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Claremont McKenna College

The Pursuit of a Meaningful Life Through Taoism and the Golden Ratio

Submitted to

Professor Robert J. Valenza

By

Robert “Quincey” Williams II

For

Senior Thesis

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Acknowledgments

The journey of reflection and development for this thesis is one which I will never forget as it serves as a constant reminder for myself of what I am truly capable of in life; for that, I have to share my utmost gratitude.

First and foremost, I must give thanks to Professor Valenza for agreeing to sponsor my thesis. Although my time with Professor Valenza before this thesis involved just one course I took back in my first semester at CMC, the inspiration and passion demonstrated in that calculus class sparked my interest in the mathematics major. This thesis topic is one which I have grown a strong passion for, and my appreciation for Professor Valenza's willingness to let me put that passion onto paper should not go unnoticed. The informative insights and feedback he provided throughout the past year opened the door for some interesting conversations and opportunities to refine the ideas presented. The overall construction of this thesis would not have happened without Professor Valenza and the impact he left on me throughout my time at CMC.

Next, there are my mom, dad, and brother. For the past four years (and my life really), my family has always found a way to put a smile on my face. Their constant belief in me and my capabilities greatly assisted me during my undergraduate experience, especially when I did not believe in myself. My family celebrated with me through all the highs as well as encouraged me through all the lows - they will forever be a primary source of inspiration in my life.

Finally, I truly appreciate all the relationships created and developed during my CMC experience in giving me a sense of belonging. Given the prestige behind the Claremont Colleges, I came into CMC feeling anxious that I would not meet the level of demand and expectations presumed. Nonetheless, the tight-knit community of CMC and the endless support from peers, faculty, and staff reassured me that I made the right college choice.

While this thesis strives to provide some direction on answering what makes one's life meaningful, my general approach will not rely too heavily on philosophers and professors with expertise in this pursuit. Instead, I intend to illustrate more of a thorough, informal discussion of my thoughts and perspectives on this philosophical question. That said, I hope the reader enjoys the intellectual journey to explore my interpretation of a mathematical phenomenon and how its properties may assist in understanding meaning in life.

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Introduction

What constitutes a meaningful life is perhaps the most crucial question we can ask ourselves throughout our lifetime; for what we know, the desire to become knowledgeable of a definitive answer is a journey traveled by humans as early as the 6th century BCE. Nonetheless, history illustrates various paths that brave individuals took to provide guidelines for today's society to reflect on and choose whether or not they wish to follow them. To portray some of these philosophies in greater detail, we begin by exploring the term "meaning" from a metaphysical perspective and then the categories such philosophies might fall under. Our main discussion will emphasize a mathematical concept that might initially seem insufficient in answering such a complex and abstract question. However, by evaluating the mystical and mathematical properties of the Golden Ratio, we might get a glimpse into how we could begin to answer what makes one's life meaningful. This mathematical phenomenon alone might still not be enough to convince readers that it has a place in living a meaningful life, so I will also introduce a philosophy that, coincidentally, began in the 6th century BCE - Taoism. The development of this philosophy, despite not being as well-known or practiced as other belief systems, provides fascinating insights, which we will notice have similarities with what we illustrate through Phi (Φ). I conclude that this seemingly unexpected synergy between Taoism and the Golden Ratio demonstrates a valid relationship that mathematics has with portraying how we can live well.

Chapter 1: What Gives Life Meaning Anyway?

What is your reason for getting out of bed in the morning? For many of us, this question is likely not the first thing that comes to mind when waking up to a new day - it might not even be something we ask ourselves at all. Having a definitive answer to such a question requires patience, mental effort, and inward reflection to understand one's reason for living. When someone reflects on the term "meaning," they probably associate it with similar words like motivation, purpose, fulfillment, and belonging. While these synonyms provide some assistance in putting this question into different contexts, there is much more behind "meaning." Although one might not have a concrete answer to their life's purpose, one might unconsciously act upon it through daily actions. For example, someone might say their reason for getting out of bed in the morning is to enjoy that first sip of a Starbucks coffee, go on that morning walk at the crack of dawn, or practice mental perseverance through a cold shower (no thank you). Essentially, defining one's life purpose does not have to involve some personal enlightenment. However, many of us desire that greater sense of fulfillment in our lives which is why, for the majority, we remain unsure of our life's purpose for quite some time. Hence, to gain some understanding of what gives life meaning, we begin by further analyzing "meaning" itself.

What Do We Mean by “Meaning”?

The ability to evaluate oneself inward to comprehend what makes their life meaningful is a difficult enough task alone, but to take that additional step in asking, “What is the proper interpretation of the term ‘meaningful’?” leaves us wondering where exactly to begin (Figure

1.1).¹ As mentioned, adjectives associated with “meaning” can potentially provide some initial insights into approaches individuals can pursue in reshaping their perspective of the question. Instead of asking oneself, “What is the meaning of my life?” which contains abstract components to it, one might replace meaning by asking, “What is my life’s purpose?”, “How and where

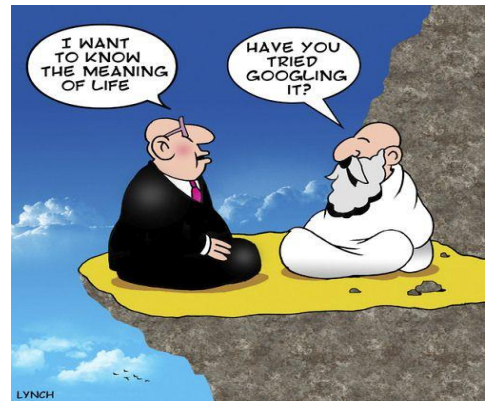


Figure 1.1: Where Might One Find Meaning?

might I find more fulfillment in my day-to-day life?” or “Where is my place of belonging in society?”. The advantage of such adjectives is their concrete definitions. For example, “meaning” might indicate the following:

noun

1. what is intended to be, or actually is, expressed or indicated; signification; import:

the three meanings of a word

2. the end, purpose, or significance of something:

What is the meaning of life? What is the meaning of this intrusion?

3. Linguistics.

- a. the nonlinguistic cultural correlate, reference, or denotation of a linguistic form; expression.

¹ Lynch, Mark. “Meaning of Life by Toons: Philosophy Cartoon.” *TOONPOOL*, https://www.toonpool.com/cartoons/meaning%20of%20life_176324.

b. linguistic content (opposed to expression).²

While the second statement illustrates our ideal interpretation, it does not provide any beneficial information on the word itself. Instead, it redirects to terms such as “purpose” and “significance.” So while these synonyms have their place when evaluating what makes an individual’s life meaningful, they illustrate distinct contexts of this philosophical pursuit.

Nonetheless, reflecting on the second statement of the above definition, it suggests that, alongside “purpose” and “significance,” “meaning” indicates the end of something (in our case, that something is life itself). That introduces an additional question we might ask, “If meaning is something not rewarded until the end of one’s life, is there even a reason for pursuing it in the first place? In other words, should we not just simplify this question by resorting to nihilism (the philosophy suggesting that life is meaningless)?” It seems that, perhaps, many individuals find it difficult to clearly define meaning in their lives due to the mindset that meaning is either something one has or does not - and once someone finds it, it’s theirs forever. However, the issues with this interpretation of meaning are twofold. The first involves the notion that meaning is not something an individual obtains on a predefined day. The perspective that we must wait until the stars align to gain some insight into achieving this desired end is a one-way journey in the opposite direction; focusing a significant amount of our effort and energy into discovering what makes one’s life meaningful results in more confusion and conflict. While it seems counterintuitive to ignore the pursuit of meaning, doing so will allow those moments to arise throughout one’s lifetime. The second issue goes as such: suppose, after many years of waiting for that enlightening day in which someone has the answer they seek - they have that envisionment detailing what it is that will bring meaning into their life. Well, then what? How is

² “Meaning Definition & Meaning.” *Dictionary.com*, Dictionary.com, <https://www.dictionary.com/browse/meaning>.

one supposed to live the rest of their life once they achieve this outcome they yearned for? Essentially, this perspective revolves around the notion that meaning, at the root of the term, is not a desired end but rather an aspect of our lives that already exists within us and will arise through the act of not trying. This art of not acting upon our actions to guide us toward our goals and aspirations will go into further detail through our discussion of Wu-Wei.

One remaining aspect of “meaning” that needs acknowledgment before analyzing this term in different philosophical contexts involves explicitly distinguishing meaning from other human desires, such as happiness and fulfillment. The pursuit of happiness does not directly relate to the pursuit of meaning; at the surface level, these two terms seem interchangeable due to the assumption that one immediately leads to the other. To ask someone whether or not they are happy does not necessarily have to lead to them detailing some meaningful or fulfilling experience. For example, when one immerses themselves in an activity or hobby that pleases them, they would likely say such engagement makes them generally happy. However, when pondering on whether or not the particular activity brings a sense of satisfaction or meaning to their lives, because these terms subtly suggest underlying expectations that need fulfillment, determining whether or not a happy experience also provides meaning often becomes inconclusive. Moreover, happiness emphasizes more individualistic senses of satisfaction, whereas meaning tends to expand beyond the self. An example of a correlating philosophy of happiness is hedonism. In essence, hedonism involves the pursuit of immediate pleasure and gratification and, as a result, avoidance of pain-causing thoughts or experiences. While this lifestyle initially seems enticing, it is not the most rewarding long-term. When reflecting on meaning, suffering and delayed gratification are necessary conditions for this pursuit; it is through acknowledging that humans are flawed regarding various aspects of their lives.

However, those willing to take the human responsibility of continually seeking personal development and persevering through life's challenges establish a stronger foundation for understanding what it means to live a meaningful life. This state of being is self-actualization; once someone meets the necessary conditions for this form of being, they enter a state of transcendence, allowing them to assist those pursuing the same path.

A Glimpse Into Supernaturalism

With this foundation for understanding the underlying properties of meaning, we now transition to discussing the theories behind this term relating to life. The first of the two is supernaturalism. This theory emphasizes engagement with spirituality as a necessary condition for gaining insight into meaning. Another interpretation of this theory involves the discovery of inner peace and harmony; both of these goods (harmony in particular) will have their place throughout later subsections and chapters, but for now, we recognize them as elements of spiritual well-being crucial for the supernaturalist. Of course, when evaluating a philosophical theory such as supernaturalism, there exist levels of demand. There are extreme supernaturalists who acknowledge God's existence as a strictly necessary condition for living a meaningful life. And there are moderate supernaturalists who admit that, while one can experience impactful moments throughout their lifetime without the existence of God, such a life cannot reach its full potential. Due to the extreme perspective sentencing humanity to nihilism, given that God does not exist, we proceed with the moderate mindset. While God plays a role when discussing spirituality, supernaturalism also acknowledges a perspective on meaning that emphasizes the impact of one's internal soul on such matters. With this, we briefly evaluate these two branches of supernaturalism.

When evaluating the God-centered perspective, pursuing a meaningful life relies not on one's perception of meaning but that of God; discussing God's impact on society shifts this philosophical question we seek to answer toward religion. In essence, following God's plan is the only method to ensure one lives life to the fullest. Reflecting on the conclusion of the previous subsection, a critical aspect of supernaturalism involves prioritizing goods worthy and aligned with God's purpose. Our distinction between the role of happiness and meaning illustrates

examples of human desires which, while one might assume are interchangeable, do not hold the same value. According to the supernaturalist, deficient needs such as pleasure and happiness do not depend on God's existence, yet growth needs such as self-actualization and transcendence do. Nonetheless, there are concerns regarding the supernaturalist theory. For one, if God's standards for living a meaningful life are too demanding for human existence, we have no choice but to resort to nihilism. There are situations where the guidelines of a particular religion make living the life God envisions for those following its plan seem impossible. Moreover, when reflecting on individuals who made positive contributions to society without following guidelines established by a particular religion, are their lives truly any less meaningful? With this, supernaturalism revolving around God-centered perspectives unfortunately illustrates some concerning controversies.

With the soul-centered perspective, pursuing a meaningful life relies on the immortality of an individual's soul through successfully transitioning onto the next stage of their life. For many, this perspective seems comforting as the very thought of our mortal existence, knowing that tomorrow does not exist and that death is inevitable, leaves them wishing they were immortal. There are many experiences that one will not get to live out due to the limitations of their very existence; however, the immortal soul allows individuals to have all such desires eventually met. Nonetheless, is immortality the key to living a meaningful life? While death remains a dominant fear among humans, perhaps such an aspect of our lives grants us the ability to live a meaningful life. Through the everlasting transition from one stage of an individual's life to the next, while it seems as if there are infinite experiences to have, it is probable that, eventually, we find ourselves bored for eternity. Moreover, mortality keeps us in moderation; that is, knowing that our immortal souls grant us immunity from death's grasp, our everyday actions

and decisions become insignificant as they would prevent us from any form of struggle or negativity. With this, the foundation of the soul-centered perspective seems somewhat contradictory; while such a theory provides an alternative supernaturalist understanding of what is necessary for a meaningful life, it also places a heavy burden on us to choose between living an everlasting life or a meaningful one.

Which Is More Persuasive: Subjective or Objective Naturalism?

The theory of supernaturalism deserves some attention when analyzing the philosophical foundations for understanding the meaning of life. However, due to the controversies regarding both branches illustrated and the direction of this thesis topic, we will rely more on analyzing the naturalist theory. The naturalist perspective emphasizes that one's physical life is the primary condition for gaining insight into their life's meaning. Before proceeding, it is crucial to acknowledge that while supernaturalism and naturalism illustrate a similar distinction to the well-known debate between religion and science, these theories do not disregard the ideologies of one or the other. Unlike supernaturalism, the naturalist theory prioritizes elements of physical well-being in living life to the fullest over God and soul-oriented perspectives, yet like supernaturalism, they acknowledge that such approaches could still provide an individual with some meaning. There are also extreme and moderate levels of demand where, once again, we will focus more on the latter. The philosophical foundation of this thesis topic relies on analyzing the advantages and flaws between subjective naturalism (subjectivism) and objective naturalism (objectivism) and determining which better aligns with our overall conclusion. Following this will then involve some insights into two particular philosophies of the naturalist perspective and highlight both their influence on defining the meaning of life as well as their mathematical components that will transition us into discussing more of the mathematical significance behind this thesis topic.

Out of curiosity, I asked ChatGPT what the meaning of life was; it responded as such: "The meaning of life is a philosophical question that has been debated by scholars, theologians, and thinkers for centuries. There is no single answer to this question, as the meaning of life can be different for each person and may change throughout their lifetime. Some people find

meaning in their relationships with others, some through their work or personal achievements, while others may find it through spirituality, religion, or a connection to something greater than themselves. Ultimately, the meaning of life is a deeply personal and subjective question, and the answer will depend on each individual's beliefs, experiences, and values.”³ With this, we can put the foundation of this thesis topic behind us as the all-mighty ChatGPT has sided with subjectivism - right? Subjectivism is the naturalist theory that dictates that the answer to what makes life meaningful is “personal” and “subjective.” Why might this overwhelmingly popular AI software suggest that life has subjective meaning instead of some objective value? Sure, it might not compare to the level of intellect that a human in favor of subjectivism might defend such a theory, but perhaps, just this once, we might agree with the machine.

If ChatGPT provides users with a subjectivist approach to understanding the meaning of life, then there must be something appealing about the theory. For one, the convenience behind subjectivism does not require one to pursue some objective truth that everyone must abide by. To say that life has subjective meaning allows the pursuer to have complete control over this question which typically leaves many people initially unsure how to answer it. Nonetheless, one must pursue the subjectivist approach with caution, as an inward reflection on oneself and who one wants to become is a constantly changing, perpetual process, making it possible to encounter a state of boredom along the way. Take the classic subjectivist example of Sisyphus, condemned by the Gods to push a stone up a hill for eternity (Figure 1.2).⁴

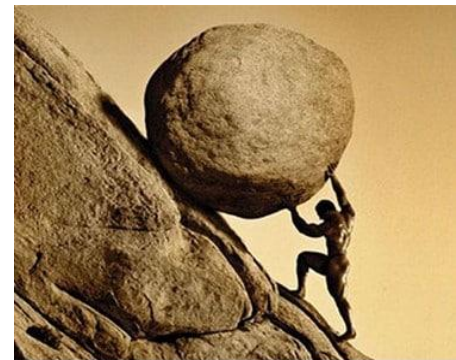


Figure 1.2: Sisyphus’s Fate

³ Chat.openai.com. <https://chat.openai.com/>.

⁴ Pursuit-of-Happiness.org. “What Would Sisyphus Do?” *Pursuit of Happiness*, 13 Feb. 2021, <https://www.pursuit-of-happiness.org/what-would-sisyphus-do>.

With no other means of living, someone might look at Sisyphus and think that life for him is as meaningless as it gets; who would possibly find meaning in the most menial of tasks?

Nonetheless, subjectivism suggests that if Sisyphus himself finds passion in the act of constantly working against gravity meaningful, then we can do nothing more than accept his fate as significant as well. As a result, by focusing on the journey within instead of attempting to find some external end to meet, so long as it continues to provide one with a sense of enjoyment along the way, then meaning will arise.

While subjectivism can appeal to someone unfamiliar with the foundational theories of our philosophical question, some concerns need addressing. The main of which is the level of freedom that comes with subjectivism; despite the pleasure that comes from being able to control one's definition of meaning, this abuse of power can convince many individuals to act unethically. A straightforward example of this notion is serial killers; to them, murdering innocent people brings about a concerning sense of meaning, yet asking any non-serial killer if their actions are justifiably meaningful seems like a naive question to ask in the first place. Even though serial killers might use subjectivism to defend their actions, they do not get an "escape from morality card." In addition, without that objective value or desired end for one to strive for, there lacks guidance of any kind throughout one's life; we have acknowledged various times that defining what makes life meaningful is a difficult task, so by living life under the ideologies of subjectivism, one must be absolutely willing to commit to the process without violating ethical standards established by society. So before relying on ChatGPT to answer this question of a meaningful life for you, perhaps reconsider other available theories that expand beyond the AI algorithm.

Epicureanism suggests that meaning comes from living a tranquil life free from anxiety and pain. Stoicism suggests that meaning in life comes from optimizing one's mental state so one can live virtuously. The consequentialist suggests doing the most good for the most amount, yet the opposing ethical view of Kantianism believes meaning arises from the Golden Rule. These philosophies illustrate just some of the many individuals who reject ChatGPT's response and side with objectivism. Unlike subjectivism, objectivism is the naturalist theory dictating that living a meaningful life requires searching beyond oneself and accepting some external end or standard to guide one in the right direction.

While objectivism might not have as straightforward of an approach as subjectivism, it remains a persuasive theory for those who need help knowing where to begin. For centuries, great minds have pondered and developed insights and guidelines on how someone should think and act to pursue some objective end they deem meaningful. The daunting task of figuring out how to live a meaningful life for oneself is no more thanks to those who went through that trouble themselves. For the objectivist, instead of defining meaning from within, they evaluate what matters most to them; by examining the various aspects of their life, one prioritizes such aspects to align with the values and objective elements provided to them in the physical world. The main issue mentioned with the subjectivist theory is not an issue for the objectivist as the pursuer of this approach must act toward something of objective value. The serial killer who values his actions can no longer deem them worthy as murder is most certainly not objectively valuable. This alignment between one's desires and objective worth provides individuals interested in objectivism with some guidance in understanding what is meaningful for them as long as they first recognize what they value most.

As with every other theory discussed up to this point, objectivism has its fair share of flaws. The main issue revolves around the notion that such a theory contains subtle elitist connotations. Despite the pursuit of something that is objectively valuable being the foundation for the objectivist making sense on some level, this perspective tends to guide individuals toward activities or occupations that provide a sufficient balance between contribution and acknowledgment. The more one contributes to bettering society, the more likely one will find meaning in what they do. However, if society does not perceive the activity one does as meaningful, then might that cause the individual providing their services to feel discouraged? For example, early in an individual's life, many are encouraged to go and pursue their dreams. The ambition a child has to become a doctor, lawyer, or engineer receives high praise from most (if not all) parents as they recognize that their child will not only get to contribute to society greatly but will also receive generous salaries. Suppose now that the child's ambitions guide them toward a career as an athlete, writer, or chef. In that case, although not all parents would discourage their children from such dreams, there is a negative stigma behind these occupations as they do not provide as much stability in the long run. Does that mean the life of an athlete, writer, or chef is not as meaningful as that of a doctor, lawyer, or engineer? This elitist view that objectivism illustrates in pressuring individuals to pursue activities deemed worthy by society is an ongoing issue even today that prevents many people from pursuing what aligns with their values or ambitions.⁵

⁵ Metz, Thaddeus. "The Meaning of Life." *Stanford Encyclopedia of Philosophy*, Stanford University, 9 Feb. 2021, <https://plato.stanford.edu/entries/life-meaning>.

Some Noteworthy Philosophical Views: Platonism and Aristotelianism

Aristotle and Plato are two of the most influential philosophers in history. Their insights and contributions provide foundational knowledge for a variety of fields beyond philosophy itself. Throughout their most well-known pieces, Aristotle and Plato illustrate how they approached what makes life meaningful by analyzing what it means to live well. The discussions each philosopher outlines within their respective pieces emphasize how one can find happiness over meaning; however, they still illustrate perspectives relating to objectivism. Although their solutions to a meaningful life were similar, their methods of pursuing it differed. Throughout *Nicomachean Ethics*, a key term Aristotle used to describe how one can live well is eudaimonia; this Greek word directly translates to "the condition of human flourishing or of living well."⁶ Aristotle believed that our reason for being was to live up to our fullest potential through acts of virtue. In particular, through his twelve virtues, one can pursue eudaimonia so long as one not only abides by these twelve virtues but does so in moderation. Throughout *Republic*, Plato determined that the optimal path for living well involved pursuing knowledge.⁷ For many, their interpretation of this pursuit requires getting an education or actively reading. Although these are not necessarily incorrect, Plato's interpretation of pursuing knowledge involves understanding and mastering oneself. By developing our inner wisdom through life experiences and, as a result, becoming more knowledgeable of who we are, we embody our most authentic selves - and are then capable of persevering through what is necessary to live well.

Many philosophers made impactful contributions to fields outside philosophy, so why only focus on the teachings of Aristotle and Plato? The reasoning behind this brief description of Aristotelianism and Platonism over other philosophies that provide some objective value to

⁶ Aristotle et al. *Aristotle's Nicomachean Ethics*. University of Chicago Press 2011.

⁷ Plato, and Francis Macdonald Cornford. *The Republic of Plato*. Oxford University Press, 1945.

living a meaningful life involves the mathematical contribution these philosophers made in addition to such insights on meaning. In particular, subsections of the next chapter will highlight Plato's influence on the interpretation of numbers as well as Aristotle's influence through the development of terms such as the Golden Mean and the Extreme and Mean Ratio as they relate to his emphasis on pursuing moderation between the two extremes of excess and deficient.

Chapter 2: How Divine Is the Golden Ratio?

It is reasonable to assume that, for many individuals, mathematics is not the most enjoyable subject matter to study. Sure, mathematics seemed manageable when first learning how to count to one hundred or when competing with classmates to see how many correct answers one had with the multiplication tables in one minute. However, that transition into the middle school level, when one first encounters letters and symbols in their equations instead of numbers, is the moment many perceive mathematics as challenging and, unfortunately, “useless.” From this point to high school and college, their experiences with the subject matter do not alter much; they begin questioning their capabilities to understand the material taught and the overall resourcefulness of mathematics in their daily lives. “Why am I learning this?”, “How will I use algebra or calculus in my future occupation?”, “I am not smart enough to learn mathematics.” are common phrases I notice even if the word mathematics arises out of nowhere. Nonetheless, I know many can comprehend the complexities behind mathematical concepts and principles; what is missing for most individuals is a sense of passion. The beauty of mathematics is that, while one of the more objective subjects to study, there remains room for subjectivity and interpretation. So before exploring one of the most significant mathematical symbols and its vast properties, we need some background information on symbolic interpretation and manipulation.

The Distinction Between Formalism and Platonism

The beginning aspects of college mathematics cover courses that have more “algorithmic” methods. For example, someone who has or is taking calculus, linear algebra, statistics, or differential equations will, most of the time, learn a concept, receive a problem set relating to such a concept, and follow a series of steps to obtain the solutions. These courses primarily cover the “how” behind mathematics. Nonetheless, sometimes an instructor will sprinkle in a theorem, a statement generalizing a particular principle, and ask how one might prove such a statement (Figure 2.1).⁸ On

Geometry test: prove that triangle ABC is a triangle Me:



Figure 2.1: Prove This Is a Triangle!

these occasions, students gain insights into the “why” behind mathematics; however, proving generalized statements is the primary emphasis for higher-level classes such as real analysis, abstract algebra, number theory, combinatorics, etc. For those unfamiliar with these branches of mathematics, do not fear - you will not need any significant background knowledge of them. For now, our focus will be on a field of study known as the philosophy of mathematics, a branch emphasizing classical philosophy to better understand the foundations of mathematics.

The development of calculus by Isaac Newton likely leaves many students taking calculus to initially question how he managed to establish such a complex branch of mathematics without the use of today’s technology.⁹ The transition from courses in algebra, geometry, and trigonometry to calculus has a similar effect as the transition from middle school to high school mathematics. With this curiosity regarding the significance of Newton’s contributions, let’s

⁸ George. *Geometry Was Annoying*. 17 June 2020, https://www.reddit.com/r/memes/comments/hau5u5/geometry_was_annoying/

⁹ Newton, Isaac, and William Jones. *Analysis per Quantitatum Series, Fluxiones, AC Differentias: Cum Enumeratione Linearum Tertii Ordinis*, 1711.

reflect further in asking the following: did Isaac Newton discover or invent calculus? This debate on the discovery or invention of mathematics sets the foundation for the distinction between two schools of thought - formalism, and Platonism. For the formalist, humans invent mathematics; that is to say, we control the formulation and interpretation of mathematical objects and symbols. For the Platonist, humans discover mathematics; that is to say, we cannot manipulate the rules or symbols of mathematics as the formalist would since such objects truly exist beyond the physical world. Unlike in the last chapter, we will now analyze Platonism for its mathematical ideologies rather than its philosophical ones.

Similar to the layout of the various theories justifying the meaning of life, the school of formalism has its distinct branches. The first of two positions of formalism comes from mathematicians Heinrich Heine and Johannes Thomae, referred to as game formalism.¹⁰ This branch of formalism is all in the name; the game formalist suggests that mathematics, in essence, is just a game like any other where the rules of such a game, so long as they follow some logical construct, have no meaning behind them. Moreover, if one were to adjust the rules slightly, they then end up engaging in a different mathematical game. For example, take Monopoly. Every time someone makes a trip around the board, they receive two hundred dollars; these are the standard rules created by the makers of Monopoly. Let's now adjust that rule to say that every moment someone makes a trip around the board, they receive three hundred dollars. There is nothing illogical regarding this rule adjustment, it also does not truly matter what the established payment is when making a trip around the board, so this now becomes your variation of the Monopoly game. Think of game formalism as the nihilism of mathematical schools, not to immediately suggest any negative connotations behind the theory; this relationship does,

¹⁰ Weir, Alan. "Formalism in the Philosophy of Mathematics." *Stanford Encyclopedia of Philosophy*, Stanford University, 23 Aug. 2019, <https://plato.stanford.edu/entries/formalism-mathematics/>.

however, introduce a flaw made by Gottlob Frege.¹¹ With our desire to explore the significance behind Phi, we cannot have this pessimistic mindset that mathematical objects and symbols have no crucial role in the physical world. Beyond our illustration of this phenomenon that is Phi are various examples where the interpretation of mathematical objects and symbols as meaningful entities has demonstrated significance in today's society.¹²

The second of the two positions is the more persuasive argument in justifying formalism; it comes from the contributions of fellow mathematician David Hilbert, referred to as Hilbertian formalism.¹³ This branch of formalism acknowledges that mathematical objects can entail some meaning and truth, yet Hilbert also believed that their overall significance depended on successfully formalizing mathematical language involving the following properties: variables, symbolic connectivity, equality, quantifiers, and parameters. I know what most readers are likely thinking - what?! How did we go from comparing Monopoly with game formalism to all this mathematical jargon? Do not worry - let's explore these properties one by one. Firstly, there are variables, those exciting mathematical entities first seen in middle school mathematics that set the foundation for the rest of one's mathematical experiences. Next is symbolic connectivity; this property is not as straightforward as saying, "here we have some variable x let $x = 5...$ " Symbolic connectivity comes in various forms - common symbols seen in those higher-level mathematics courses that demonstrate connectivity are \Rightarrow and \Leftrightarrow where the former represents "if then" and the latter represents "if and only if." Then there is equality, which we all know as the $=$ symbol; assigning some mathematical entity to another, and having them equal each other, is a

¹¹ Frege, Gottlob. *Grundgesetze Der Arithmetik: Begriffsschriftlich Abgeleitet*, vol. 2, Pohle, 1903.

¹² Wigner, Eugene, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences." *Communications in Pure and Applied Mathematics*, vol. 13, no. 1, New York: John Wiley & Sons, Inc, 1960, pp. 1–14.

¹³ Campbell, Douglas M., et al. "The Three Crises in Mathematics: Logicism, Intuitionism and Formalism." *Mathematics: People, Problems, Results*, vol. 52, no. 4, Wadsworth International, 1984, pp. 207–216.

fundamental aspect of mathematical language. Following equality, we have quantifiers. Similar to symbolic connectivity, quantifiers have their place in more theoretical math topics - common symbols include \forall and \exists where the former represents “for all” and the latter represents “there exists.” Finally, there are parameters that are essentially just “undefined terms” in a given mathematical statement.

As an example, let’s illustrate the formal definition of a limit. For those unfamiliar with a limit, this calculus concept demonstrates how the input of some function behaves as it approaches some point. Typically, calculus students will recognize this concept as such:

$$\lim_{x \rightarrow 5} x^2 = 25 \quad (1)$$

where the input (x) of our function $f(x) = x^2$ as it approaches the number 5 equals 25.

Depending on the instructor, they will introduce the following definition of a limit:

“Let $f(x)$ be a function defined on the interval that contains $x = a$. Then

$$\lim_{x \rightarrow a} f(x) = L \quad (2)$$

if, for every number $\varepsilon > 0$, there exists some real number $\delta > 0$ such that if $0 < |x - a| < \delta$, then $|f(x) - L| < \varepsilon$.”¹⁴

Notice that this definition of a limit consists of the necessary properties Hilbert describes as mathematical language.

Given this formalization technique, Hilbert believed he could formalize any axiomatic system to prove everything there was to mathematics. Nonetheless, about a decade after the establishment of Hilbertian formalism came the works of another mathematician, Kurt Gödel,

¹⁴ “Epsilon Delta Definition.” *Calcworkshop*, 22 Feb. 2021, <https://calcworkshop.com/limits/epsilon-delta-definition/>.

who not only “destroyed” Hilbert’s contributions but also left fellow mathematicians questioning the philosophy of mathematics altogether. Gödel’s Incompleteness Theorems are one of the most fundamental and fascinating mathematical statements - this contribution even leaves well-knowledgeable mathematicians wondering how he managed to develop this notion. Essentially, Gödel illustrated the limitations of mathematics with the following claim: “This statement cannot be proven.”¹⁵ To put this notion as simply as possible, we recognize that mathematics is one of the more objective subject matters; frequently, the outcomes produced are either true or false, so suppose a given mathematical statement is true. According to Hilbertian formalism, since such a statement is true, the formalist can develop a set of axioms to prove it; this is an “if and only if” claim. In other words, if one can develop a set of axioms to prove some mathematical statement, then it must be true. Suppose now the mathematical statement is false. In this case, we know one can prove, through contradiction, the validity behind such a statement. Nonetheless, if one can develop a set of axioms to prove some mathematical statement false, does that then make the mathematical statement true or false? I will leave the decision up to you (I might agree with Gödel on this one).¹⁶

I emphasize again that Plato is one of the most profound individuals to exist based on his contributions to various fields of study. As illustrated in the previous chapter regarding his work in philosophy, we now investigate his mathematical contributions. Needless to say, while I perceive something mystical about his perspective on mathematics, we should not interchange mysticism with Platonism as such terms do not exist in the same domain. For Platonists, mathematical objects and symbols exist in a world beyond the physical one we reside in;

¹⁵ Gödel, Kurt. *Über Formal Unentscheidbare Sätze Der Principia Mathematica Und Verwandter Systeme I*. Akademische Verlagsgesellschaft M. B. H., 1931.

¹⁶ Hofstadter, Douglas R. *Gödel, Escher, Bach : An Eternal Golden Braid*. 20th anniversary ed., Basic Books, 1999.

everything expressed mathematically here on Earth, such as numbers, shapes, formulas, etc., illustrates merely a materialistic representation of the actual object beyond our supposed knowledge of them. I like to think of Platonism as the supernaturalism of mathematics, a more optimistic perspective in comparison to game formalism which believes mathematics most definitely has meaning despite its place in the supernatural realm.

It may seem like a challenge to accept, or even comprehend, that something as seemingly objective as mathematics could have some mystical properties to it. To compare a subject matter containing concrete concepts and principles with the belief of something beyond our control may feel somewhat uncomfortable. This feeling is natural, as mathematics, from the moment first introduced as a child to your adult years, has emphasized its practical abilities over its symbolic interpretations. Some note-worthy individuals have critiqued this Platonist perspective; one of the most significant yet straightforward critiques comes from philosopher Paul Benacerraf, who was skeptical of the notion that we can accept these real, abstract mathematical entities that exist in some world outside our own without having a concrete understanding of them.¹⁷ Although a valid epistemological argument, it does not seem like the kind of sophisticated argument that we might have expected. Even outside mathematics, individuals who favor reason over faith tend to emphasize that aspects of life that require a belief in the existence of something beyond the physical world cannot possibly be true due to our lack of knowledge regarding such things. Fortunately for us, the general consensus among mathematicians favors this Platonist perspective in believing that we hold responsibility for discovering these mathematical wonders beyond our immediate comprehension. Hopefully, this thesis topic does just that.

¹⁷ Benacerraf, Paul. "Mathematical Truth." *The Journal of Philosophy*, vol. 70, no. 19, 1973, pp. 661–679. JSTOR, <https://doi.org/10.2307/2025075>.

How Should We Then Define Divinity?

The primary concept of discussion, Phi, goes by many other names. We have the Extreme and Mean Ratio, the Golden Mean, the Golden Ratio, and the Golden Section. In addition, I have previously denoted Phi by Φ , yet there is also phi, denoted as φ . Nonetheless, the name for this mathematical phenomenon I wish to analyze briefly is the Divine Proportion. While most alternate names for Phi involve the terms golden, mean, and ratio, something is appealing about Phi being divine. To start, what exactly does it mean for something to be divine? Moreover, there seems to be a relationship between mysticism and divinity as both terms have this supernatural property which, unfortunately for us, complicates the assignment of a definitive definition for them. For example, something being divine might indicate the following:

adjective

4. godlike; characteristic of or befitting a deity:

divine magnanimity.

5. heavenly; celestial:

the divine kingdom.

8. of superhuman or surpassing excellence:

*Beauty is divine.*¹⁸

These statements make sense given our discussion of the relationship between philosophical supernaturalism and Platonism, yet to suggest that Phi is “godlike” might not be the most appropriate association. With this, we can attempt to combine this notion of mathematical mysticism and, perhaps, the third definition provided above to formulate a proper definition of divinity as it relates to Phi.

¹⁸ “Divine Definition & Meaning.” *Dictionary.com*, Dictionary.com, <https://www.dictionary.com/browse/divine>.

Phi explicitly obtaining divinity status comes from Luca Pacioli through his book *De Divina Proportione* (The Divine Proportion), who found inspiration in the aesthetically appealing works of Leonardo da Vinci.¹⁹ Nonetheless, the acknowledgment of Phi's divine attributes goes back to historic Greek mathematicians and philosophers Euclid and Pythagoras (more on such individuals and their contributions soon). The beauty of the Platonist perspective is this open mindset in allowing us to discover forms of mathematics with relationships to aspects of life that might not initially make much sense yet demonstrates some validity and accuracy. Mathematics having this reputation of objectivity due to the experiences many individuals have with the subject matter can lead them to have a Hilbertian formalist mindset in believing that we can extract all mathematics through some logical construct. The desire to obtain all knowledge, whether within mathematics or any field of study, has a similar route to someone who strives to find a direct path to the obtainment of meaning. There are limitations regarding what the laws of science and nature reveal to us that prevent us from being omniscient. However, not knowing everything there is to mathematics is what makes it a beautiful subject to study; a true mathematician would rather spend their entire life discovering as much of the subject matter as possible than gaining access to all of its absolute truths. With this, we might perceive Phi as a divine entity to mean that it contains properties that are not universal truths yet can still illustrate unexpected connections beyond our initial comprehension.

¹⁹ Pacioli, Luca. *Divina Proportione*. Dominioni, 1967.

Pythagorean Numerology

The mathematical experiences students go through in the modern education system strongly emphasize the material's practical application; unless pursuing a major in mathematics, most of the time, the mathematics one encounters requires some algorithmic approach in following a series of steps in obtaining a desired result. Even if one were to explore those higher-level division courses, it frequently involves proving theorems and statements already proven by previous generations of mathematicians. While I recognize that the intention behind the system guides individuals to develop beneficial skills, leading them to land a career in some applied field or further research in graduate school, something about it feels somewhat flawed. Not so much that there is a need for any significant adjustments in how students should learn mathematical concepts and principles - it just feels as though the material taught tends to go in one ear during class and out the other the moment one walks out the door. To be fair, instructors only have a couple of months to teach all there is about a particular branch of mathematics for semester systems and even less time for quarter systems, so the issue seems to be one with time. So how can a mathematician possibly transfer the level of passion for the subject they devoted their lives to into the next generation of mathematicians in such a short time frame? For this, we reflect on some of the more nontraditional teachings of one of the most historic and influential mathematicians - Pythagoras.

When you think of the name Pythagoras, what first comes to mind? You thought of the classic Pythagorean Theorem, right? If not, I am curious to learn more about what you thought. Along with the Pythagorean theorem, Pythagoras has various contributions ranging from astronomy and metaphysics to music theory and numerology. That is correct - music theory and numerology. We might ask, "How does a well-respected mathematician such as Pythagoras

associate himself with astrological interpretations of numbers?” Well, numerology is the study of the mystical properties behind numbers and their influence on a human's life; Pythagoreanism is the religious-philosophical movement that strived to investigate numbers in pursuit of a better understanding of the dynamics of the universe. In today's society, many are skeptical when they hear phrases such as numerology and astrology due to this negative stigma for it being pseudoscience. Just the thought of someone believing that mathematical entities such as numbers can provide insights into our personality and life's purpose has some people rolling their eyes. Nonetheless, given our acceptance of the Platonist mindset, let's explore this ancient way of thinking and teaching mathematics.

One of the more prominent aspects of Pythagoreanism was the harmonious behavior numbers illustrated. As an example of this idea, returning to his contributions to music theory, the mathematical connection the Pythagoreans made with music involved investigating particular ratio combinations and determining which ratios produced delightful and undelightful notes. Through experimenting with various string lengths, the pitches guided Pythagoreans in recognizing the kinds of numerical ratios with a pleasant auditory rhythm. This significant discovery by the school of Pythagoreanism is just one of many that justified the sort of harmony numbers possessed. From the behavior of planets and galaxies to the formation of atoms and DNA strands, numeric harmony through music set a strong foundation for these additional discoveries (covered in more detail and imagery in the next chapter). This engagement with mathematics is something I feel is a missing element in one's education up to the undergraduate level, as these experiences do not occur until one gets to graduate school. So unless one is

willing to remain patient with the education system or has a developed passion for mathematics, I recommend connecting math to another field of interest (there are many to choose from)!²⁰

²⁰ Stewart, Ian. "Number Symbolism." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 4 Nov. 2020, <https://www.britannica.com/topic/number-symbolism>.

A Reflection on *The Hitchhiker's Guide to the Galaxy*: Number 42

There are a couple of elements that inspired the topic of this thesis. However, this might be one of the first. As I attempted to develop ideas during the summer before my senior year, I wanted to find something within mathematics that connected with aspects of life I felt passionately about. My fascination for better comprehending what makes one's life purposeful and meaningful is a topic I saw potential in, yet how I might relate this philosophical question to the objectiveness behind mathematics left me in a state of contemplation, wondering if it was even possible. After days of research for academic articles and journals, I still felt lost in putting all the pieces I wanted together. Eventually, I recalled something I looked into before my search for a thesis topic - 42. For those unfamiliar with what I am referencing, this number is the solution to the complex question of what makes one's life meaningful! Kind of.

In 1979, Douglas Adams published *The Hitchhiker's Guide to the Galaxy*.²¹ I will not go into full detail regarding the plot, but in the novel, there is this super-intelligent race of beings who, like us, want access to a definitive answer to the meaning of life. Unable to comprehend the answer, they created a supercomputer named Deep Thought. When first asked by the super-intelligent beings, the supercomputer indicated it would need 7.5 million years to compute the solution (if you could, would you wait that long for such an answer?) Eventually, 7.5 million years pass, and they ask Deep Thought the same question, "What is the meaning of life, the universe, and everything?" The long-awaited answer: 42. Like you probably are, the super-intelligent beings were not so satisfied with the computation Deep Thought came up with and decided to move on by creating an even stronger computer to assist them.

²¹ Adams, Douglas. *The Hitchhiker's Guide to the Galaxy*. New York, Harmony Books, 1979.

So was there any significance behind Adams's number choice of 42 to illustrate the meaning of life? Throughout the years, mathematicians and fellow math enthusiasts have developed intriguing theories justifying some relationship between the number 42 and this philosophical question. One that stands out involves some knowledge of computer science, yet the concept is not difficult to comprehend; essentially, 42 is the ASCII (American Standard Code for Information Interchange) character * (asterisk). This symbol is a wildcard character, a symbol with unlimited possible interpretations when inputted into a string. The takeaway from this theory is that the role of the asterisk in computer programming implicitly suggests a subjectivist perspective on defining meaning, where we can interpret it as we wish. The validity of this theory is twofold. To have a supercomputer provide an answer to the "Ultimate Question" with a computer programming concept seems plausible. In addition, it so happens that Adams had a passion for computers and technology. There are other theories for this surprising coincidence in *The Hitchhiker's Guide to the Galaxy*, yet are any objectively true? No, because, at the end of it all, Adams claimed that his decision on 42 in his novel was random.

Although Adams's solution for the meaning of life, the universe, and everything was supposedly out of random chance, it allowed mathematicians and fellow math enthusiasts to formulate their thoughts and perspectives on this fascinating topic. This notion, along with others I thought of during that summer, inspired me to follow Adams in exploring the meaning of life through some mathematical entity. The only question remaining was, "What concept or principle would I want to choose? Moreover, what connections can I make with a particular philosophical theory of my choice?" Finally, after much philosophical and mathematical foundational description, I introduce you to my answer to the meaning of life, the universe, and everything!

The Golden Ratio and the Mathematical Significance Behind Phi (Φ)

Early in chapter two, I detailed the various names that Phi goes by, then transitioned to only focusing on the Divine Proportion. However, this is not the first name for this mathematical concept. The discoveries behind the vast applications of Phi date back to Euclid's *Elements*, regarded as one of the most profound and influential contributions to mathematics.²² Interestingly, this piece's axiomatization of geometry inspired Hilbert throughout his pursuit to advance the formalist school of thought. In Book VI, Definition III, Euclid referred to this Golden Ratio we interchange with other names for Phi as the Extreme and Mean Ratio, giving us the following illustrations (Figures 2.2 & 2.3).²³



Figure 2.2: Line Segment Division

Euclid's reasoning for calling this concept the Extreme and Mean Ratio is due to the evaluation of the "mean" or average values between the extreme ratios of this illustration. First, we look at the two smaller line segments that make up the whole line: CB and AC , and denote this ratio as AC/CB . Now, we look at the two larger line segments that make up the whole line: AC and AB , and denote this ratio as AB/AC . Would it surprise you if these two ratios were equivalent to one another? As you might have already known or guessed, this definition Euclid details showed that



$$AB / AC = AC / CB = 1.618$$

Figure 2.3: Line Segment Division With Ratios

²² Euclid, et al. *The First Six Books of the Elements of Euclid : In Which Coloured Diagrams and Symbols Are Used Instead of Letters for the Greater Ease of Learners*. Taschen, 2010.

²³ Bradley, Steven. "How to Use Golden Section Proportions in Your Designs." *Vanse Design*, 14 May 2016, <https://vanseodesign.com/web-design/golden-section-proportions/>.

Euclid’s observation set the foundation for mathematicians to explore Phi’s additional numeric and algebraic properties. Similar to the square root of five ($\sqrt{5} = 2.23606\dots$), Phi is an irrational number ($\Phi = 1.61803\dots$), a value incapable of being expressed as a simple fraction. We can illustrate the irrationality of Phi as such: let’s define the lengths of the line segments in the illustration above, where $AC = x$ and $CB = 1$. With this, we can implement such values into the equation for the ratios of the line segments detailed where

$$\frac{AB}{AC} = \frac{AC}{CB} \Rightarrow \frac{AC + CB}{x} = \frac{x}{1} \Rightarrow \frac{x+1}{x} = \frac{x}{1} \quad (3)$$

Now, to remove that pesky x from the denominator, we multiply both sides of the rightmost equation within (3) to get the following quadratic equation:

$$x\left(\frac{x+1}{x}\right) = x\left(\frac{x}{1}\right) \Rightarrow x + 1 = x^2 \Rightarrow x^2 - x - 1 = 0 \quad (4)$$

Solving for x using the good old quadratic formula then outputs two numeric values, each of which represents the Golden Ratio:

$$x_1 = \frac{1+\sqrt{5}}{2} = \Phi \quad (5)$$

$$x_2 = \frac{1-\sqrt{5}}{2} = \frac{-1}{\Phi} \quad (6)$$

I will leave it as an exercise for the reader to explore the other fascinating algebraic and numerical properties of Phi, but I will provide just one more, a property that has high importance in mathematics as a whole. Let me start by asking, “Which came first, the chicken or the egg?” But instead of chickens, we have bunnies, and instead of eggs, we have... baby bunnies. I ask this because, as it turns out, the investigation of the ideal population growth of bunnies, given some assumptions, led to the development of the Fibonacci numbers.²⁴ For those unfamiliar, the

²⁴ “Fibonacci Sequence.” *Fibonacci*, <https://fibonacci.com/fibonacci-sequence/>.

Fibonacci numbers follow this sequence of values: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89... so on and so forth. The main pattern to recognize regarding the Fibonacci numbers is that the next value of the sequence is the sum of the previous two numbers. In this case, the next value would be $55 + 89 = 144$; this type of numeric behavior is a recurrence relation. To illustrate the recurrence relation regarding the Fibonacci sequence, we have the following formula and defined terms:

$$F(0) = 1, F(1) = 1, F(n) = F(n - 1) + F(n - 2); n > 1 \quad (7)$$

One might now ask, “How does this sequence of numbers relate to the Golden Ratio?” There are two methods of seeing this notion for yourself - the simple method and the fun method. For the simple approach, pull out a calculator, and start with $1/1$, then $2/1$, $3/2$, $5/3$, $8/5$, $13/8$, and continue with the Fibonacci sequence until you notice something familiar about the values you are getting. For the truly mathematically curious, evaluate the following limit:

$$\lim_{n \rightarrow \infty} \frac{F(n+1)}{F(n)} \quad (8)$$

When it comes to the geometric properties of Phi, this involves the infamous golden spiral. A common misconception regarding the golden spiral is that it is the same as the Fibonacci spiral as they both illustrate similar behaviors, almost to the point where they appear indistinguishable (Figures 2.4 & 2.5).²⁵ Nonetheless, as you may have seen (if you did the various division procedures using the Fibonacci numbers), they are merely approximations to the actual value of the Golden

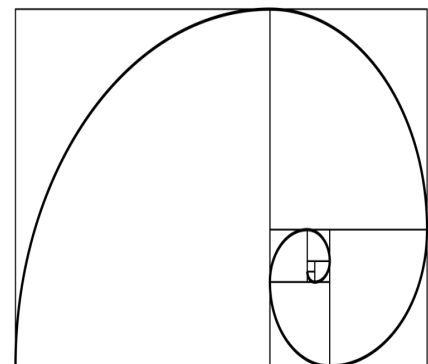


Figure 2.4: The Golden Spiral at Its Finest

²⁵ “Golden Spiral.” *Wikipedia*, Wikimedia Foundation, 19 Feb. 2023, https://en.wikipedia.org/wiki/Golden_spiral.

Ratio, so the Fibonacci spiral is then an approximation of the golden spiral. The rectangles used to form this golden spiral are golden rectangles, where the proportion of the length and width of such rectangles equals Phi. The fascination behind this construction illustrates that, when dividing a golden rectangle into a square and a rectangle, that rectangle turns out to be a smaller golden rectangle, creating a visual

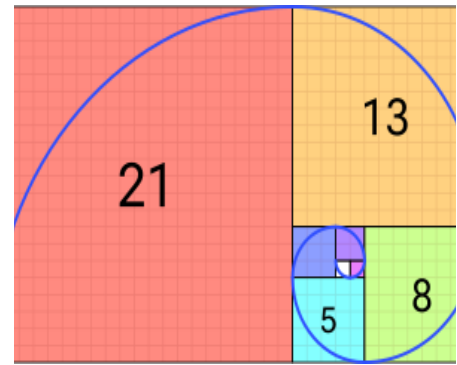


Figure 2.5: The Fibonacci Spiral at Its Finest

recurrence relation! This geometric property of the Golden Ratio is the foundation for demonstrating various aesthetically pleasing visuals that will assist us in better understanding why Phi is a quintessential mathematical concept of balance, harmony, and duality.²⁶

²⁶ Livio, Mario. *The Golden Ratio: The Story of Phi, the World's Most Astonishing Number*. Broadway Books, 2008.

Chapter 3: Where Might I Find This Divine Proportion?

Mathematics is the language of the universe; effectively conceptualizing the notion that the world in which we exist has a language of its own requires years of engagement with the subject, just like any other language one might be interested in learning more about. Nonetheless, it seems as though individuals find themselves understanding and even appreciating the universe's language more frequently when they do not realize that what they are witnessing or experiencing has mathematical properties to it. While visualizing the mathematical significance of some objects requires a bit of background knowledge of a particular concept or principle, such knowledge is typically nothing too rigorous. With this, we reflect further on the geometric properties of Phi. Like much of mathematics, the Golden Ratio is ubiquitous; regardless of where you look, this concept will somehow demonstrate itself. Although there are many examples of where one might find this Divine Proportion, I picked examples to compare to one another within some subsections of this chapter with a theme in mind that might assist with discussions for the remaining chapter - any guesses on what that theme might be? Here is a hint, you might discover the idea in subsections one and two (the answer in more detail in the final subsection).

Luxurious Architecture or Scenic Nature?

You are in your twenties, finalizing the conclusion of your undergraduate studies, and exploring an occupation that will bring a sense of meaning to your life. While many workplaces may require one to become comfortable with suburban or urban environments, some do not operate near areas with much city life. Nonetheless, you still have to decide where you hope to reside for the next couple of years and maybe even the rest of your life. Now, do you choose to live away from the city with the option to surround yourself more with nature and commute to work, or do you decide to immerse yourself in the luxuries of the big city with the possibility of walking every day to work? Regardless of your decision, your surroundings will have subtle

illustrations of the Golden Ratio. The association of the golden spiral and rectangles with architecture dates back to a familiar period in history - ancient Greece; the classic example of utilizing the Golden Ratio in the construction of Greek architecture is the Parthenon (Figure 3.1).²⁷ ²⁸ Even with this architectural approach taking place during the 6th century BCE, modern architects and building designers continue to apply the resourcefulness of the golden spiral and rectangles in producing aesthetically pleasing structures. Opposite to these human-made structures are naturally-made flowers and plants (Figure 3.2).²⁹



Figure 3.1: Phi in Architecture...



Figure 3.2: And in Nature

²⁷ The Arch Insider. "Importance of Golden Ratio in Architecture." *The Arch Insider*, 26 Apr. 2020, <https://thearchinsider.com/importance-of-golden-ratio-in-architecture/>.

²⁸ Stewart, Josh. "People Walking near Brown Concrete Building During Daytime." *Unsplash*, 5 Feb. 2019, <https://unsplash.com/photos/CbpLSNep0l4>.

²⁹ Cleveland, Jonathan. "The Nature of Design: The Fibonacci Sequence and the Golden Ratio." *Cleveland Design*, 19 Nov. 2020, <https://clevelanddesign.com/insights/the-nature-of-design-the-fibonacci-sequence-and-the-golden-ratio/>.

Throughout the development of a plant's leaves or a flower's petals, their quantity will either align with a number from the Fibonacci sequence or their shape will form similar to the golden spiral. One might then perceive that the presence of Phi in the growth of plants and flowers represents a form of self-actualization. That is, this process of continual development demonstrated through the behavior of a plant or flower might inspire someone who feels interconnected with Phi's impact on nature and, as a result, guide them to a life of continual self-improvement.

From Small Strands of DNA to Large Galaxies

Given the brief discussion on mathematics being the language of the universe, this might have one thinking just how incredible the universe truly is. Whether you are a believer in science and evolution, a follower of some form of religion and faith-driven, or are accepting of a little bit of both, the primary overlap between this popular yet controversial debate regarding the formation of the universe is the appreciation of just that. While the sciences provide humans with available evidence and explanations to better understand the dynamics of the universe, no matter how much one relies on verifiable solutions, there are just some things so spectacular about life that science cannot directly provide reasoning for. For example, take something as tiny as the DNA strands that make up our mortal bodies. Biology assists in comprehending exactly how these microscopic molecules manage the immense responsibility of carrying the genetic information of our being that makes every human unique. On top of that, it just so

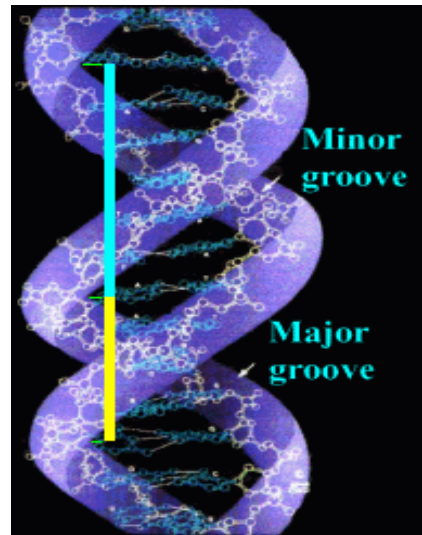


Figure 3.3: Phi in the Smallest...

happens that human DNA contains, within it, the Golden Section (Figure 3.3).³⁰ Specifically, the image of the DNA strand is a double-helix spiral broken down to highlight the major and minor grooves. Through the Golden Section, the ratio between the major and minor grooves measures twenty-one angstroms to thirteen angstroms, implying then that the ratio between the total length of the double-helix spiral and the major groove measures thirty-four angstroms to twenty-one angstroms. With this, these measurements portray some of the first numbers of the Fibonacci sequence, with each ratio approximating to the value of Phi. Opposite of this microscopic

³⁰ Meisner, Gary, et al. "DNA Spiral as a Golden Section." *The Golden Ratio: Phi, 1.618*, 27 Sept. 2020, <https://www.goldennumber.net/dna/>.

material is the astronomical example of planets and galaxies. Although astronomy is beneficial in comprehending the formation and behavior of planets and galaxies, how these astronomical objects developed as nicely as they did seems like it has a significantly small probability to it. However, there is a guaranteed probability that one might find a golden spiral in particular galaxies with the assistance of a high-quality telescope (Figure 3.4).³¹



Figure 3.4: And Largest Life Forms

³¹ Dvorsky, George. "14 Interesting Examples of the Golden Ratio in Nature." *Mathnasium*, 20 Feb. 2013, <https://www.mathnasium.com/blog/14-interesting-examples-of-the-golden-ratio-in-nature>.

The Golden Ratio in Art and Music?!

Now I know the title of this subsection ends with a question mark followed by an exclamation point to emphasize the fascination regarding these particular applications of Phi, yet this “exaggeration” is more toward the latter topic. Given the illustrations shown throughout the previous two subsections of this chapter, I feel the notion of the Golden Ratio having its place in art pieces would not surprise many. While there are countless examples to choose from, I have my thesis advisor to thank, Professor Valenza, for introducing one of such examples to me back when I was a freshman taking his Calculus 1 course. While the details of the calculus material taught that day are not as vivid as I might hope, I distinctly remember him discussing and sharing with the class the visualization to the right, known as *The Creation of Adam*.³² Do you see where Professor Valenza guided his students to look (Figures 3.5 & 3.6)?³³ If not, no worries, as I did not see it at first glance either. The key to visualizing the Golden Ratio of this Michelangelo piece starts with the gap separating the fingers of Adam and God; as the visual expands from that point

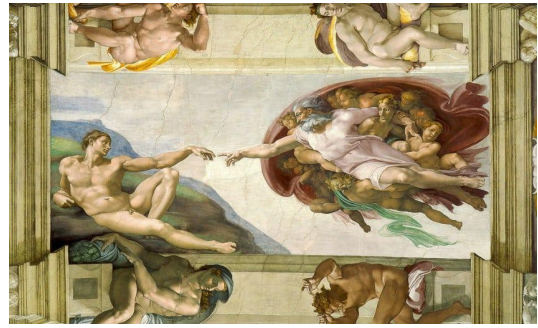


Figure 3.5: *The Creation of Adam (Before)*

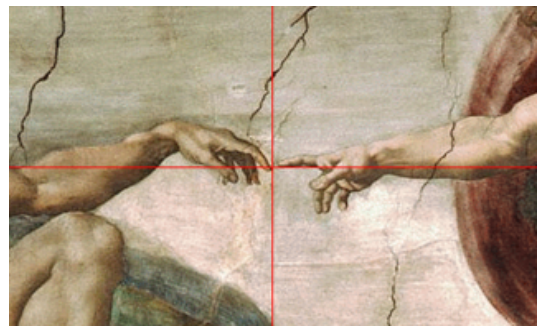


Figure 3.6: *The Creation of Adam (After)*

³² Michelangelo. *The Creation of Adam*. Vatican City, 1512.

³³ Meisner, Gary, et al. “Michelangelo and the Art of the Golden Ratio in Design.” *The Golden Ratio: Phi, 1.618*, 24 Sept. 2016, <https://www.goldennumber.net/michelangelo-sistine-chapel-golden-ratio-art-design/>.

to show the rest of the work, that small gap leaves just enough room for a vertical line to illustrate the Extreme and Mean Ratios. What left me more flabbergasted was when Professor Valenza followed that up by connecting mathematics with music through various classical songs. Although first-year Quincey did not initially understand this relationship, having learned about the Pythagoreans and their pursuit of musical harmony through numerical patterns as well as the behavior of the Fibonacci numbers in making such harmonious sounds, I reflect on that particular class and cannot help but smile at the realization that so much time has flown since then.

Maslow's Pyramid of Needs

From this point forward, we start to bridge the notion that Phi has its place when questioning what makes one's life meaningful. The inclusion of this particular subsection is twofold; the first reason is more straightforward and follows similarly to the role of the golden spiral with the Parthenon, only now with the structure of pyramids (Figure 3.7).³⁴ The second reason is more intriguing and worth further



Figure 3.7: The Great Pyramid of Giza

investigation. To begin, I introduce this psychological concept of motivation known as Maslow's Hierarchy of Human Needs. Developed by psychologist Abraham Maslow in a 1943 paper titled *A Theory of Human Motivation*, Maslow categorized particular human needs in the form of a pyramid where, once one satisfied a level on the pyramid, they then would proceed to obtain the succeeding category of human needs.³⁵ This process

continues until one reaches the human desire that Maslow deemed worthy of being at the top. There are two illustrations of Maslow's Pyramid. However, the one I wish to include involves eight levels of human needs: physiological, safety, belonging/love, self-esteem, cognitive, aesthetic, self-actualization, and

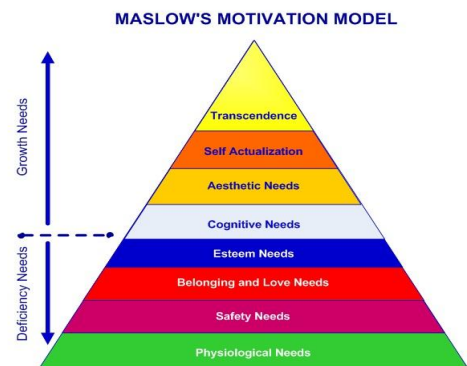


Figure 3.8: The Great Pyramid of Maslow

transcendence, where the first four levels represent deficient needs (human needs that need

³⁴ Davis, Spencer. "Person Walking Near The Great Sphinx." *Unsplash*, 29 Mar. 2019, <https://unsplash.com/photos/ONVA6s03hg8>.

³⁵ Maslow, A. H. "A Theory of Human Motivation." *Psychological Review*, vol. 50, no. 4, American Psychological Association (APA), Jul. 1943, pp. 370–396, <https://doi.org/10.1037/h0054346>.

fulfilling when lacking such), and the remaining four represent growth needs (human needs that arise from self-development) (Figure 3.8).³⁶

To keep consistent with this thesis topic, we will focus on the growth needs. After one satisfies their deficient needs, they begin the pursuit of their growth needs, starting with the cognitive ones. This particular category of needs fits well with our desire to determine what makes one's life meaningful, as the underlying conditions for fulfilling one's cognitive needs involve knowledge, meaning, and understanding. I feel Plato's philosophical perspective regarding the optimal path to a meaningful life involving this pursuit of self-knowledge and that of the world surrounding oneself does justice to Maslow's reasoning behind the significance of one's cognitive needs. Throughout the first two chapters of this thesis lie the philosophical and mathematical foundations I hope are sufficient to gain greater clarity of the overall motivation of this thesis topic. If that is the case, we then proceed to the aesthetic needs. Engaging with one's aesthetic needs is somewhat tricky to conceptualize, yet one can perceive such needs as having some level of curiosity and appreciation for the beautiful and balancing aspects of the world. This particular category of needs fits well with our illustration of the geometric properties behind the Golden Ratio. Whether through the balancing effect that the Golden Ratio has with ancient and modern architecture, the harmonious sounds produced through the Fibonacci numbers, or even the formation of the golden spiral in the development of plants and flowers, perceiving Phi as this balancing and harmonious mathematical phenomenon provides an example of how one might fulfill their aesthetic needs.

After fulfilling one's cognitive and aesthetic needs, one proceeds to recognize their potential through self-actualization and, following that, assisting others to do the same through

³⁶ "Maslow's Hierarchy Needs." *The Peak Performance Center*, <https://thepeakperformancecenter.com/educational-learning/learning/principles-of-learning/maslows-hierarchy-needs/>.

transcendence. As these categories of human needs represent the highest levels of Maslow's hierarchy, this psychological concept indicates that meaning in one's life can arise through continual self-improvement and devoting oneself to serving and guiding others toward their best selves. However, in accordance with this pyramid of human needs, one cannot get to such a state of being without fulfilling the preceding needs. In the end, the motivation for this connection I am attempting to make in gaining clarity into what makes one's life meaningful and investigating the aesthetically appealing applications of the Golden Ratio is to inspire readers of all mathematical backgrounds to perceive this phenomenon similarly as I do.

Every Action Has an Equal and Opposite Reaction

At the beginning of this chapter, I mentioned having a particular theme in mind to begin illustrating the vast geometric applications of the Golden Ratio. While I should reemphasize that Phi is a ubiquitous mathematical phenomenon, my intention behind the first two subsections was to highlight its appearance in opposing aspects of life. Demonstrating the Golden Ratio in rural and urban lifestyles as well as the smallest and largest scientific entities provides one with some new insights into the balancing property Phi contains. With the direct visualizations of how the Golden Ratio emerges in opposing forms of art and architecture, this particular interpretation of how balance relates to this mathematical concept is more subtle. Nonetheless, it also brings about the opportunity to view Phi from a different lens - a Newtonian lens.

We earlier acknowledged one of Newton's contributions to mathematics involving the establishment of calculus, yet now we briefly examine his work in physics, specifically his laws of motion.³⁷ Recall the first two laws, including, as simply put as possible, the law of inertia, and force equalling mass times acceleration. However, our attention calls us to his third law of motion, which, as mentioned in this subsection's title, is that every action has an equal and opposite reaction. From a literal and more complex standpoint regarding Newton's third law of motion, connecting it to the illustration of some mathematical concept such as Phi might raise some questions. However, from a more simplistic and indirect perspective, Newton's third law of motion is essentially just about balance. At the root of this physics principle is the realization that two forces applied to each other produce an outcome involving symmetry and a state of equilibrium.

³⁷ Newton, Isaac. *Philosophiæ Naturalis Principia Mathematica*. Londini, Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno, 1687.

Newton's third law of motion also set the foundation for deriving the law of conservation of momentum. Given that this physics principle is likely something many primarily learn about during high school, recall that an object's momentum involves the product of its mass and velocity, denoted as $p = mv$. The law of conservation of momentum then states that for two or more objects in some closed system, provided no external force acts on the closed system, their sum momentum before a given event, like a collision, equals their sum momentum after such an event. For example, take two objects with an arbitrary mass and velocity and measure

$$p_0 = m_0 \cdot v_0 \quad (9)$$

$$p_1 = m_1 \cdot v_1 \quad (10)$$

where p_0 is the momentum before the objects collide, and p_1 is the momentum after the objects collide. By the law of conservation of momentum, p_0 and p_1 equal each other, providing yet another ratio with underlying properties of balance through this particular physics concept:

$$m_0 \cdot v_0 = m_1 \cdot v_1 \Rightarrow \frac{m_0}{v_1} = \frac{m_1}{v_0} \quad (11)$$

Hence, by perceiving Phi from this Newtonian standpoint, we might finally have enough of an understanding of the pursuit of a meaningful life and this mathematical concept to discuss the relationship between the Golden Ratio and the Chinese philosophy of Taoism.

Chapter 4: What Is This Taoism You Speak Of?

Living in the West, primarily the United States, one might perceive that this particular area of the world prioritizes a work-oriented lifestyle over a holistic one. Many might be familiar with the following “ideal” life path: primary/secondary school, college, entry-level job, marriage, starting a family, various job promotions, sending children to college, retiring at the age of sixty-five, then, from that point forward, one begins to live a life of peace and harmony. This particular lifestyle that many in the United States view as a meaningful life is the “rat race.” While people can still find meaning in this “rat race” through their occupation, prioritizing one’s life through their job causes many to self-identify by assigning themselves one label, specifically with their job title. Once this aspect of their lives encounters negative experiences, it becomes easy to perceive life from the lens of the nihilist in the sense that orienting oneself through their job causes a significant amount of unhappiness once one loses their job title. This so-called “American Dream” makes the journey to better understanding what makes an individual’s life more meaningful a challenge as many grow up believing that orienting oneself toward a lucrative career innately grants us meaning and purpose. Conversely, through Eastern ideologies, their view on a meaningful life follows a more holistic approach; that is, engaging with and balancing (not necessarily equally) the various aspects of one’s life gives the individual greater chances of having meaningful experiences. Moreover, such philosophies are more accepting of a slower-paced lifestyle that just seems nonexistent in America. As one of the predominant philosophies for living a life of balance and harmony, we explore the development of the Taoist philosophy, its foundations, teachings, and, ultimately, its similarities to the mathematical concept of Phi.

When Taoism Began and... Who Is This Lao Tzu?

For some, this thesis might be the first instance in which one learns about Taoism or even hears of such a philosophy. While regarded as a philosophy and a religion, we will remain focused on its philosophical origins. Credit for establishing the Taoist system belongs to Chinese philosopher Lao Tzu; similar to the mathematical phenomenon Phi, Lao Tzu went by many names. Nonetheless, these various names that many see when exploring the origins of Taoism are not actual names, rather titles associated with the philosopher that translates to the “Old Man” or “Old Master” (I would prefer the latter myself). The curiosity that arises when questioning why one learns about a philosopher’s title over their name comes from the notion that the life story of philosopher Lao Tzu might be just that - a story. The origins of Taoism date to the 6th century BCE, a period in which one can reasonably ask if such an individual existed in the first place. In the religious context, it seems Taoists accept the existence of Lao Tzu as not just a philosopher but also as a deity. In the philosophical context, the existence of the Chinese philosopher is not as well accepted. Outside of the possibility that Lao Tzu lived to develop the early stages of Taoism are beliefs that Lao Tzu represented the Sage (a Chinese term detailing the “perfect” being) or a cumulation of various other philosophers. Regardless of the reasoning to believe one or the other, we proceed to explore the certainty behind the development of the Taoist school of thought.

Despite this ambiguity in the life story of Lao Tzu, many acknowledge that the Chinese philosopher’s teachings arose due to his internal conflicts with the overall dynamics of humanity. Place Lao Tzu in today’s Americanized society, and he would likely have had a heart attack; Lao Tzu believed and encouraged individuals not to corrupt themselves under governmental law as such an act disconnects them from the natural flows of the universe. The reader might question and even feel concerned regarding the notion of dismissing governmental regulations as such a

lifestyle might conflict with people's sense of morality. Would life truly bring about more meaning if society were to reject established laws that prevent humanity from going into anarchy? While one might gain this impression when learning about Lao Tzu's intentions for the Taoist philosophy, it is also a slight misconception of the philosopher's message. Ideally, an individual does not completely give into humanity's societal and political systems and, instead, finds a balance between such systems and individual freedom with nature. Moreover, given the fast-paced, complex nature of developed societies such as that in America, it is frequently beneficial for the individual to embrace a slow-paced, simplistic way of life, whether that involves choosing to opt out of political activities or prioritizing personal development. That said, I would not fear Lao Tzu's perspective concerning the corruptness that civilization encounters when in conflict with the universe's flow - just be sure to find that balance between humanity's societal norms and nature's harmonious elements.

Lao Tzu's attempts to persuade other civilians to apply the lifestyle he deemed worthy of living a meaningful life into their lives did not go as the philosopher might have hoped. As a result, he felt no reason to remain with society and removed himself to live isolated and immersed in the natural world. If humanity did not disregard Lao Tzu's teachings, the philosopher might not have had as much incentive to develop the *Tao Te Ching*; this Chinese text, comprised of eighty-one verses, provides insights into the Taoist philosophy from the founder himself.³⁸ Similar to Aristotle's *Nicomachean Ethics*, this Chinese text emphasizes a particular term to describe meaning - Tao. While the primary interpretations of the term are "the way" or "the path," there are various other descriptions of the Tao, yet it may appear challenging to conceptualize what exactly Lao Tzu meant by the Tao. From a philosophical context, the Tao

³⁸ Tzu, Lao. *Tao Te Ching*. Translated by Arthur Waley, Wordsworth Editions, 1996.

does not portray itself as some deity or as some objective end like other objectivist philosophies do. Instead, it seems as though Lao Tzu and followers of the Taoist philosophy perceive this concept not in alignment with something materialistic but rather something informational; by informational, perhaps a greater understanding of what it means to live a meaningful life.

For one to follow “the path” of the Tao implies that the pursuer should, firstly, recognize the Tao as a universal force that carries with it a natural energy flow. However, one cannot effectively do so when contemplating the past or worrying about the future. Only by remaining in the present moment can one truly become aware of this way of life; as a result, “the path” tends to begin with consistently reflecting on oneself through mindfulness practices such as meditation. While one's choice of mindful practice does not diminish as one becomes more aligned through the balance of the mind and body, following such action is the acknowledgment that one must embrace simplicity and structure as well as complexity and chaos (more on this in the discussion on Yin and Yang). Another crucial aspect of the Tao involves compassion for oneself and those surrounding them, which essentially means living as the most authentic self and developing a greater sense of acceptance, empathy, kindness, and respect for other people's authenticities. In the end, “effortlessly” engaging in this continual pursuit of “the way” of the Tao through inward reflection, a balanced lifestyle, and meaningful experiences with others and nature, one gains valuable insights and builds knowledge of what it means to live in accordance with the Tao.³⁹

³⁹ Mark, Joshua J. “Lao-Tzu.” *World History Encyclopedia*, <https://www.worldhistory.org/#Organization>, 17 Apr. 2023, <https://www.worldhistory.org/Lao-Tzu/>.

The Foundation of Taoism: Yin and Yang

It's safe to assume many would agree that the Yin-Yang symbol is one of the ideal and classic representations of harmony and balance. This illustration shows two spiral-like objects, one white and one black, each containing a small dot of the opposite color, coming together to form a circle. The overall inspiration behind the combination of the Yin and Yang symbols depicts a unifying illustration of the universe's underlying duality. Although one may perceive Yin and Yang from a Newtonian lens considering these two opposing symbols demonstrate an equal amount of force on one another, it is crucial to acknowledge that these opposing elements are not in opposition and, instead, portray complementary and independent forces. Despite the rise of this Yin-Yang principle occurring during the 3rd century

BCE, the symbol and its teachings align with Taoism (Figure 4.1).⁴⁰ Recall that the Taoist perspective heavily emphasizes the pursuer of the Tao to live a life revolving around balance and harmony. That said, another interpretation that might assist in better conceptualizing what exactly the Tao is involves



Figure 4.1: Yin and Yang

looking at the one aspect of the symbol not yet covered - the line separating the Yin and the Yang. To pursue the Tao, one must channel their inner Wizard of Oz and follow instead of a yellow brick road, this line with each foot in the domain of both Yin and Yang.

Firstly, there is Yang, the white spiral with the black dot. Yang associates itself with various terms such as light, day, warmth, strong, summer, assertive, sun, loud, positive, logical, and the known. Living in alignment with the Yang energy involves effectively disciplining oneself for a life of order and structure. An aspect of an ordered and structured lifestyle is this

⁴⁰ Cartwright, Mark. "Yin and Yang." *World History Encyclopedia*, <https://www.worldhistory.org/#Organization>, 29 Mar. 2023, https://www.worldhistory.org/Yin_and_Yang/.

sense of predictability to it. When we go about our day following a plan either internally or through a planner, it allows the individual to eliminate some of life's struggles and stresses, putting us in a tranquil state. This state of comfort and control provides temporary satisfaction and relief to those who embrace the Yang energy. However, given the Taoist theme of balance, a life solely revolving around order and structure sometimes wounds up doing more harm than good. While it seems counterintuitive to not benefit from planning one's day down to the hour, that is just not how life works. Frequently, unexpected situations occur out of nowhere, forcing the individual to step out of their comfort zone and handle such events just as they would in the expected scenarios. The Taoist philosophy acknowledges this notion through the black dot within the Yang spiral. Essentially, such a dot serves as a reminder to the pursuer of the Tao that while engaging with this Yang energy does provide many benefits, heavily relying on just order and structure is not the optimal way of life.

Then, there is Yin, the black spiral with the white dot. Similarly to Yang, Yin associates itself with various terms (one might guess what these terms are by looking at the opposites that make up Yang). Nonetheless, I will highlight them as dark, night, cold, weak, winter, passive, moon, quiet, negative, intuitive, and the unknown. Living in alignment with Yin energy involves the realization as well as acceptance that life is, at times, innately chaotic and unpredictable. Although harder for order and structure enthusiasts, those who live spontaneously without much concern for what life throws at them do not mind this Yin energy. When we go about our day free from tomorrow's worries knowing that such a moment does not even exist, it reduces the anxiety that arises from attempting to control the future. Again, there are limitations regarding the benefits of engaging with the Yin when it is the only source of energy one relies on. Despite the complex nature of chaos and the unknown, what seems simple concerning the engagement of

too much Yin energy is that it prevents one of their human responsibility to continually seek personal development and persevere through life's challenges with a plan in mind. As a result, there is a white dot within the Yin spiral. Maybe it is easier for me to understand this notion in comparison to the "counterintuitive" nature of an overly structured lifestyle due to my personality aligning more with an ordered lifestyle. While I strive to find more opportunities to embrace spontaneity and flexibility (and encourage fellow Yang enthusiasts to do the same), I feel more comforted knowing that life also requires just a bit of structure.

An Expansion of Taoism Through Bagua and Wu-Wei

With this understanding of how Yin and Yang serve as the foundation for Taoism, we now transition to introducing two additional Taoist concepts that also hold significance regarding this Chinese philosophy. Firstly, there is Bagua, the cosmological system demonstrating eight trigrams to portray an octagonal map. Each trigram represents a particular aspect of one's life and, at its center, is the Yin-Yang symbol as another reminder to find a balance amongst all aspects of one's life. Then there is Wu-Wei, directly translated as “non-action” or “actionless action.” Along with the pursuit of the Tao, Wu-Wei is a concept of great importance as it portrays another theme illustrated throughout the *Tao Te Ching*. Given some description through the previous subsections on how one can pursue the Tao, these particular Taoist principles provide insights and guidelines directly from the philosophy itself.

Each of the trigrams of the Bagua map involves three horizontal bars. If the bar shows two smaller bars, it represents Yin energy, and if the bar remains as one, it represents Yang energy. The aspects of life these eight trigrams demonstrate include family, abundance, fame, relationships, creativity, service, career, and knowledge. Along with the Yin-Yang symbol illustrated at the center of Bagua, this concept also emphasizes that health belongs at its center to remind one that health and well-being hold responsibility for the remaining aspects of one's life (Figure 4.2).⁴¹ While there



Figure 4.2: Bagua

are various dimensions of well-being, it is one's physical and mental health that Bagua places greater significance on. The reasoning behind this prioritization of health revolves around the

⁴¹ Gehrman, Valeska. “Bagua.” *Bagua, Early Heaven Sequence, Later Heaven Sequence - Chinese Customs*, https://www.nationsonline.org/oneworld/Chinese_Customs/bagua.htm.

notion that an individual cannot excel at their careers, have a steady income, and provide for their families if they are in bed recovering from some illness. Essentially, without proper health, it deprives the individual of personal development in other areas of their lives, giving light to the phrase “health is wealth.” There is another Chinese practice associated with this Taoist concept worth mentioning, known as Feng Shui. While more applicable within an individual’s home or room, Feng Shui provides insights into achieving balance and harmony in their current environment. By effectively organizing a given space in alignment with the principles of Feng Shui, it allows for a positive flow of Chi energy to bring one to a state of peace and tranquility.

In chapter one, with our discussion of what we mean by “meaning,” I briefly mention the concept of Wu-Wei without going into any detail regarding the intention behind bringing it up early in this thesis. As a refresher, I shared that those who deliberately act with the mentality of wanting to achieve more meaning in their lives have less probability of actually having meaningful experiences. By intentionally not acting upon our actions to guide us toward our goals and aspirations, the desires one strives for will eventually present themselves. The translation of Wu-Wei as “non-action” or “actionless act” might have one believing that this practice emphasizes completely aligning oneself with Yin energy through a life of spontaneity. Nonetheless, this notion is not exactly what this Taoist concept suggests; instead, the intention behind the Wu-Wei practice involves an individual being aware of the precise moments throughout their lifetime in which they should act, as the execution of such actions is natural and authentic. For example, as a track athlete, I typically perform better when I do not force myself beyond my limitations (this is something I continue to work on even after a decade in the sport). Clouding my mind with sprinting mechanics and micro-adjustments that could improve my overall performance tends to result in running worse times due to it feeling and appearing less

natural with such thoughts in the back of my head. This notion that performance declines when forcing or intentionally thinking about the activity is true for any activity one pursues, causing individuals to feel discouraged and disappointed when actively trying to better themselves.

Although this Taoist concept of Wu-Wei does not seem as beneficial for the pursuer of the Tao with short-term gains, in the greater perspective of things, through patience and perseverance, it rewards the individual with a lifestyle of balance and inner harmony.

Unity in Duality

To solidify this interpretation of the balancing and harmonious properties of the mathematical phenomenon Phi and its relations to the Chinese philosophy of Taoism, we briefly introduce the metaphysical principle of unity in duality. This concept is quite fascinating when reading through the definitions of unity and duality, respectively. Unity is the unification or combination of multiple things to form something singular or whole, whereas duality involves two aspects with opposing characteristics or elements. The concept of unity is far more straightforward to comprehend than that of duality, as the latter term derives itself from the concept of dualism, the metaphysical theory emphasizing a distinction between the body and mind. Although dualism is a topic that offers insightful and interesting points of conversation, for the sake of the desired connection between Phi and Taoism, we will not go into further depth on the subject matter. If curious to explore the philosophical significance of dualism, I recommend René Descartes's *Meditations on First Philosophy*.⁴² As a philosopher and fellow mathematician, Descartes puts together four observations where, within each, he essentially supports the dualist theory that the mind and body are separate entities. With this, we conclude this analysis by reflecting once more on the Golden Ratio and Taoism and observe how this metaphysical concept of unity in duality demonstrates itself in both.

Given the exploration of the numeric, algebraic, and geometric applications of the Golden Ratio, it seems an injustice to call such a mathematical entity anything outside of extraordinary. Starting with the discovery of this phenomenon through Euclid's definition, there is the Extreme and Mean Ratio which illustrates how the lengths of two different line segments and their respective ratios equal the value of Phi. While such line segments are not necessarily direct

⁴² Descartes René, and Bernard Williams. *Meditations on First Philosophy : With Selections from the Objections and Replies*. Edited by John Cottingham, Second ed., Cambridge University Press, 2017.

opposites of each other, there is still something dualistic regarding these two separate ratios coming together through some equality and outputting Phi. Then, given the description of some fascinating algebraic properties of the Golden Ratio, one additional insight needs addressing concerning the solutions to the quadratic equation as shown in (5) and (6). Throughout the process, we obtained solutions of Phi and negative one divided by Phi, otherwise known as the inverse of the negative of Phi. Every mathematical number except zero has an opposite value in the form of a reciprocal or multiplicative inverse. Thus, having the two solutions to the quadratic equation illustrated in chapter two be the Golden Ratio and its negative multiplicative inverse also portray a rather dualistic property. Finally, with the intended theme of chapter three in demonstrating Phi through its appearance in opposing aspects of life, the geometric properties of the Golden Ratio provide visuals of the dualistic nature behind this mathematical phenomenon.

The preceding subsections of this chapter provide an introduction to Taoist philosophy through a description of its origin, foundation, and some teachings and practices. Throughout the *Tao Te Ching*, an underlying theme revolves around the sense of duality and its impact on one's life. Specifically, it is the second verse of the *Tao Te Ching* where Lao Tzu compares terms such as beauty/ugliness, good/evil, and other opposing aspects of life. Essentially, the acknowledged founder of the Taoist philosophy suggests that the way of the Tao involves a dualistic mindset and approach to life. Similar to how the Yin-Yang symbol is one of the ideal and classic representations of harmony and balance, it is also an ideal and classic example of unity in duality. The terms associated with Yin energy serve as antonyms to terms associated with Yang energy. Nonetheless, this Taoist symbol suggesting the way of life involving acceptance of these two opposing entities as complementary and independent forces is additional support for a dualistic perspective when discussing Taoism as a philosophical approach to a meaningful life.

Conclusion: Do Taoism and Phi Together Truly Demonstrate a Meaning for Life?

Living a meaningful life is an essential human desire, and there are numerous paths one can pursue to become more knowledgeable of what meaning means to them. Whether through supernaturalism, subjectivism, or objectivism, the development of these theories emphasizes that there is no absolute truth to what a meaningful life requires as we get to choose which path to follow. An underlying motivation for this thesis topic was to provide a meditation on how mathematics, as the language of the universe, can reveal opportunities for individuals to perceive properties of a particular mathematical concept and connect it to a philosophy known for its association with meaning in life. One of the values in life I prioritize is balance; by embodying the essential traits of self-actualization through consistent development and balance of the various aspects of my being, this approach resonates with me when reflecting on what gives my life meaning. The value of balance in mind then brought about the opportunity to explore and discuss the balancing and harmonious properties behind the Golden Ratio and how such properties set the foundation for the Taoist philosophy. This demonstration of balance, harmony, and duality within these two separate concepts ultimately gave me a greater sense of appreciation for mathematics as a whole. The connection between Phi and Taoism may or may not have as much of a significant impact on you as it has on me - if it did, great! If not, no worries, as this thesis is not suggesting this relationship to be an objective truth, as it is just a personal interpretation of such a connection (I appreciate you taking the time to at least read the thesis in its entirety). In the end, I simply hope the discussions throughout this thesis leave you feeling more curious and knowledgeable about how you might define and interpret meaning in your life!

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