is infinite extension, I agree. But at the same time I contend that we can understand it. We can imagine a greater extension, and then a greater one, but we understand that there exists a greater extension than we can imagine.[30]

His remark that we can understand infinity without our souls being able to imagine it through our faculty of imagination is interesting indeed. As a mathematical entity, infinity is often used in mathematization.[31] That we can intuit infinity despite of our inablity to imagine it points to the important aspect that

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maintain that mathematics should be studied "as something simpler, more immediate than metaphysic", consequently severing any relation between the two. See A. Heyting, "Disputation", op. cit., pp. 66-7.

[29]See "De Gravitatione et Aequipondio Fluidorum," in A.R. Hall and M.B. Hall, Unpublished Scientific Papers of Isaac Newton, (Cambridge, 1962). pp. 102-3. Hereafter cited as De Gravitatione.

[30]See De Gravitatione, p.134.

[31]See Newton's comment on Wallis' Arithmetica Infinitorum in Papers and Letters, p.295.

mathematics is a "way of knowing" the intelligibles.

Numerically speaking, infinity for Newton is synonymous with "innumerable" or "uncountable". States Newton:

> If any man should say that a number and a sum, to speak properly, is that which may be numbered and summed, but things infinite are numberless or, as we usually speak, innumerable and sumless or insummable,...[32]

Accordingly from Newton's point of view, something is infinite when it is no longer countable. This rather banal mathematical statement belies an important aspect of infinity in Newton's mathematical thinking; that infinity arises out of mathematizing the countable sensibles, so to speak. Therefore in addition to the claim made earlier that mathematics is a "way of knowing" the intelligibles, in Newton's point of view, mathematics serves also as a nexus between the sensibles and the intelligibles.

Moreover, Newton upholds the position that there are levels of infinity. It is not the case that all infinites are necessarily equal. He admits in his letter to Bentley that "The generality of mankind consider infinites no other ways than indefinitely; and in this sense they say all infinites are equal,..." before reminding Bentley that the masses (the vulgar) "would speak more truly if they should say they are neither equal nor unequal, nor have any certain difference or proportion one to another".[33] In similar

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[32]See ibid., p.304.

[33]In his letter to Bentley, Newton was trying to show the fallacy of the argument that "if an inch may be divided into an infinite number of parts the sum of those parts will be an inch; and if a foot may be divided into an infinite number of parts the

vein, he writes elsewhere,

> ...that infinities, when considered absolutely without any restriction or limitation, are neither equal nor unequal, nor have any certain proportion one to another, and therefore the principle that all infinities are equal is a precarious one.[34]

Accordingly, a reasonable way to use infinites is by considering them "under certain definite restrictions and limitations, wherein infinites are determined to have certain differences or proportions to one another",[35] that is, there are different levels of infinites.

What is more interesting is that Newton's concept of infinity points to his belief that there are levels of reality. Since infinity can be predicated to so many different objects, they can be construed in consonant with their levels of perfection. Each level corresponds to their degrees of perfection. God is the most perfect for He possesses perfection infinitely. "And from his true dominion it follows that the true God is a living, intelligent, and powerful Being; and, from his other perfections, that he is supreme

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sum of those parts must be a foot; and therefore, since all infinities are equal, those sums must be equal, that is, an inch equal to a foot". Ibid., p.294.

[34] Ibid., p.299.

[35] When infinities are viewed as such, the fallacy of the argument given in footnote 34 is obvious because following Newton, "although there be an infinite number of infinite little parts in an inch, yet there is twelve times that number of such parts in a foot; that is, the infinite number of those parts in a foot is not equal to but twelve times bigger than the infinite number of them in an inch". Ibid., p.295.

or most perfect",[36] says Newton.

Only God is "absolutely perfect" and Newton maintains that his perfection lies by having dominion, that is by having creations which have lesser degrees of perfection. Thus:

> The Supreme God is a Being eternal, infinite, absolutely perfect, but a being, however perfect, without dominion, cannot be said to be "Lord God"; for we say "my God," "your God," "the God of Israel,"....; we do not say "my Infinite," or "my Perfect": these are titles which have no respect to servants.[37]

Consequently God is the highest level of reality. His Essence is beyond any determination. His Names and Attributes are the most perfect of all.[38] "We are therefore to acknowledge one God, infinite, eternal, omnipresent, omniscient, and omnipotent, the creator of all things, most wise, most just, most good, most holy, and to have no other Gods but him",[39] writes Newton. To be conscious of Him amounts to experiencing the state of that level of reality whereby the mathematician experiences Divine Immanence and sees with his heart, more than anything else, Divine Unity.

In addition to infinity, other mathematical entities include

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[36]See Principia, Motte-Cajori, p.545.

[37] Ibid., p.544.

[38]As we have pointed at an earlier occasion, Newton does not subscribe to the view that God is equivalent to Power, Goodness or Wisdom. Rather, Newton holds the position that power, wisdom and good, for examples, are transcendental attributes that God has in the most perfect manner, to wit, infinitely. Thus "all our notions of God are taken from the ways of mankind by a certain similitude, which though not perfect, has some likeness". See ibid., p.545.

[39]See Theological manuscripts, p.51.

geometrical figures which basically consist of circles, lines and points. What is Newton's view of them? We will begin with examining Newton's concept of points.

According to Newton, points are constituents of a line. A point is viewed as that indivisible part of a line when the latter is divided continuosly. Therefore a point does not have breadth, length or thickness. Its existence is not in the physical realm but in the realm of imagination. States Newton:

> I likewise call attraction and impulses...or 'propensity' of any sort toward a center, promiscuously and indifferently, ...considering those forces not physically but mathematically; wherefore the reader is not to imagine that by those words I anywhere take upon me to define ...the causes or the physical reason thereof,..., in a true and physical sense, to certain centers (which are only mathematical points)...[40]

Interestingly in the case of Newton, discussion involving mathematical centers leads to conciousness of God. If viewed as mathematical centers, "points" lend a sense of ultimate equilibrium and perfect harmony; features which are not easily discernable merely by observing the physical world without going beyond by mathematizing them and perceiving the centers as mathematical points with all of their subtility and exactness.

> The reason why matter evenly scattered through a finite space would convene in the midst you conceive the same with me, but that there should be a central particle so accurately placed in the middle as to be always equally attracted to all sides,..., seems to me a supposition fully as hard as to make the sharpest needle stand upright on its point upon a looking glass. For if the very mathematical center of the central particle (not the central particle itself!) be not accurately

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[40]See Principia, Motte-Cajori, p.546.

> in the very mathematical center of the attractive power of the whole mass, the particle will not be attracted equally on all sides.[41]

Notice that in the above passage, Newton is shifting the focus from the brute facts of the material world (the contents of the physical world) to a finer physical analogy (the needle) and moves on to the finest abstraction (mathematical center). In the continuation of the above passage, Newton convenes on the most subtle reality of all which is God. (The passage also indicates that in Newton's conception of mathematics, the latter can function as a ladder from the sensible to the intelligible). The above passage continues:

> And much harder it is to suppose all particles in an infinite space should be so accurately poised one among another as to stand still in a perfect equilibrium. For I reckon this as hard as to make, not one needle only, but an infinite number of them (so many as there are particles in an infinite space) stand accurately poised upon their points. Yet I grant it possible, at least by a divine power; and if they were once to be placed, I agree with you that they would continue in that posture without motion forever, unless put into new motion by the same power.[42]

This is a subtle and yet a significant qualitative aspect of points in Newton's philosophy of mathematics. The mathematician can appreciate more of the power and capability of God which is reflected in the subtility and the exactness of his works.[43] Note

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[41]See Papers and Letters, p.292.

[42] Ibid.

[43]This feeling of awe of Divine Wisdom arising from mathematization is reflected in the following passage which appears in the same paragraph whereby he talks about God's "implanting

also that his line of argument is in accord with his belief in the various levels of reality discussed earlier.[44]

Furthermore, there is another aspect of points worth mentioning. In Newton's conception of mathematics; lines, circles and consequently all geometrical figures are generated from the point which is analogous to his believe commented earlier that all knowledge issues forth from God and that all multiplicity come from Him. His belief that all those mathematical entities are generated from the point is clearly imbedded in the following passage:

> ...if the earth (without the moon) were placed anywhere with its center in the orbis magnus and stood still there without any gravitation or projection, and there at once were infused into it both a gravitating energy toward the sun and a transverse impulse of a just quantity moving it directly in a tangent to the orbis magnus, the compounds of this attraction and projection would, according to my notion, cause a circular revolution of the earth about the sun. But the transverse impulse must be a just quantity; for it be too big or too little, it will cause the earth to move in some other line[45]

We can see in the above passage the closeness of the analogy between God as the Creator, that all creations originate from Him, and the qualitative aspect of the point; that all mathematical figures can be viewed as its extension. Accordingly, it is not

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principles...that we may understand as little". Writes Newton:" ...how light,...should for many successive thicknesses of the plate in arithmetical progression be alternately reflected and transmitted, as I find it, puzzles me as much". See Brewster, Memoirs...., Vol. 1, p.400.

[44]See Chapter 5, p. 213. See also O. Bakar, Tawhid and Science, op. cit., p.22.

[45]See Papers and Letters, pp. 296-7.

surprising when Newton continues the above passage with his statement about the creator, saying that "I do not know any power in nature which would cause this traverse motion without the divine arm".[46]

So far we have explored Newton's conception of mathematical entities such as infinity, points, lines and circles. Now we will examine his position regarding numbers. Naturally we will begin with the number One.

In Newton's view, one is usually associated with God, more so than its "derivative" which is the numerical order "first". For example, Newton writes "And we are to believe in one God, the Father, almighty in dominion, the maker of heaven and earth and all things therein...",[47] "we are to acknowledge one God, infinite, eternal...",[48]"There is one God, the Father, ever living,...",[49] "To us there is but one God, the Father, of whom are all things...",[50] and in the Principia, Newton even identifies God with One, without "the". "And if the fixed stars are the centers of other like systems, these, being formed by the like wise counsel, must be all subject to the dominion of One;..."[51]

It is instructive to draw distinction between "one" and

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[46] Ibid., p.297.

[47] See Theological Manuscripts, p.31.

[48] Ibid., p.51

[49] Ibid., p.56

[50] Ibid., p.57.

[51] See Principia, Motte-Cajori, p.544.

"first" because obviously they are not necessarily in the same category. It is from the One that there is the first whereas to be the first is not necessarily to be the One. The first is part of the Many and with the last, we have 'all' and all are of the One. Thus in Newton's philosophy of mathematics, "One" bears the qualitative aspect of Divine Unity.

In addition to the numerical One, the other 'natural' numbers likewise bear ontological aspects of Unity. They are definitely more than pure quantities. Indeed they function as symbols expressing Unity in multiplicity. Just as a line is generated from the point, so are all numbers generated from One. In considering all of the numbers, Newton writes:

> And yet if any man shall take the words 'number' and 'sum' in a larger sense, so as to understand thereby things which, in the proper way of speaking, are numberless and sumless (as you seem to do when you allow an infinite number of points in a line), I could readily allow him the use of the contradictious phrases of 'innumerable number' or 'sumless sum,'...[52]

Therefore in Newton's conception of numbers, there are traces of the Pythagorean conception of number,[53] in particular the projection of Unity which is an aspect of God as the Center and Origin for everything. Numbers bear in themselves the ontological relation which they have with Unity.

It is Newton's view of the qualitative aspects of numbers as

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[52]See Papers and Letters, pp. 304-5.

[53]Newton mentions the Pythagorean school in his introduction to Bk.III of the Principia. See Principia, Motte-Cajori, p.549. Newton, however, cannot be classified as a Pythagorean because of his quasi-mechanical view of nature as we have shown in Chapter V.

mathematical entities that at some instances where he uses numbers in mathematization, he is aware of Divine Presence and Wisdom. Let us consider as an elementary but not trivial example, the number two. 'Double' is derived from two (since from two equals we have double) and two is derived from one (having two ones we have two). In his discussion pertaining to gravity where he uses the concept of double, Newton states:

> And this is true, supposing the gravitating power of the sun was double at that moment of time in which they all arrive at their several ords; but then the divine power is here required in a double respect, namely, to turn the descending motions of the falling planets into a side motion and, at the same time, to double the attractive power of the sun.[54]

Newton's awareness of God is likewise indicated when he uses these numerical entities in his mathematization as documented in the Principia because in relation to the above passage whereby he uses the concept of double, his study of gravity leads him to write:

> But if the gravitating power of the sun was not doubled, they would go away from their orbs into the highest heavens in parabolical lines. These things follow from my Principia mathematica, Lib. i, Prop. 33, 34, 36, 37.[55]

We wish to add here another aspect of numbers functioning as mathematical entities in Newton's philosophy of mathematics. We maintain that apart from One, the rest of the series of natural

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[54]See Papers and Letters, pp. 297-8.

[55]See ibid., p.309. For the content of the various propositions, see Principia, Motte-Cajori, p.118 (Proposition 33), p.120 (Proposition 34), and p.123 for both Propositions 36 as well as 37.

numbers are contingent on the concept of order. For example, "order" is reflected in Newton's position regarding the creation of the world in six days.[56] It is worthy to note that chaos is opposite to order and preceding the act of creation, there is chaos. "That they all, and the sun too, had at first one common chaos", writes Newton.[57] Order begins to take place once the chaos is separated, that is, "by the spirit of God moving upon it, became separated into several parcels, each parcel for a planet",[58] and elsewhere, "for it became him who created them to set them in order".[59] In addition to that, Moses, who according to Newton "had before called the chaos "the deep",...teaches the division of all those waters into two parts...".[60] We will not proceed with the Biblical concept of creation here because it is not our intention to do so. Suffice it to say out of this example that the orderly series of natural numbers is intricately bound to Newton's cosmological view particularly pertaining to the act of creation,[61] that is, before the number of days or in more specific terms, the series of days (first, second, third,..., sixth), there is always the One.

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[56]See Brewster, Memoirs..., Vol. II, p.453.

[57] Ibid., p.451.

[58] Ibid.

[59]See Opticks, p.402.

[60]See Brewster, Memoirs..., Vol. II, p.452.

[61]Perhaps the key to have a greater insight into the traditional account of creation lies in the understanding of the mathematical concept of six!

Thus in Newton's philosophy of mathematics, numbers can be regarded as the results of a process. They are not necessarily abstract, timeless and non-spatial entities existing simultaneously and independently of human thought. They are more than marks on pieces of paper[62] and not simply entities such as ideas in the mind.[63]

Besides those mathematical entities that we have explored, there is still another mathematical entity in Newton's philosophy of mathematics which we have not discussed. It is his concept of zero. We have in mind the qualitative aspect of zero such as its inner meaning and its significance with respect to Newton's philosophy of mathematics.

In so far as we know, Newton never mentions the number zero in any of his discussion about God. What we are attempting to do here is to construct his qualitative concept of zero based on his cosmology. Does Newton's zero amount to a state of "nothingness" or is it synonymous to a state of chaos, bereft of any sense of order? From Newton's point of view of creation briefly explicated above, God creates the world out of something.[64] Thus there is no such thing as a state of "nothingness". Yet it is reasonable to say that

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[62]This is the belief of the formalists, followers of Hilbert.

[63]The latter position is based on the belief that psychology is the foundation of philosophy. Among its propounder is J.K. Fries and F.E. Beneke. They argue that introspection is the primary method of philosophical enquiry, a sufficient guide to complete self-knowledge. For a critique on their position, see G. Ryle, The Concept of Mind, (London, 1949).

[64]See also Chapter 4, p. 147 ff.

zero is synonymous with a state of "nothingness" because Newton believes in the existence of the vacumm or the void. He asks in the Principia, " All spaces are not equally full;...And if the quantity of matter in a given space can, by any rarefaction, be diminished, what should hinder a dimunition to infinity?"[65] In fact, Newton goes further by drawing the conclusion that "If all the solid particles of all bodies are of the same density, and cannot be rarefied without pores, then a void, space, or vacuum, must be granted".[66]Elsewhere he writes:

> But it is usually believed that these spaces are nothing; yet indeed they are true spaces. Although space may be empty of body, nevertheless it is not in itself a void; and something is there, because spaces are there, although nothing more than that.[67]

In light of these statements, we submit that in Newton's philosophy of mathematics, "zero" refers to a state of 'temporal' non-entity which corresponds to the absence of anything (thus the nothingness) indentifiable (hence the state of chaos).[68] It is worthy to note

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[65]See Principia, Motte-Cajori, p.414

[66] Ibid., p. 414. It is worthy to note that another definition of vacuum appears in Newton's Definitiones whereby he defines it as 'every place in which a body moved without resistance' since there is no particles to provide the resistance. See also University Library, Cambridge. Add. MS 3965, f.437.

[67]See De Gravitatione, p.138.

[68]Cf. Clarke's statement:

> Void space is not an attribute without a subject, because by void space, we never mean space void of everything but void of body only. In all void space, God is certainly present and possibly many other substances which are not matter; being neither tangible, nor object of any of our senses.

that there is no perfect state of nothingness in Newton's cosmology because God "is everywhere present" (Divine Immanence), and that "he constitutes duration and space".[69] Besides, Newton believes that God "is omnipresent not virtually only but also substantially; for virtue cannot subsist without substance".[70] Since God, the sole Creator, necessarily exists, accordingly zero symbolizes the state of precreation by Him of something other than Him.

Furthermore Newton believes (like realists do) that mathematical entities such as numbers and points exist objectively in the realm of imagination. His discussion on refraction and reflection leads him to write the following passage:

> For as the rarer air within a small glass pipe, and the denser without, are not distinguished by a mere mathematical superficies, but have air between them at the orifice of the pipe...[71]

Since points, lines, geometrical figures and numbers exist objectively in the realm of imagination in Newton's philosophy of mathematics, it follows that any mathematical interpolation that necessarily involves them are also mental constructions. By and large they are the results from the activity of the internal senses. In accord with Newton's point of view, mathematicians do not have at their disposal exact images of the mathematical

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[I.B. Cohen, Leibniz-Clarke Correspondence, op. cit., p.47]

[69]See Principia, Motte-Cajori, p.545.

[70] Ibid., p.545.

[71]See Brewster, Memoirs..., Vol. I, p.401.

entities in the external world.[72] The place of mathematics has to be between the world of sensibles and the intelligibles.

In more specific terms, mathematics functions as a nexus between the material world to the subtle world since they are neither metaphysical beings which are not in matter nor natural intelligibles which are always attached to matter.[73] In the case of Newton, an understanding of the quantitative aspects and a little bit of the qualitative aspects of mathematical entities will help the mathematician in his striving for spiritual perfection, in knowing more about Divine Qualities and Divine Essence. The discussion about the qualitative aspects of mathematical symbols in his Principia, however, is not as much as the discussion on the quantitative 'mechanics' of nature. In light of the strength of emphasis, one can say that Newton's treatment on the qualitative aspect of mathematics is more of a transition from a holistic view of mathematics which take both qualitative and quantitative aspects as equally important, to that of a purely mechanical and quantitative enterprise.

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[72]A current philosophy of mathematics which, unlike Newton's conception of mathematics, considers mathematics solely for its quantitative aspects likewise shares the same position; that human reason does not have exact images of mathematical entities. The formalists contend that mathematics is nothing more than 'meaningless games of signs' and that mathematical exactness lies in the method of interpolation of the signs, "independent of the significance one might give to the relations or the entities which they relate". See L.E.J. Brouwer, "Intuitionism and formalism" in R.C. Goodstein, op. cit., p.78.

[73]See O. Bakar, Tawhid and Science, op. cit., p.22 for a similar outline of the levels of reality adopted by the Sufis.

6.4 Mathematical proof.

The concept of what constitutes a mathematical proof is a subject of much discussion in studies concerning the foundation of mathematics. Some have argued that a mathematical proof must be 'constructive'[74] while others contend that a mathematical proof need not necessarily be so.[75] In this section, we will investigate Newton's concept of a mathematical proof and to study its features.

In one of his methodological remarks about mathematics, Newton says that "Synthesis consists in assuming the Causes discover'd, and establish'd as Principles, and by them explaining the Phenomena proceeding from them, and proving the Explanations".[76] He was referring to the mathematical arguments that he presents ubiquitiously in the Principia. A mathematical proof is a subset of what Newton calls a mathematical reasoning or a mathematical demonstration. What is a mathematical reasoning to Newton? In his preface to the second edition of the Principia, Cotes states:

> Now it is evident from mathematical reasoning, and rigorously demonstrated, that all bodies that move in any curved line described in a plane and which, by a radius drawn to any point, whether at rest or moved in any manner, describe areas about that point proportional to the times are urged by forces

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[74]An example is the position taken by the intuitionists. See A. Heyting, "Disputation," in R.C. Goodstein, op. cit., pp.66-75. See also R.L. Wilder, Introduction to the Foundation of Mathematics, (London, 1965), pp.246-256.

[75]We have in mind the formalists and the followers of Russel, the latter otherwise known as the logicists. See R.L. Wilder, ibid., pp.264-74.

[76]See Opticks, pp.404-5.

directed toward that point.[77]

In addition to the above passage, he likewise states:

> Moreover, it must be granted, as being mathematically demonstrated, that if several bodies revolve with an equable motion in concentric circles and the squares of the periodic times are as the cubes of the distances from the common center, the centripetal forces will be inversely as the squares of the distances.[78]

Elsewhere, Newton writes "...in the particles that remain undivided, our minds are able to distinguish yet lesser parts, as is mathematically demonstrated".[79] In Cotes' preface which was sanctioned by Newton,[80] the phrase "mathematical reasoning" or the phrase that a particular problem "as being mathematically demonstrated" involves geometric figures, rigor and calculations.

The important thing to take into account is that "mathematical reasoning" as presented in the Principia is written in an Euclidean manner.[81] Problems are solved based on propositions and the latter are further verified based on general principles of

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[77] See Principia, Motte-Cajori, p.xxii.

[78] Ibid., p.xxii.

[79] Ibid., p.399.

[80] Letters between Cotes and Newton are documented in J.Eddleston, Correspondence of Sir Isaac Newton and Professor Cotes, op. cit. With regard to Cotes' Preface, see pp.147-159.

[81] Surely there are differences between Euclid's Elements and the Principia. Just to cite an example, Newton's first principles or axioms, unlike Euclid's parallel postulate which can never be proven experimentally, "are deduced from phenomena and made general by induction". See J. Eddleston, Correspondence...., ibid., p.155.

phenomena, called axioms[82] which are established in the early part of the book.[83] Just as Euclid's axioms follow from definitions preceding them, so does Newton's.[84] If we were to say that Newton's mathematical reasoning or demonstration corresponds to mathematical modelling, then we should say that his is a "structured modelling".

His "structured modelling" is an indepth account and an extensive elucidation of notional explanation.[85] Thus one has to bear in mind the connection between the problem that he mathematizes and its significance to his belief in God.[86] As part of a "structured modelling", a mathematical proof shares the same feature as a notional explanation since a mathematical proof is not to be studied only from the angle of a symbolic structure that can be characterized by referring only to the system of rules governing the construction of the proof. Rather one has to take into consideration that the nature of the "structured modelling" is determined by the lists of axioms which in the case of Newton, are

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[82]See Principia, Motte-Cajori, p.13.

[83]See Opticks, p.405.

[84]For example, for Definitions I and II Newton states: "The quantity of matter is the measure of the same, arising from its density and bulk conjointly" and "The Quantity of motion is the measure of the same, arising from the velocity and quantity of matter conjointly." Other definitions that he gives include "innate force", "impressed force", and "centripetal force". See Principia, Motte-Cajori, pp.1-3.

[85]We have given our remarks on notional explanation in Chapter 4, pp.177-8.

[86]As written in the preface, "The business of true philosophy is to ...inquire after those laws on which the Great Creator actually chose to found...the World". See Principia, Motte-Cajori, p.xxvii.

in turn based on metaphysical principles. The Principia, which Newton presents "as the mathematical principles of philosophy",[87] is written based "upon such principles as might work with considering men for the belief of a deity;...".[88]

A consequence of such sacred relation is to include the acts of God in shaping a mathematical proof. Two features characterizing mathematical proof follow from the metamathematical connection. The first concerns the completeness of a mathematical proof and the second involves nevertheless an important aspect of a mathematical proof, as an argument to save the phenomena. Writes Newton:

> It is indeed a matter of great difficulty to discover and effectively to distinguish the true motions of particular bodies from the apparent, because the parts of that immovable space in which those motions are performed do by no means come under the observation of our senses. Yet the thing is not altogether desperate; for we have some arguments to guide us, partly from the the apparent motions (part of phenomena) which are the differences of the true motions; partly from the forces (mathematical), which are the causes and effects of the true motions.[89]

We will deal with the first feature which revolves around the question of mathematical truth in the next section. It is to the second feature, mathematical proofs functioning as arguments of saving the phenomena that we will now turn to.

In the case of Newton, mathematical proofs when viewed as "saving the phenomena" resulted when the mathematician descends

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[87]See ibid., p. xvii.

[88]See Papers and letters, p. 280.

[89]See Principia, Motte-Cajori, p.12.

from contemplating the qualitative aspect of mathematics to mainly its quantitative aspect without negating the importance of the former, that is without losing insight of the sacred aspect of mathematical knowledge. In Newton's philosophy of mathematics, where he stresses more on the mechanical and quantitative rather than the qualitative aspects of mathematics, the place of the arguments (as far as saving the phenomena is concerned) is in the world of quantity. Mathematical proofs which are founded on axioms and propositions and more often than not elaborated with figures construed as convenient geometrical devices[90] are, but one of the most plausible evidence to support the phenomena.

Since all physical bodies and the relations between them can be quantified in some respect, they are "savable" or "preservable", so to speak. Yet we have to bear in mind that in the case of Newton, mathematical proofs are not in any sense exact images of the phenomena. At most they are only saving certain aspects of the phenomena. Thus his statement that "the reader is not to imagine that by those words I anywhere take upon me to define the kind or the manner of action, the causes or the physical reason thereof,..."[91]

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[90]The mathematical proofs presented in the Principia are very dependent upon geometrical figures to the extent that almost every page has one and that in the preface, Newton not only commended Halley because "it was through his solicitation that it came to be published", but also for the latter's effort of "preparing the geometrical figures." See ibid., p. xviii.

[91]See ibid., pp.5-6.

6.5 Mathematical Truth

So far we have explored several features of Newton's philosophy of mathematics. We have not examined one of its vital aspect which is Newton's position with regard to mathematical truth. We want to know the nature of his concept of mathematical truth. We have in mind problems such as whether there is any connection linking his mathematical enterprise and truth, whether to him mathematical truth amounts to belief, whether mathematical certitude does exist, and whether it makes any sense at all to talk about mathematical truth.

Newton does talk about truth in his mathematical enterprise. He views mathematics as a pathway, as one of the ways of knowing that can procure truth. The truth about the external world which is initially created by God can be found through mathematics. His discussion pertaining to the laws of motion leads him to write:

> These principles I consider, not as occult qualities supposed to result from the specific forms of things, but as general laws of nature by which the things themselves are formed, their truth appearing to us by phenomena,...[92]

In fact, Newton not only concerns himself that his discoveries and his laws of nature are true; he also sought "true steps" in his mathematical enterprise because these "true steps" bring him nearer "to the knowledge of the first cause".[93] Therefore truth is central to both his method as well as in his mathematical discoveries in

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[92]See Opticks, p.401.

[93] Ibid., p.370.

his mathematical enterprise. It does make sense to talk about truth in his philosophy of mathematics.

According to Newton, mathematical truth or mathematical certitude are bounded by the truth of its axioms. Their truths are very much dependent upon the truth of the main principles. It is not the case that the axioms are false and yet the theorems derived from them can be true.[94] In his letter to Oldenburg, he states:

> ...I said, indeed, that the science of colors was mathematical and as certain as any other part of optics; but who knows not that optics, and many other mathematical sciences, depend as well on mathematical demonstration? And the absolute certainty of a science cannot exceed the certainty of its principles.[95]

In the case of Newton, the truth of each of the principles is verified by experiments. An axiom is true not because other competing axioms are false.

Moreover Newton claims that to grant that an axiom is true simply because the others are false is beyond human capability because he believes that such method presumes that the mathematician knows before hand all the competing axioms. Thus:

> ...I cannnot think it effectual for determining truth to examine the several ways by which phenomena may be explained, unless where there can be a perfect enumeration of all those ways. You know, the proper method for inquiring after the properties of things is to deduce them from experiments. And I told you that the theory which I propounded was evinced to

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[94]This is interesting indeed because, contra Newton, it is unreasonable to say that since Newton's Laws of motion are false, all theorems derived from them are necessarily false.

[95]See Newton's letter dated July 11, 1672 in Opera Omnia, IV, p.342.

> me, not by inferring 'tis thus because not otherwise, that is, not by deducing it only from a confutation of contrary suppositions, but by deriving it from experiments concluding positively and directly.[96]

In order to enumerate all the competing axioms (which in Newton's terminology are usually called hypotheses if they are unproven by experiments) presupposes that the mathematician knows an infinite list of possibilities.[97] In similar vein, he also states:

> If anyone offers conjectures about the truth of things from the mere possibility of hypotheses, I do not see how anything certain can be determined in any science; for it is always possible to contrive hypotheses, one after another, which are found rich in new tribulations.[98]

Newton was very much aware of the limitation of being human. "To explain all nature is too difficult a task for any one man or even for any one age",[99] he writes. In Newton's philosophy of mathematics, only God has complete knowledge of all the possibilities for "he governs all things and knows all things that

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[96]See Newton's letter to Oldenburg, dated July 1672, ibid., pp. 320-21.

[97]To this effect, Newton states in his rejoinder to criticisms made by Huygens:

> Nor is it easier to frame an Hypothesis by assuming only two Original Colours, rather than an indefinite Variety; unless it be easier to suppose that there are but two Figures, Sizes, and Degrees of Velocity or Force of the Aethereal Corpuscles or Pulses, rather than an indefinite Variety;... [See Philosophical Transactions, No. 97, 1673, p.6108]

[98]See Newton's letter to Oldenburg, dated June 2, 1672 in Opera Omnia, IV, p.314-315.

[99]See the text reproduced by I.B. Cohen in his Creative..., op. cit., p.99.

are or can be done"[100] and that he "hath all knowledge originally in his own breast".[101] Here we can see an implication of his belief in God that has an important bearing on his concept of mathematical truth.

Newton believes that although mathematicians can arrive at truth by way of mathematics, since "it is the best way of arguing which the Nature of Things admits of,..."[102] mathematical truth at the level of sense experience are never final. At that level, mathematics are open ended so to speak. By its very nature, mathematical knowledge at the level of sense experience is incomplete. It is only that by mathematizing nature, "we argue more safely concerning the physical species, causes, and proportions of the forces...".[103]

In addition to the above, Newton believes that mathematical knowledge at the level of sense experience is uncertain. In writing the Principia, Newton realizes that his whole mathematical corpus can be rejected and thus can be replaced by other laws, propositions and theorems. "I hope the principles here laid down will afford some light either to this or some truer method of philosophy",[104] says Newton in his preface to the Principia.

Although all the axioms are "deduced from phenomena, and made

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[100]See Principia, Motte-Cajori, p.545.

[101]See Theological Manuscripts, p.56.

[102]See Opticks, p.404.

[103]See Principia, Motte-Cajori, p.192.

[104] Ibid., p.xviii.

general by induction, which is the highest evidence that a proposition can have in (this) philosophy,"[105] yet Newton was never absolutely sure about them. In fact, the truth of the laws, propositions and theorems varies. There are 'horizontal' degrees of truth. In his own words, they are "so much the stronger, by how much the Induction is more general..."[106]

In mentioning mathematical truth, Newton is also aware of the 'vertical' aspect of truth. He believes that there are levels of truth. These levels correpond to the various levels of reality explicated earlier.[107] He draws distinction between physical and mathematical truth because of the differences in their orientation. Says Newton:

> In mathematics we are to investigate the quantities of forces with their proportions consequent upon any conditions supposed; then, when we enter upon physics, we compare those proportions with the phenomena of Nature, that we may know what conditions of those forces answer to the several kinds of attractive bodies.[108]

Elsewhere, in the beginning of the Principia wherein he expounds the difference between "quantities" and their "sensible measures," he states:

> Wherefore relative quantities are not the quantities themselves whose names they bear, but those sensible measures

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[105]See Newton's letter to Cotes in J. Eddleston, op. cit., p.155.

[106]See Opticks, p.404.

[107]See Chapter V, pp. 213-4.

[108]See Principia, Motte-Cajori, p.192.

> of them (either accurate or inaccurate) which are commonly used instead of the measured quantities themselves. And if the meaning of words is to be determined by their use, then by the names 'time,' 'space,' 'place,'and 'motion' their [sensible] measures are properly understood; and the expression will be unusual, and purely mathematical, if the measured quantities themselves are meant. On this account, those violate the accuracy of language, which ought to be kept precise, who interpret these words for the measured quantities. Nor do those less defile the purity of mathematical and philosophical truths who confound real quantities with their relations and sensible measures.[109]

Accordingly in Newton's philosophy of mathematics physical truth lies in the domain of the material or gross world which is the world of "sensible measures" whereas mathematical truths are closer to the subtle world which is more abstract.[110] Ultimately absolute truth belongs to God for only He is "absolutely perfect"[111] and it is "from this fountain that those laws which we call the laws of Nature have flowed".[112] We can discern the remnants of holistic orientation in Newton's philosophy of mathematics wherein the vertical notion of truth is manifested. More importantly, it is the arrival at these various levels of truths that mathematicians should strive and seek for because essentially it is truth that separates imagination and understanding. "A man may imagine things that are false, but he can only understand things that are true,

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[109] Ibid., p.11.

[110] To this effect, "Geometers", Newton says, "define a Line which has length without width that their Propositions about this sort of Lines only maybe understood, and yet in Mechanics and other Sciences a wide line has a place..." See I.B. Cohen, Creative..., op. cit., p.127.

[111] See Principia, Motte-Cajori, p.544.

[112] Ibid., p. xxxii.

for if the things be false, the apprehension of them is not understanding",[113] writes Newton.

6.6 Conclusion

In Newton's philosophy of mathematics, the result of any mathematical endeavour points to the pervasive Divine Wisdom which is manifested everywhere. Observations and experimentations lead to the discovery of certain exoteric aspects of nature but the ultimate objective of mathematical activity is to connect these discoveries to their inner reality or noumenon, which is the essence relating them to the Truth.

One can say that Newton's philosophy of mathematics is an apologia for theology because of the emphasis on the mechanical and quantitative rather than the qualitative aspects of nature. Mathematics is but one way of knowing among other ways of knowing reality and in Newton's mathematical enterprise, mathematical discoveries can still serve as aids for the mathematician's spiritual journey in his quest for studying nature so much so that he will understand that in the ultimate analysis, all of the variety of forms and motions are connected to the Creator.

Despite paving the way for a mechanical and quantitative view of nature, Newton cannot be classified under any of the modern western philosophy of mathematics because of the centrality of God in his philosophy of mathematics and consequently in his mathematization of nature. If one considers his view of

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[113]See Theological Manuscripts, p.127.

mathematical truth, proof, infinity, numbers and other mathematical entities, one cannot place him without remainder into any of those philosophical category, the latter of which are nothing more than consisting of sophisticated arguments at the level of sense-experience. After three hundred years, Newton is definitely a mathematical philosopher to be reckoned with.