# THE QUARK

Brought to you by the Society of Physics Students

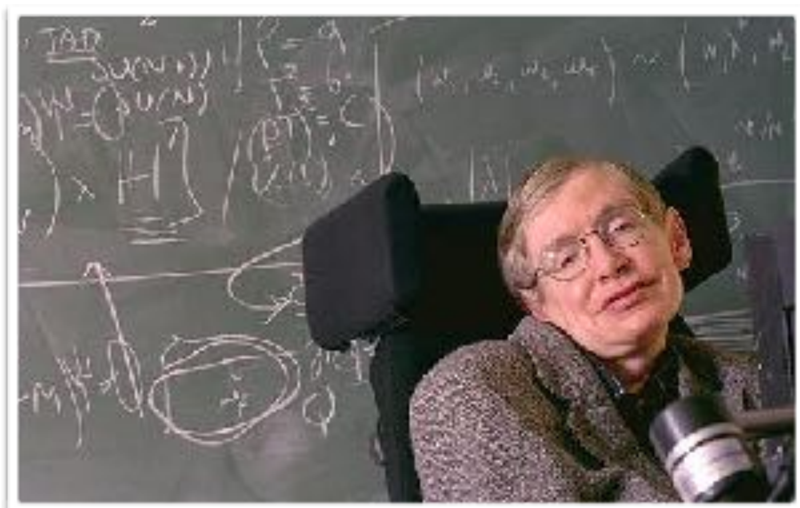
## Upcoming Events

- Women in Physics
  General Meeting #3
  04/05 at 6pm in SCI 234
- Society of Physics Students
  General Meeting #6
  04/09 at 6pm in SCI 234

## About the Quark

The Quark is a monthly newsletter written by the members of the Public Relations Committee of the Society of Physics Students at Texas Tech University.

All questions, comments, concerns, or suggestions may be directed towards the current SPS Public Relations officer, Sadman Ahmed Shanto, at sadman-ahmed.shanto@ttu.edu.



## Stephen Hawking

*By Giovan Baltazar & Carlos Perez*

British theoretical physicist, Stephen William Hawking, passed away on the fourteenth of March 2018, aged 76. His contributions to general relativity and cosmology revolutionized our understanding of the geometry of the universe.

Hawking first showed signs of interest for mathematics and the physical sciences during secondary school. Inspired by the work of mathematician, Dikran Tahta, Stephen decided to pursue a degree in physics at the University of Oxford. He did his graduate studies in Cosmology at the University of Cambridge and later obtained his Ph.D. in applied mathematics and theoretical physics with a concentration in cosmology and general relativity. Hawking was diagnosed with ALS (amyotrophic lateral sclerosis) at age 21 and was given only two years to live. Despite all odds, Hawking lived until the age of 76. He did not let his disease get in the way of his work and always kept a positive attitude stating that "[his] advice to other disabled people would be, concentrate on things your disability doesn't prevent you doing well, and don't regret the things it interferes with. Don't be disabled in spirit as well as physically." Stephen Hawking was living proof that the mind rules matter.

Most notably known for his four appearances on the American prime time TV show, "The Simpsons", Stephen Hawking had a self-driven, fulling, and above all, meaningful life.While working on his Ph.D. at the University of Cambridge, it was during this time that Stephen Hawking proposed his physics-defining and world-changing theory: the Big Bang. Hawking's legacy in the physics world is arguably on par with that of Albert Einstein and Sir Issac Newton. There's no denying the intellectual void left by this man and the impact Hawking has had on the science world. Words would do no justice in describing just how vital Hawking's works have been to the astrophysics field. The best way to describe his intellectual impact would be to imagine life a hundred years from now, when the next gifted individual shows up and isn't compared to Albert Einstein, like we do today, but instead as that generation's Stephen Hawking.

Hawking is survived by his three children, Robert, Lucy and Timothy. As the world's most famous physicist, his time with his children was short, however, he did make the most of his time with them. Later in life, Hawking would even help co-write a novel with his daughter, Lucy. At the time of the his passing, his children were quoted saying, "he was a great scientist and an extraordinary man whose work and legacy will live on for many years. His courage and persistence with his brilliance and humor inspired people across the world" adding that "he once said, 'It would not be much of a universe if it wasn't home to the people you love'". Hawking was not only a father to three successful adults, but also a "figure of hope" to the physically impaired. Hawking joined the Motor Neurone Disease Association in order to help spread the awareness of neurological diseases such as ALS. Accompanied by stars such as Benedict Cumberbatch, Hawking has spoken at conferences, such as UNESCO, about the importance technology has in aiding people of disability. To the disabled community, Hawking has been a beacon of will and grit. Despite all the odds, Stephen Hawking never once gave up on neither himself nor his efforts to enable the disabled community.

As one of the greatest minds known to mankind, it isn't all surprising how humorous Dr. Hawking was, having appeared in shows such as Futurama, The Big Bang Theory, Star Trek, and the Simpsons. Simpson's cowriter, Matt Selman, once described Hawking as a "beautiful man", and called him the smartest guest

## 1st Annual STEM Dodgeball Tournament

*By Diane Ha*

On Sunday, March 25th, the Society of Physics Students (SPS) hosted the 1st Annual STEM Org Dodgeball Tournament at the TTU Recreational Center.

They were joined by Women in Physics (WiP), the Mathematical Association of America (MAA), and the Society of Hispanic Professional Engineers (SHPE).

The organizations held a friendly double elimination tournament at the indoor soccer field to have fun and meet their fellow STEM colleagues.

### Tournament Results

1. SPS | ttusps.com
2. SHPE | ttushpe.org
3. MAA | math.ttu.edu/Undergraduate/Resources/maa/
4. WiP | ttuwip.com

## Want to do Undergraduate Research with Dr. Maccarone?

The following is a list of requirements which Dr. Maccarone expects if an undergraduate is to be assigned a research project under him:

- Experience with calculus-based physics
- Basic understanding of programming
- Strong willingness to learn what you don't understand

The last bullet point is the most important to Dr. Maccarone for understanding the unknown is what drives physicist around the world.

What would an undergraduate expect to work on under Dr. Maccarone?

This hugely depends on what they can do and what they are interested in; however, one should expect to work with huge data sets.

star to ever appear on the show. While writing the script for the episode, Matt Selman was not intimidated to say the least and determined that the script would have to go through Hawking for approval. Humorously, Hawking suggested adding a boxing glove to his animated wheel chair. Hawking would go on to guest star in three more episodes of the Simpsons with the most recent airing in 2010. Homer and Hawking discussed the possibility the universe possibly being shaped as a giant doughnut in the season 10 episode 22 entitled, "They Saved Lisa's Brain". His most notable appearance on tv was in an episode of Stark Trek where Hawking played a game of poker with Albert Einstein and Sir Isaac Newton — proving there's a direct correlation between intelligence and comedy!

Having been a father, a scholar, an activist, and a comedian, it shows just how human Stephen Hawking was compared to the average Joe. His works will remain with us and his spirit will remain admired by millions.

# Professor Spotlight: Dr. Thomas Maccarone

*By Cristobal Moreno & Carlos Perez*

Dr. Thomas Maccarone is a professor at Texas Tech University. He first came to Tech in 2013 and throughout his time at Tech, he has taught a variety of courses ranging from Physics I to upper-level astronomy courses.

He first developed his interest in physical sciences at a young age since his father was a high school physics teacher. His father was his physics teacher when he was a senior.

Dr. Maccarone started off as a chemistry major at the California Institute for Technology because he "grew up in Massachusetts and wanted to get as far away from there [as possible]." During his freshman year he realized he liked physics more than chemistry and then took an Introduction to Astronomy and Cosmology course during his sophomore year — this prompted his interest in astrophysics and astronomy during his undergraduate studies.

Dr. Maccarone attended Yale University for graduate school. He chose Yale because "the environment was friendlier when compared to other universities." His first taste of research was during the summer after his sophomore year. He was part of a program sponsored by JPL to develop a course to teach to high school students. They sought to identify which teaching methods were most effective when teaching students physics.

He obtained his masters in astronomy from Yale in 1999 and his PhD in astronomy in 2001. The title of his dissertation was "The constraints on Black Hole Emissions Mechanisms." He studied X-rays from the accretion disks around black holes. He spent his first two years of graduate school taking classes, his third working as a TA, and his final two as a full-time researcher. His favorite things about graduate school were "being able to work on a problem without worrying about it being published and the pizza in New Haven, Connecticut."

After obtaining his Ph.D., Dr. Maccarone attended the International School for Advanced Studies in Trieste, Italy as a post-doctoral researcher. He obtained his second post-doctoral research position at the University of Amsterdam. Thereon after, he was a lecturer and then reader at the University of Southampton for 7 years before he *became* an associate professor at Texas Tech University.

Currently, Dr. Maccarone is conducting research on X-ray binary systems to better understand the physics that occurs within them. For example, a phenomena called an accretion disk occurs when a normal star comes within very close range of a black hole. This process creates x-rays that can be detected via telescopes on Earth. He also studies binary stellar evolution and jet formation in stellar black holes and quasars.

Dr. Maccarone's favorite physics problem is the transit of Venus. More about this problem can be found at this link. The study of Venus's transit led to a better understanding of the size of solar system. Aside from being a physicist, Dr. Maccarone is also a huge sports fan. He enjoys watching basketball, baseball, and football. Teams from Boston are his favorite.

# Student Spotlight: Colin Brown

*By Priyadarshini Rajkumar & Edith Gallegos Ramos*

Colin Brown, an editor of the Society of Physics Student's (SPS) newsletter, *Quark*, was born in Escondido, CA and studied at San Pasqual High School. Coming from southern California, he misses the hills and the beach. During his high school years, he was a part of a For Inspiration and Recognition of Science and Technology (FIRST) Robotics team called "Team 3255 Super Nerds". Along with his team, he participated twice in the Robotics World Championship (during his freshman in 2012 and his senior year in 2015). This opportunity and his interest in research led him towards a STEM major. Currently, he is a junior at Texas Tech University, majoring in professional physics with minors in mathematics and electrical engineering.

During his freshman and sophomore year at Texas Tech, he continued to be a part of FIRST Robotics with the team "Robo Raiders 1817". As a Robo Raider, he mentored robotics to high school students using Computer Numerical Control (CNC) machining at the Reese Tech Center. His participation in FIRST Robotics helped him hone his professional skills like team organization and technical skills such as design process, information systems, fabrication and testing. In his leisure time, he taught himself to code in MATLAB, Mathematica, C++, and LaTeX.

All of these skills came extremely handy for him while he, along with two other Tech students, participated in the eighth annual University Physics Competition (UPC) for undergraduate students on November 10, 2017. The team was given 48 hours to consider one of the two questions assigned, do research or experiments, and then write a 10-page paper with a potential solution. Over 300 groups from top institutes around the world participated in the competition this year. Despite this being the first time for Tech to participate in UPC, the team bagged a silver medal for its outstanding work. He says this experience was "well worth [it]." From his experiences, he advises his fellow students that "no matter what field you go into, you will end up using specific software like MATLAB and LaTeX, so, becoming experienced in software like them can only benefit you."

His hobbies include playing video games such as Dungeons & Dragons (D&D) and occasionally writing short stories for D&D. As an eagle scout, he also enjoys biking and backpacking. The best tip he would give his peers is to "find the aspect of physics that you enjoy and care more about than your grades and focus on it." In the future, he wishes to go to graduate school and specialize in computational science and do more outreach in physics.

# Women in Physics Presents: Resume Builder

*By Diane Ha*

Writing a resume can be intimidating even with the wealth of information available the internet. Not sure where to start? The Women in Physics organization has compiled the best tips and tricks to aid you in building your perfect resume.

> Your Name
>
> Local Address
> City, State ZIP
> 000-000-0000
> first.last@ttu.edu
>
> **CAREER OBJECTIVE**
>
> Entry level candidates should utilize a career objective introduction This type of introduction targets a desired position by addressing goals specific to each company.
>
> **EDUCATION**
>
> Texas Tech University — Start Month Year - End Month Year
> B.S. Physics — Overall GPA 0.0/0.0
> Minor in Mathematics

Begin with your outline. The components of a good resume should be composed of the following sections: Contact Information, Introduction, Education, Work Experience, and Skills. Depending on the position you're seeking, the following additional sections may also fit with your resume: Languages, Licenses and Certifications, Publications, Professional Affiliations, Professional Memberships, Awards and Recognition, and Portfolio.

Your contact information section should include your full name, local address, phone number, and email. To follow, select an introduction type that best suits you. For entry-level candidates, a career objective should be utilized to target your desired position by addressing the specific goals of the company you are seeking employment at.

Depending on how much work experience you have will determine what the focus of your next two sections are. For college students with little work experience, it is recommended that you elaborate on aspects of your academic life. Treat activities such as group projects and participation in student organizations as professional experiences that highlight your skills and abilities. Students with some work experience can follow suit but the majority of their focus should be on their professional experiences.

Unsure about how to write about your accomplishments effectively? Avoid using passive language and unconvincing adverbs and rely instead on action verbs. Consider using verbs such as "managed" and "developed" instead of "responsible for".

Write about your accomplishments using bullet points that identify a responsibility or issue, elaborate on how the issue was addressed, and discuss the outcome of you action — otherwise known as the PAR method. Show that you are results oriented by quantifying your accomplishments as well. Consider your

**EXPERIENCE**

**Company Name** Start Month Year - End Month Year
*Job Title* City, State

- Write about your accomplishments effectively by identifying a responsibility or issue, elaborating on how you addressed the problem, and discussing the outcome of that action
- Always begin your bullet point details with an action verb rather than using passive language or unconvincing adverbs. Opt for using action verbs such as "managed," "implemented," or "developed" instead of "responsible for"
- Quantify your accomplishments to highlight you ability to achieve solid results. Consider percentage, time, and money. Numbers show that you are results-oriented

effect in terms of percentage, time, and money. Similarly, your skills section should highlight abilities that are relevant or transferable to the position you are seeking.

Free resume critiques are available through Texas Tech University's Career Center. Get your resume critiqued by a professional on a series of dates which can be found at https://www.depts.ttu.edu/careercenter/resumecritiqueday/index.php.

Want even more help? Join Women in Physics at their next meeting to be held Thursday, April 5th, at 6pm in SCI 234. We will discuss professional development topics including email signatures, resume writing, interview questions, and how to make a LinkedIn profile. Learn more at ttuwip.com.

# The Most Difficult Way to Earn a Million Dollars: The Riemann Hypothesis

*By Sadman Ahmed Shanto*

Observe the following sequence: 1, 3, 5, 7, 9, …. Can you predict the next term? Can you create a formula that creates this pattern? If you said yes, great! Now observe this sequence: 1, 1, 2, 3, 5, 8, 13, … What about now? Can you formulate this trend? Too easy, right? Try this last sequence: 2, 3, 5, 7, 11, 13, 17, 19, …

Interestingly enough, I am confident that you can predict accurately all the next numbers in this infinite series, but cannot articulate a neat equation as to why. Well, don't worry, you are great company of the biggest names of Mathematics: Euclid, Euler, Johanne Bernoulli, and the list goes on.

This sequence, as you may already recognize, is known as the prime number sequence and is arguably comprised of the most important numbers in all of mathematics. Humans tend to be excellent at recognizing patterns and when it came to finding one hiding amongst the distribution of prime numbers, we remain to date collectively stumped. This is why this very simple problem is worth a million dollars. Actually, the problem of finding the pattern behind the prime numbers is worth way more than a million dollars; the monetary prize is associated with proving/disproving the Riemann Hypothesis, which, as we will later see, has profound implications in the theory of prime numbers.

First, what is the Riemann Hypothesis? Stated literally it is the statement "the non-trivial zeroes of the Riemann Zeta Function $\zeta(s)$ have real part Re(s) =1/2". What does that mean and how does it relate to prime numbers? Visit https://medium.com/@JorgenVeisdal/the-riemann- hypothesis-explained-fa01c1f75d3f for an in depth explanation or read on for a layman's explanation.

Bernhard Riemann, a German polymath, is the only person in history to have made the most contribution to the study of prime numbers. In his famous paper, “On prime numbers less than a given magnitude” of 1859, he introduced what is known as the Riemann Zeta Function, which is a complex valued zeta function — you can think of the Zeta Function as the most general form of a harmonic series. Also in his paper, he went on to describing the function as being holomorphic with applied analytical continuation to span out the domain of the function to all complex numbers. Most importantly, he derived an explicit formula for the number of primes less than a given number by using the Riemann prime counting function, defined using the non-trivial zeros of the Riemann zeta function.

$$\sum_{n=1}^{\infty} \frac{1}{n^s} = 1 + \frac{1}{1^s} + \frac{1}{2^s} + \frac{1}{3^s} + \frac{1}{4^s} + \cdots$$

The Riemann Zeta Function for n where s = σ + it is a complex number where both σ and t are real numbers.

Basically, the Zeta functions have roots whenever “s” is an even negative integer, and these roots are called trivial zeroes. Consequently, all the other zeroes are called the non-trivial zeroes. To understand why these zeroes are important and what they mean, we need to know about the Euler Product.

$$\sum_{n} \frac{1}{n^s} = \prod_{p} \frac{1}{1 - p^{-s}}$$

The Euler product formula, the identity which shows the connection between prime numbers and the zeta Function

The Euler Product shows the beautiful relationship between the zeta function (L.H.S) and the certain product of prime numbers (R.H.S). So it follows that the zeta ζ(s) cannot be zero in the area with real part of s larger than 1 because a convergent infinite product can only be zero if one of its factors is zero. The proof of the infinity of the primes denies this. This result drastically shortens our contenders for the non-trivial zeros of the zeta function; they have to be between 0 and 1 in the complex number plane. This region is where we can find the non-trivial zeros known as the critical strip.


## Acknowledgements

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## Writers

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## Editors

- Victoria Blackmon
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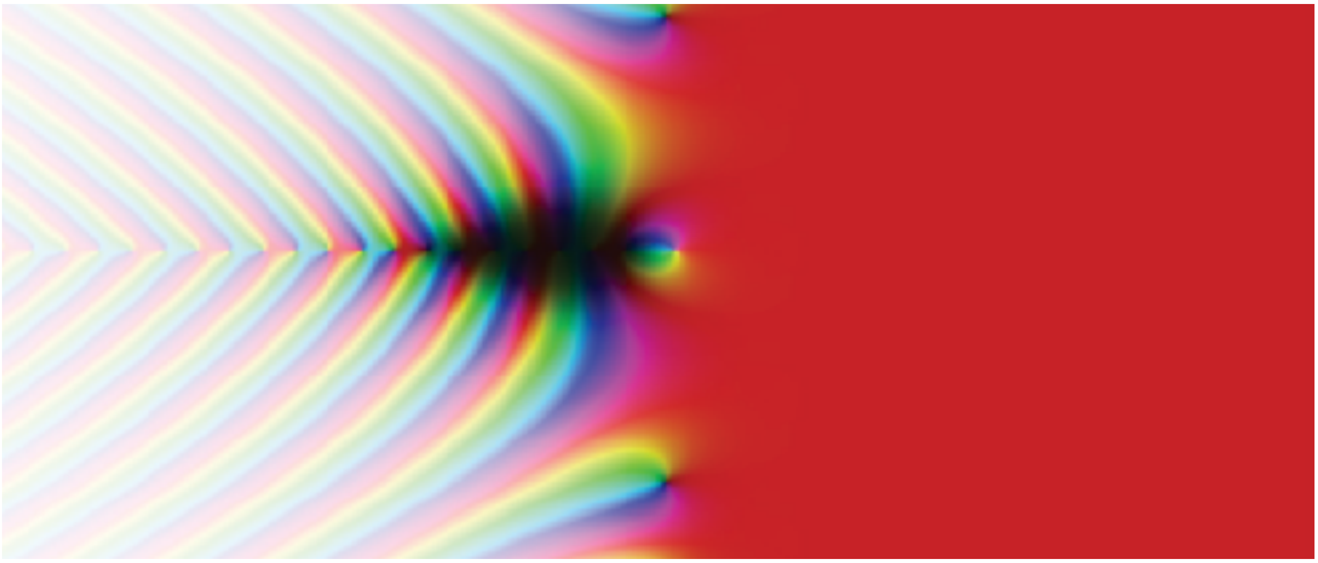


On further analysis, Riemann had discovered that all the non-trivial zeroes he found lie on the line, called the critical line, Re(s) = ½, and has stated boldly that all the non-trivial zeroes must lie on this line, aka the Riemann Hypothesis. However, he has not provided a reason as to why this occurs and also has not proven whether there are other points in the critical strip where more of these non-trivial zeros can be found, or whether this trend of finding zeroes on the critical line is true for any value "n", where "n" is the imaginary part of the complex critical line: Re(1/2)+Im(n); thus, there is room for disbelief in his ingenious work, even though there are countless reasons to believe the hypothesis. The mathematics community is known for its pedantic obsession with specificity and absolute truths, and so it is no wonder why Riemann's unproven hypothesis caused major upsets throughout the entire world of mathematics. Despite the fact that computational analysis has kept on showing that all the non-trivial zeroes lie on the critical line, human curiosity and mathematical clarity are not satisfied. This is why the Riemann Hypothesis is still an unsolved mystery in math and is also why one cannot claim the million dollar reward by using a computer to find a non-trivial zero in some other place in the critical crisp — assuming there is one!

So far, we have understood what the zeros of the zeta function mean, how prime numbers aided in the search for the non-trivial roots, and what the Riemann Hypothesis is about. In the following paragraph we will see how the Riemann hypothesis is crucial for finding the patterns behind the distribution of prime numbers. The Prime number theorem states that "As x goes to infinity, the prime counting function π(x) will approximate the function x/ln(x). In other words, if you count high enough, and plot the number of primes up to a very large number x, then plot x divided by the natural logarithm of x, the two will approach the same value.

$$\lim_{x \to \infty} \frac{\pi(x)}{\frac{x}{\ln(x)}} = 1$$

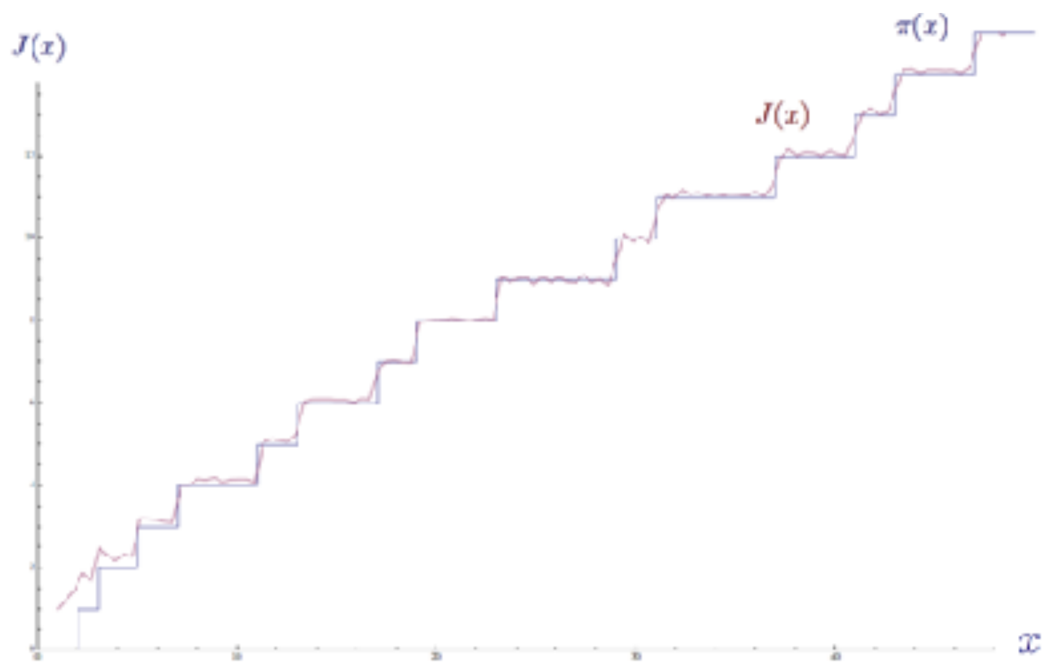
The Prime Number Theorem

This simple formula, however, has very high errors associated with it even when x is large. Building on the works of Gauss, Möbius Bernoulli and Goldbach, Riemann had created his own prime counting function J(x), which he beautifully presented in his reputed paper. His gorgeous counting function J(x) is quintessentially the analytic representation of the Euler product in the language of calculus.

$$J(x) = Li(x) - \sum_{p}^{\infty} Li(x^{\rho}) - \log 2 + \int_{x}^{\infty} \frac{1}{t(t^2-1)\log t} dt$$

"Riemann's prime number theorem" guessing the number of primes under a given magnitude x

Each term in this function symbolizes an important property of the prime numbers. In addition to this, the accuracy rate of his function is absolutely stellar, making his formula an improvement on the prime number theorem. The beauty of his explicit formula can be appreciated graphically where we can see how the continuous function J(x) models Pi(x).




The prime counting step function π(x) being approximated by the explicit formula for the Riemann prime counting function J(x) using the first 100 non-trivial zeros ρ of the Riemann Zeta function.

The Riemann Hypothesis, if true, would guarantee a far greater bound on the difference between this approximation and the real value. In other words, the importance of the Riemann Hypothesis is that it tells us a lot about how chaotic the prime numbers really are. Thus, the Riemann Hypothesis remains integral to finding out the pattern behind the distribution of prime numbers.

# Resources


[01] www.heavy.com/news/2018/03/stephen-hawkings-family-wife-children-kids/

[02] www.bbc.com/earth/story/20160107-these-are-the-discoveries-that-made-stephen-hawking-famous

[03] www.mndassociation.org/

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[12] www.mathworld.wolfram.com/RiemannHypothesis.html