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On the Reality of Mathematics

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ABSTRACT

Mathematics is an integral cornerstone of science and society at large, and its implications and derivations should be considered. That mathematics is frequently abstracted from reality is a notion not countered, but one must also think upon its physical basis as well. By segmenting mathematics into its different, abstract philosophies and real-world applications, this paper seeks to peer into the space that mathematics seems to fill; that is, to understand *how* and *why* it works. Under mathematical theory, Platonism, Nominalism, and Fictionalism are analyzed for their validity and their shortcomings, in addition to the evaluation of infinities and infinitesimals, to show that mathematics, in its purest form, has little to do with tangible things. Under the physics section, quantum mechanics and astrophysics are investigated, but for the opposite purpose: to show, using the examples of black holes and quantum entanglement, that mathematics is, at base, still the language of the "real" and formal sciences. All of these pieces are contrasted with their philosophical and theological principles to show their ramifications with regard to both atheistic and theistic worldviews. Finally, my personal, synthetic philosophy concerning numbers is delineated in contrast to the ideologies mentioned before.

Introduction

Students of mathematics, especially the less intellectually curious ones, often complain that higher level mathematics is, practically speaking, useless. After all, when might one use geometric proofs in “real life”? Of what use are these so-called “imaginary” or “complex” numbers? Why must one learn to calculate the volume of a triangular prism? To many people both young and old, the appending of symbols into mathematical equations seems almost arbitrary and unnecessarily confusing. It would seem to them that the rationale behind these and other inclusions are rarely explained, and never justified. Calculus seems entirely useless, for one will never need to calculate the area under a curve in real life. It quickly becomes clear that there is a lack of appreciation for the beauty of mathematics. We often miss that mathematics is a language that unites the scientific community and provides a common basis upon which to develop technology and scientific rhetoric. In fact, I postulate that mathematics practically relates to reality in physics, but is also heavily abstracted from reality in theory; mathematical truths were created by God for us to use as tools.

Mathematical Theory

Mathematics is the language of the scientist. It is extraordinarily unique in its continuity and its unity. In fact, it was created, developed, and perfected for use in the sciences. Historically, mathematics was studied largely in relation to physical phenomena: the Greeks and Egyptians formulated the foundations of geometry and applied them to architecture and astronomy; the Arabs conceptualized algebra and trigonometry for their own scientific endeavors; Newton, Leibniz, Kepler, and others put to work symbolic algebra, calculus, and logarithms in their preliminary research in physics. However, mathematics is now studied separately, almost as an art form. In fact, the study of mathematics is widely considered to be the study of “pure” mathematics. James Nickel, in his book *Mathematics: Is God Real?*, speaks to this idea:

> Professionally, mathematicians can be found in two camps. Most call themselves pure mathematicians while a minority call themselves applied mathematicians or physicists. To the mathematicians of the pure camp, mathematics is studied for its own sake. If the theories formulated happened to apply to the real world, it is okay, but not to be expected. The pure camp looks with disdain upon the applied camp as if they are not fit to be called mathematicians. To the purists, those applied rascals have too much dirt on their shoes and dust on their computers from meddling with the real world (163).

Unfortunately, the pure mathematician can run into problems, as his newly abstracted animal quickly runs away from him. The Hungarian-born mathematician John von Neumann offered a little-heeded warning in 1947:

> As a mathematical discipline travels far from its empirical source, or still more, if it is a second and third generation only indirectly inspired by ideas coming from "reality," it is beset with very grave dangers. It becomes more and more purely aestheticizing, more and more purely *l’art pour l'art* [art for art's sake]. This need not be bad, if the field is surrounded by correlated subjects, which still have closer empirical connections, or if the discipline is under the influence of men with an exceptionally well-developed taste. But there is a grave danger that the subject will develop along the line of least resistance, that the stream, so far from its source, will separate into a multitude of insignificant branches, and that the discipline will become a disorganized mass of details and complexities. In other words, at a great distance from its empirical source, or after much "abstract" inbreeding, a mathematical subject is in danger of degeneration (2063).

For example, using pure mathematics, it is possible to show that the sum of all positive integers is $-\frac{1}{12}$. Intuitively, the sum of all positive integers should equate to infinity, and thus not have a finite value. However, pure mathematics is so heavily removed from physical things that, in its own universe, $1 + 2 + 3 + 4 + \cdots = -\frac{1}{12}$ can be true (even though it is obviously false; the mathematician Ramanujan, who popularized this idea, made a controversial assertion in his proof). In fact, the entirety of pure, axiomatic mathematics rests upon assumptions. With postulates and axioms, we simply state that certain things are true and build from that foundation. It is for this and other reasons that there are different geometries. Euclidean geometrics is the most popular, as it is the most intuitive and logical, but it does not relate particularly well to a 3D space. Therefore, 3D space has its own geometries that play by different rules. Note, however, that this does not make Euclidean geometrics any less true, but it instead forces Euclid's geometry to exist inside itself exclusively. This is all rather confusing, of course, but it is the consequence of such forceful dissociation from the real world.

It is pertinent, then, to discuss the various philosophies of mathematics. There are three main ideologies that speak to the reality (or abstraction therefrom) of mathematics: Platonism, Nominalism, and Fictionalism. Other philosophies exist, but those are usually derived in some way from the aforementioned philosophies. These main schools of thought encompass the attitudes towards what numbers are, how mathematical operators work, and how those things interact with each other. More specifically, they respectively define the foundation from which we draw the concept of the number; that is, they provide an analysis for what the truth of mathematics is.

The Platonist, for example, believes wholeheartedly that numbers are, by definition, real. Just as you and I exist, so too does the number. As the mathematician Stewart Shapiro puts it in his article “Mathematics and Reality”:

> Platonism is the view that the subject matter of mathematics is an immaterial and non-mental realm or universe that exists independently of the physical world. According to this view, mathematical assertions are taken literally as statements about this mathematical universe. The assertion that there are infinitely many prime numbers, for example, is understood as expressing a fact about the independent domain of natural numbers, that among these numbers, infinitely many are prime (531).

The only distinction, for the Platonist, is that numbers do not exist within the confines of space and time, as we do. Rather, they are an abstract object that is a true *thing*, but not a physical thing. Shapiro also comments on this idea, saying that, “The Platonist…seems to believe that the mathematical world has an existence that is separate from and independent of the physical world” (532). Essentially, Platonism boils down to faith. The Platonist believes, or has faith in, the fact that numbers are real. However, problems quickly arise with this philosophy. Recall that the Platonist believes in the “abstract” number. In his view, numbers do exist, but they exist somewhere else, and mathematics essentially makes claims about these abstract objects and the manner in which they interact. How, then, is mathematics so reliable? The majority of the claims a mathematician makes are demonstrably true. How is it possible for mathematics, and by extension, mathematicians, to so consistently affirm the traits of these objects that are removed from the realm in which they work? These questions cannot be adequately satisfied by the Platonist.

The Nominalist, by comparison, is on the other end of the spectrum. He believes that numbers are simply an extension of language: they are used to describe a quantity. Numbers, to a Nominalist, are used to count with respect to reality. Numbers, to a nominalist, are merely a quantitative adjective that are applied with an associated object. Shapiro states:

> This philosophy holds that mathematics consists of no more than the manipulation of characters according to rules. That is, the formulas of mathematics are considered to be strings of meaningless characters, not genuine symbols (which symbolize something). A theorem of, say, arithmetic, does not represent a fact about the natural numbers (or anything else for that matter). Rather, such a theorem is the result of a series of manipulations according to the rules of arithmetic (528).

(Note that Shapiro is speaking of Formalism, the mathematical philosophy that is derived from the general philosophy of Nominalism, of which we are speaking.) If the Platonist was a rationalist, then the Nominalist is an empiricist. And, like Platonism, there are numerous (pardon the pun) problems with Nominalism. For one, there are types of numbers that are, by definition, abstracted from reality. For example, it is impossible to physically represent the square root of negative one ($\sqrt{-1}$), also known as "*i*". Where the Platonist would assert that this is simply another number, the Nominalist arises empty handed, as it is causally inaccessible. Infinities or irrational numbers are similarly unattainable, and, therefore, attempting to discern or apply their properties makes little to no sense.

Finally, to address the theories of the Fictionalist. If the Platonist and the Nominalist were on opposing sides of a spectrum, then the Fictionalist throws out the spectrum entirely. More specifically, the Fictionalist makes the fundamental assertion that mathematical discourse is entirely false. Arthur Collins, in his article "On the Question 'Do Numbers Exist?'", asserts that:

> So realism and nominalism share a certain ground. They both purport to understand that the existence of numbers would explain something we take to be true. They differ only in that the realist concludes that the story with numbers is a true story, and the fictionalist concludes that the same story with numbers is just a story (25).

The Fictionalist agrees that mathematics is a useful tool, but that it is not truth, philosophically speaking. By extension, what mathematicians demonstrate is also not true; here, the attentive reader will immediately discern the inherent logical holes of this school of thought. If mathematics is not true, then how has it been so reliably demonstrated? Mathematicians have put man on the moon. They have revealed the innermost building blocks and outermost expanses of the universe. How, therefore, can mathematics be false? The Fictionalist would argue that success is not a hallmark of truth. Mathematics is merely a convenient and effective story that man has created to assist in his exploits. From his previously quoted piece, Collins concludes:

> But what is the story? What does it explain? If we know that there are four primes smaller than 8 we cannot posit the existence of numbers in a true story to explain what we know. What we know offers no story that might be just fiction either (25).

These are the problems the Fictionalist must face.

One of the challenges mathematical philosophy faces is the concept of these numbers and theorems that exist outside of what can be empirically shown. For example, there are a group of numbers that are classified as “transcendental”. According to *The Penguin Dictionary of Mathematics*, a transcendental number is “a number that is not an algebraic number….”, which essentially means that a transcendental number is not a complex or real number that is “the root of a polynomial equation with integer coefficients” (Nelson). A few examples of transcendental numbers are Pi (π), Euler’s number (e), and the square root of two ($\sqrt{2}$). These numbers cannot be represented precisely in any real sense, and, in fact, must be frequently approximated to apply them in any way. Pi, for instance, is commonly abbreviated as "3.14" for use in geometric problems, as the abbreviation provides the majority of the utility of pi, without sacrificing sanity in its usage. These numbers and others are both derived from algebraic deduction and are used extensively in algebra, calculus, and other areas of mathematics. However, one must realize that they cannot be represented like other numbers; that is, they cannot correspond to a physical thing such two or twenty-five can. One may plant seventeen trees, but one cannot plant *e* trees. It is fundamentally impossible.

Other imaginative aspects of mathematics are the ideas of infinities and infinitesimals. They are similar to the aforementioned transcendental numbers in that they cannot be physically represented. Infinities and infinitesimals are arguably the largest departures of mathematics from reality, and can be the most difficult concepts of pure mathematics to grasp. Firstly, we shall address infinity (∞). The first thing to note about infinity is that it is *not* a number. Mathematically, it is an infinite set, or a collection of numbers that extends forever. There are, of course, different kinds of assemblages, the most common being the set of all positive integers. This set begins with one and simply adds one to the previous number forever. This set has the classification of a "countable" set, which is a misleading name, on account of the fact that it is impossible to count infinity. A better, more descriptive adjective would be "listable". This implies that the set can be visualized or verbalized; it could be physically counted, if an infinite amount of time was given to do so. George Cantor (1845-1918) developed these ideas exponentially in his lifetime. Nickel explains:

> Cantor founded his study of infinity on the bedrock that nature made use of it everywhere and that the concept of infinity effectively showed the perfection of its Author. In his

> analysis, the infinite set of counting numbers provided the foundation for his theories. From this basis, he proved many unusual and remarkable theorems about the "arithmetic" of infinite sets. For example, by extending the finite number concept to infinity, he showed that there are two kinds of "infinities". One is the infinity of the set of counting numbers, the cardinality of which he denoted as aleph-null, $\aleph_0$, (aleph is the first letter in the Hebrew alphabet). The other is the infinity of the set of real numbers (the union of rational and irrational numbers), the cardinality of which he denoted $\aleph_1$ or C for the "power of the continuum." He then went on to show that there is no infinite set, of whatever aleph, which cannot be "transcended" by another of a higher aleph. By that, he meant that there are an infinite number of infinities (183)!

In the aforementioned set of all real numbers, it is not even possible to progress from zero to one. An infinite set of numbers exist between those two numbers, in that there are an infinite amount of decimal parts between zero and one. In fact, there are more numbers in between zero and one than there are whole numbers on the entire endless number line. Furthermore, there is a mathematical proof of this concept: if one has an infinite list of decimals that all occur between zero and one, it is always possible to create a new one via a method known as Cantor's Diagonal Argument. This argument postulates that if you list an infinite amount of decimals between zero and one, and then move diagonally along the decimal places of those decimals (the first decimal place from the first decimal, the second place from the second decimal, and so on) and then change each number according to a rule (for example, adding one to each number except for nine, where you subtract one), your new number will, necessarily, not be on the original, infinite list. This is because it must be different from each decimal on the original list in at least one decimal place. Ergo, the set of all real numbers is uncountable because it is impossible to progress even from zero to one without another, inherent infinity. This would also insinuate that the set of all real numbers is a bigger infinity than the set of all whole numbers. These ideas are contained within the realm of what is known as “set theory”, the branch of mathematics that deals directly with sets, their interactions, and their implications. While set theory as a whole is very practical, this concept of eternality is not. It is one of many ways in which mathematics is abstracted from reality.

Equally confusing as infinity is its opposite. Infinitesimals are defined as everything less than all the real numbers that are still greater than zero and are included in the set of all real numbers, lending themselves to that set’s “uncountability”. Infinitesimals have been controversial for almost as long as they have been in use. Newton and Leibniz used them in developing the calculus, but they were later removed due to their inconsistencies. They were superseded by the mathematical limit, which is used when a function builds towards something but never reaches it. However, infinitesimals actually made a comeback in the 1960s where they were included in the list of real numbers as “hyperreal numbers”. Infinitesimals are a fantastic example of how mathematics diverges from reality into the realm of the axiomatic, where logic becomes so complex that we begin to establish the rules ourselves. The point is this: although mathematics originated from the need to express concrete ideas and objects, it has, in its purest form, progressed to the point where it is no longer chained to reality. It is a symbolism without a concrete sandbox.

Physics

As we have established, mathematics is often surprisingly separated from the real world. Nonetheless, it was begat by the need to relate and quantify physical things. For what use are numbers and conjectures if not to apply them? Euclid, Euler, and Einstein all flexed their mathematical muscles in their application of formulae to atoms and astronomy, and established a numerical ecosystem that has served us for generations, and will continue to be the foundation of scientific discovery for years to come. I mentioned before that mathematics was the language of the formal scientist. This is nowhere more true than in the subject of physics. In particular, the concentrations of astrophysics and quantum physics are on the cutting edge of mathematical and experimental development. As such, it is critical to at least briefly glimpse both.

Quantum physics (or quantum mechanics) deals specifically with the activities of nature on the subatomic level. What makes quantum mechanics so riveting, though, is how stunningly different it is from regular physics and how many irregularities it contains. For example, consider quantum entanglement. Basically, this theory posits that when two particles interact, they influence each other in a manner that connects their properties in some way. The Heisenberg Uncertainty Principle dictates that there is a limit to how accurately we can measure the properties of these subatomic particles. Nickel extends the origin of this principle:

> In the realm of quantum mechanics, this principle states that you cannot measure momentum and position of an atomic particle at the same time. That is, there is an inherent limitation to the accuracy that can be achieved in measurements and this limitation is *only* noticeable on the atomic level (physicists have to resort to statistical averages rather than exact measurement) (204).

Note, however, that this principle is different from the Observer Effect (which postulates that an observation can change a result regardless of the separation between the two), in that the Uncertainty Principle is a *property* and not an effect. Moving on though, the Uncertainty Principle asserts that we cannot know for certain how the particles are connected, because the moment we measure one, the other's properties are instantaneously determined, even across large distances. In fact, *any* interaction with the entangled particles can destroy the entanglement. This makes it difficult to develop the theory, especially when considering the concept of quantum "blurriness", which maintains that as one tries to observe smaller and smaller things, it becomes more and more difficult to accurately measure those things. Though, it has been shown through experiments that some of the effects that would be expected as a result of quantum entanglement do exist. Of course, mathematics is what facilitates these experiments and provides the only visible representation for these particles and interactions that exist at a subatomic level. Notes Nickel:

> It may be that behind the physics of quantum mechanics lies a higher degree of unity and harmony that our current instrumentation cannot yet measure. The wisdom and logic of the quantum realm may be so complex that we may never be able to unravel it. The only instrumentality that we have to help us describe this realm now are the wonderful tools that mathematics gives us (205).

Regardless, quantum mechanics is one of the most bizarre and fascinating concentrations of science, and this can be seen not only in quantum entanglement, but also in the plethora of other phenomena and hypotheses present in the field of quantum mechanics.

The direct effects of these phenomena can be observed on a much grander scale. Astrophysics further elevates the level of fascination associated with quantum mechanics because we can actually visualize most of what is occurring in real space. The refinement of the telescope by Galileo revealed the clinquant, crazy cosmos and opened up an entirely new and intensely diverse field of study. Quantum physics has its quarks, but astrophysics has its quasars — and supernovae, black holes, galaxies, nebulae, and dark matter. It is, quite literally, a supermassive expanse. Indeed, the universe is not only expanding, but its expansion is accelerating. The universe is enlarging more quickly as time wears on. This can be seen through the red-shifting of light from distant stars as it reaches earth. What this means is that the perceived wavelength of the light actually extends as the universe expands away from where the light was emitted, thus changing the perceived color of the light. Speaking of light, Einstein's Special and General Theories of Relativity govern the properties of light and also the interactions and properties of these stellar bodies. James Nickel relates the scope of these works:

> Experimentally, Einstein's theories were limited in application to the realms of the very fast (e.g., the speed of light) and the very large (e.g., the entire universe). Everywhere else, including flying in an airplane and sending men to the moon, Einstein's theories paralleled those forecasted by Newtonian mechanics (201).

This does not, however, negate the importance of his works. It is because of Einstein that we are able to realize and explain many of the phenomena of the universe and continue to refine our knowledge of them. Many of these phenomena manifest themselves in heavenly bodies. Of those celestial entities, black holes are conceivably the most alluring. The mystery of their existence has enraptured astronomers, astrophysicists, and sci-fi authors for years. Part of the reason for this is the necessity of a singularity. According to Newton's laws, a black hole would have an infinitely dense amount of matter in an astoundingly small space, somewhere beyond the event horizon. His gravitational equation is strange, because as "r", which represents distance, approaches and reaches zero, the gravitational force becomes infinite. This is physically impossible. Matthew O'Dowd, Assistant Professor in the Physics and Astronomy Department at Lehman College, explains that:

> So, does the fact that it includes a singularity mean there's something fundamentally wrong with Newton's law of gravitation? Well, we already know the law isn't really so universal. When the gravitational field is too strong — say, near a star or a black hole — Newton's law gives the wrong answers, and we need Einstein's general theory of relativity, which is the far more complete theory of gravity. So does general relativity rid us of Newton's pesky singularity? No. In fact, it gives us even more singularities (The Phantom Singularity | Space Time).

Although we cannot be sure of whether or not these singularities are real, as it stands, our understanding of physics would imply that these singularities are necessary, however absurd. And to be fair, it is absurd: the equations that show us this necessity are perhaps incomplete, and alternatives are being studied and considered presently.

Both astrophysics and quantum mechanics are extreme in their assertions and assumptions, but both are grounded in reality. They rely heavily upon mathematics to lead them to new knowledge, but this knowledge is directly mapped to the physical realm in some way. Physics and mathematics certainly dance hand-in-hand, and their waltz is the music of many scientists and mathematicians alike.

Theological and Philosophical Basis

Throughout history, Man has sought to expand his mental horizons and to increase his knowledge of himself and the world in which he lives. The main tool he uses to do this, of course, is science. However, science must always answer for its foundations; or rather, the scientist has had to answer for its foundations. Philosophically, if there is nothing absolute, then nothing can be absolutely true. Therefore, without a solid basis on something that is true, science cannot stand. Science, being a construct of Man, cannot explain its authority itself. That duty is left entirely to the men and women who have created it. Historically, the vast majority of innovators in science were at least deists, and at most, passionate Christians. Being of a monotheistic persuasion gave meaning to their work and purpose to their lives. That is, it was because they were Christians that their work garnered meaning; they were not scientists first and Christians second. A particularly relevant example would be the personhood of Sir Isaac Newton (1642-1727). His advancements in physics were so revolutionary and widely regarded that they paved the way for future innovation, and a large portion of his works are still in use today. Daniel J. Boorstin, a renowned historian, ascribed to Newton these praises:

> In Newton converged and climaxed the forces advancing science. His age, as we have seen, was already going "the mathematical way". New Parliaments of science, for the first time, were exposing observations and discoveries for discussion, endorsement, correction, and diffusion. For a quarter-century as president of the Royal Society in London he made it an unprecedented center of publicity and of power for science (402).

Moreover, Newton is important because his revelations in physics were predominantly proven on paper. That is, his physical laws and hypotheses were expressed almost exclusively in mathematical form. Boorstin elaborates, saying, "Reacting against these pretentious suppositions, Newton determined to stay on the straight path of mathematics. He believed that although he might seem now to explain less, in the long run his experimental philosophy would surely explain more" (403). There were others like him: Descartes, Leibniz, Einstein, and so forth, and all expressed a belief in a divine being, who was, at minimum, Aristotle's Unmoved Mover. Most often, though, they declared a faith in the God of Christianity. Many scientists and mathematicians of antiquity shared this sentiment and, according to James Nickel, "To the men of the Reformation, the final reference point in all thinking, the ultimate in intelligibility, rested in the biblical revelation of the infinite, personal God" (155).

As was previously stated, science must declare some sort of truth in order to retain any amount of validity. Logically speaking, this can be proven: assume nothing is true. How, then, can the statement "there is no truth" be true? This sort of extreme skepticism is self-defeating. We have established, therefore, that science necessitates some sort of certainty. For the atheist, that principle would be simply that there is no god. All of the atheistic scientist's assertions stem from this claim. The fundamental truth of a godless universe is, for the atheist, reflected in all of his ideas. Man exists because of evolution, says the atheist, which was set in motion when the universe exploded into being from the Big Bang. Furthermore, the atheist would argue that because these two mechanisms *must* be real for us to exist, the universe must be billions of years old. The atheist cannot see outside of this box and, as a result, the vast majority of modern science is built upon the assumption that we are here as a byproduct of chance.

At the other end of the table, we have theism, under which I will speak specifically of Christianity. I contend that Christianity not only provides a much better basis for science, but also celebrates it far more than atheism does. Where atheism *needs* scientific "advancement" to validate its rejection of the supernatural, Christianity *wants* science because it further supplements its glorification of God and supports His supernatural claims. Moreover, because Christianity maintains belief in a God of order, rather than one of chaos, it can support its scientific contentions with bookends: Christianity knows what came before and what comes after. The fact that Christianity establishes the limits of the universe grants much more weight to the insistence of the scientist and the mathematician.

In Man, these boundaries are well-established. Humanity, as a result of its nature, *must* perceive things through certain lenses; namely, Man must gaze at the physical world through the visors of space, time, and causality. Mathematically, this idea could be represented as a graph, where time is the x-axis, space is the y-axis, and causality is the binding agent in Man's frame of reference. As it happens, this concept is used frequently in modern physics to establish the uniformity of physics across all frames of reference. Thus, we can predict what we would see while moving at light speed, or, alternatively, what would appear to happen to someone moving at light speed. The mechanism that allows us to do this is called the Lorentz Transformation. The point is this: Man *must* understand reality in a very particular way as a consequence of the manner in which his mind operates. This idea cannot be substantiated by anything less than a God of order, for if there were none, what basis have we for order? If we cannot know order, then we cannot know any truth outside of chaos. As we have already concluded, science is pointless without truth, and utterly useless without order. The fact that science demands truth does not evidence the God of Christianity specifically, but rather "merely" proves that science demands orderliness and, at least, a "watchmaker" to provide it. Man must accept the God of Christianity on grounds other than those scientific because science cannot reliably prove the existence of God. Instead, it implies and glorifies His presence.

What can be attributed to Christianity, however, is the creation of these *modus operandi* (modes of operation). The Christian scientist should stipulate that God, in breathing life into us, granted us ability to reason and the ability to perceive things the way we do. It separates us from the common animal; uniquely, we can appreciate the structure and beauty of Creation because we have the exclusive attribute of being able to understand it. This same idea applies to mathematics. While humanity developed mathematics, we were given the ability to do so, and the foundation to do so, by God. Nickel asserts that "The created order is contingent in that it reflects an ontological dependence on the biblical God, the ultimate metaphysical reality that is "beyond" and "beneath" it" (144). Furthermore, "The Bible's revelation of this metaphysical reality — an infinite, personal, and reasonable God who created a real universe that can be understood by Man made in His image — is the key to the full and complete development of science and mathematics" (Nickel 144).

I wrote earlier of several philosophies regarding the tangibility of numbers and the reality of mathematics. It would be negligent not to detail the relevance of these theories to my arguments. Having laid out the theological basis for mathematical truth, which is a general assertion, it is appropriate to discuss the minutia of subjective mathematical theory, especially regarding numbers. Personally, I adopt a synthesis of Platonism and Nominalism, but one that springs from a biblical worldview. To speak Kantianly, I believe that quantity and mathematical truth exist outside of our *phenomenal* (physical) realm. More specifically, I believe that those things ultimately reside in God's *noumenal* (nonphysical) realm. This is evidenced by Revelations 21:17, which says, "He also measured its wall, 144 cubits by human measurement, which is also an angel's measurement" (ESV). This verse implies that the standard of man is the same as the standard of the angel, and evidences that quantification exists both in heaven and on earth. The unit, of course, is subjective; numerous times, the Bible mentions the tallies and enumerations of God, both of which are independent of a specific unit. Here is where the Nominalist portion of my belief is important because I believe a number is not a unit in and of itself; rather, it describes a thing. It is simply a quantitative adjective that resides first in Heaven. By combining the two aforementioned philosophies and the biblical foundation for truth, my philosophy avoids the pitfalls that either ideology would succumb to on its own.

As such, mathematics is a man-made tool that allows us to represent the highest forms of logic, and it also allows us to apply that formulation to practical matters. Man developed mathematical thought, but God provides mathematical truth and bestows upon us the ability to perceive it. Mathematics practically relates to reality in physics, but is also heavily abstracted from reality in theory; mathematical truths were created by God for us to use as tools.

> Since God's thoughts are higher than man's thoughts (Isaiah 55:8-9), mathematical thought must always be seen as a tool in understanding, developing, and using God's creation; a tool that is always open to further refinement (Nickel 145).

And it is absolutely our duty to embrace these apparatuses and apply them to their fullest potential.

Conclusion

Mathematics is not only a vital component in scientific and logical progression, but it is an undoubtedly useful tool for analyzing and appreciating the beauty of the creation around us. While it is highly complex in theory and in practice, it must, necessarily, be appreciated not only for its practicality, but for its elegance, and for its importance in history. It is applied mathematics that allowed Columbus to discover the Americas; that allowed Galileo to observe the expanses of space; that allowed Nikola Tesla to wield the awesome power of electricity; that allowed Newton to construct his theory of gravity; that allowed Albert Einstein to create his General and Special Theories of Relativity, which are still extensively praised as some of the most intellectually and scientifically insightful works of all time. To say that mathematics is useless is really an individual plea, an ignorant complaint that mathematics is useless to *me*. Perhaps you will never use calculus for the rest of your life, but to buck the learning of it is akin to blatantly disregarding the techniques of the great artists or to waive classic literature as unimportant. It is of one's utmost interest to appreciate mathematics, and it is of one's extreme benefit to immerse himself in it as the pathway to the future.

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