IMO POST 2015

THE 56TH INTERNATIONAL MATHEMATICAL OLYMPIAD
JULY 4-16, 2015 IN CHIANG MAI, THAILAND

DAILY NEWSLETTER

JULY 11, 2015

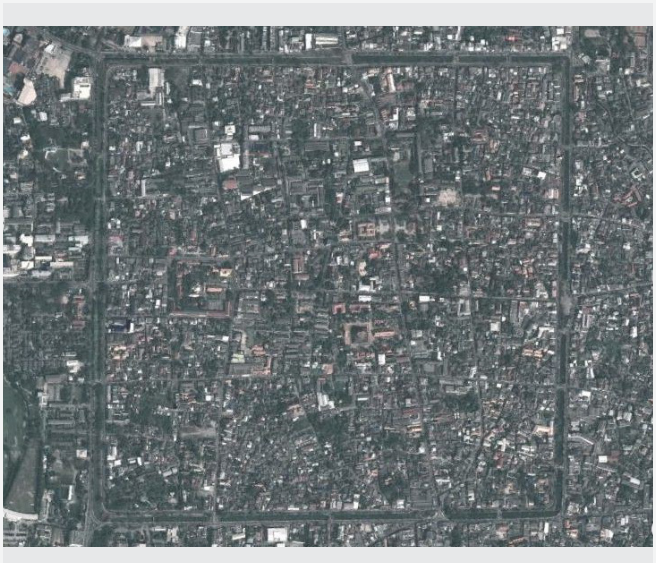
ISSUE 03

BUILDING CHIANG MAI WITHOUT PYTHAGORAS

BUILDING CHIANG MAI WITHOUT PYTHAGORAS

The city of Chiang Mai was founded in AD 1296 by King Mengrai the Great as the new capital of Lanna Kingdom, which was centered in present-day Northern Thailand from the 13th to the 18th Centuries. The city's beautiful geometric plan represents the universe according to the Hindu-Buddhist beliefs predominant at the time throughout Southeast Asia.

As depicted in the Hindu-Buddhist cosmology, the world is flat and square and floating on the cosmic ocean, with two of its sides pointing North-South, the other two pointing East-West, and a mountain, Mount Meru, rising from its center. We can see this philosophical construct in the plan of the original city of Chiang Mai (now known as the "Old City") with the walled city representing the world, the city moat representing the cosmic ocean and the city pillar symbolizing Mount Meru.



A Google Earth image of Chiang Mai's Old City

The first few years after Chiang Mai was declared Lanna's new capital must have been a busy time for the kingdom's architects, engineers and craftsmen, who had to build a new city from scratch. Unlike their counterparts in the West, however, Chiang Mai's builders likely did not have the benefit of knowing Pythagoras' Theorem, as there is no evidence that the Greek-Roman civilization ever spread to these parts during the times of Chiang Mai's founding.

Pythagoras' Theorem says that if you have a right-angle triangle, the square of the side opposite the right angle, the hypertenuse, equals the sum of the squares of the other two sides. The theorem applies to triangles with whole-number sides, such as the 3-4-5 triangle. The three integer side lengths are called Pythagorean triples.

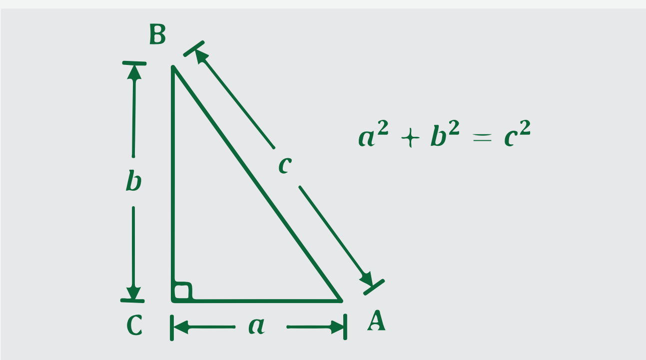


Figure 1 A Pythagorean triangle

Today, the Pythagorean Theorem is utilized on a daily basis in many fields, including architecture, design, surveying and drafting. Architects and carpenters, for example, use special right triangle whose lengths are always integers. The measures of these right triangles form Pythagorean Triples.

Builders can use Pythagorean Triples to ensure that the structure they are building is square. For example, if the length of one of the lines that form a right angle is a multiple of 3 and the length of the second leg is a multiple of 4, then the diagonal should be a multiple of 5.

Carpenters can also use their knowledge of Pythagorean Triples to make sure that the floor of the house they are building is perfectly level and the walls are perfectly straight. Utilizing the 3, 4, 5 triples, they can simply lay a piece of string 4 units long flat on the floor, with one end secured to a spot at the base of a wall, then mark a spot on the wall 3 units above the fixed end of the first string and secure a second piece of string 5 units long to that spot. If the wall and floor form a perfect right angle, the free ends of the two strings should meet exactly without slack.

As mentioned above, Lanna civilization was influenced by Hinduism and Buddhism, and in all likelihood, the people who built Chiang Mai had never heard of Pythagoras' Triples. How, then, did they build a perfectly square city?

Establishing the cardinal directions would have been the first order of the day for those ancient builders. A compass didn't exist at the time, and given that Chiang Mai is situated in a basin surrounded by mountains, they couldn't have determined east and west simply by watching sunrise and sunset.

If we were to travel back in time to the year 1296, we could use our knowledge of basic geometry to help the builders work out this problem. By setting up a tall pole in the middle of their building site, we could have observed the shadow it cast as the sun moved overhead from morning to afternoon. Since the sun is highest in the sky at noon, the shadow cast by the pole at noon would be shortest and indicate north (as Chiang Mai is in the northern hemisphere).

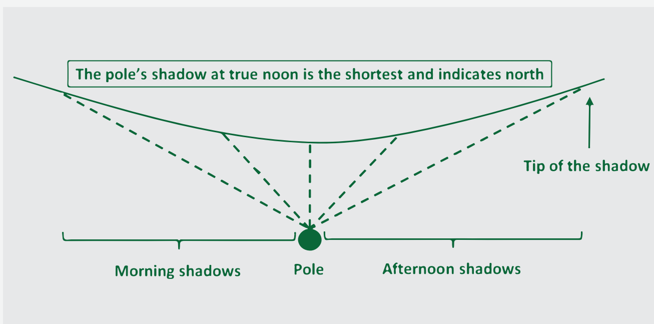


Figure 2 Shadows cast by a pole from morning to afternoon

Now, knowing that the diagonals of a parallelogram are axes of symmetry, we could draw up a parallelogram, AOBC (see Figure 3), with O located at the base of the pole and A at the tip of the longest morning shadow cast by the pole. By tying a long piece of rope to O, we could measure OA. Next, we'd need to cut a piece of rope the length of OA, fix one end to O and pull the other end towards the tip of the afternoon shadows. Marking the spot at the end of the rope (let's call it B), we could now remove both ropes from O, leaving the other end secured to A and B.

We could then draw the free ends together and fix them to a point, C, opposite O, then draw a line, CO and another, AB. Let's call the spot where the two lines met "X." If AX = BX, then we could use AOBC to determine the four cardinal points (with AOBC pointing West, South, East and North, respectively).

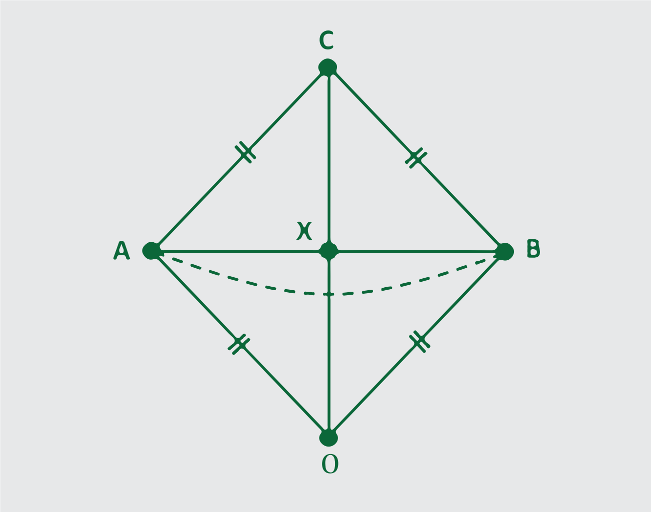


Figure 3 Parallelogram AOBC showing the four cardinal points

To test that OC truly pointed North-South and AB pointed East-West, we would need to create a rectangle, ORPQ, with P located north of C on OC, Q located east of B, R located west of A and RQ forming a straight line. If XR=XP=XQ (and thus PR=PQ), then AOBC could reliably be used to determine the four cardinal directions (see Figure 4).

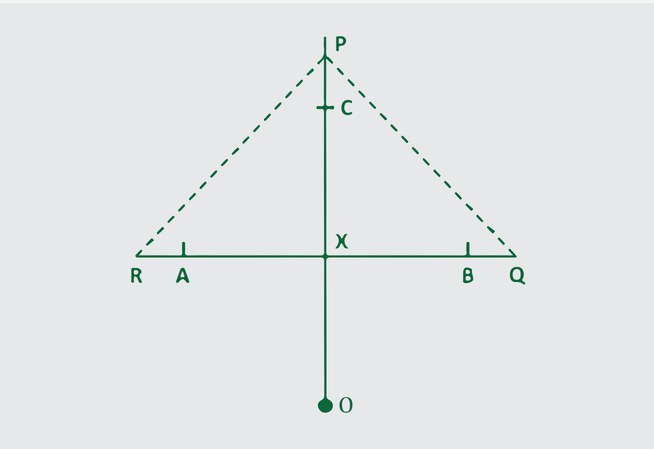


Figure 4 Rectangle ORPQ

Once the builders had picked a site for the city pillar (let's call the site "M"), we could help them further. Using our knowledge of basic geometry once again, we would draw a line NS through M, with NM = XP and MS = XP (see Figure 5).

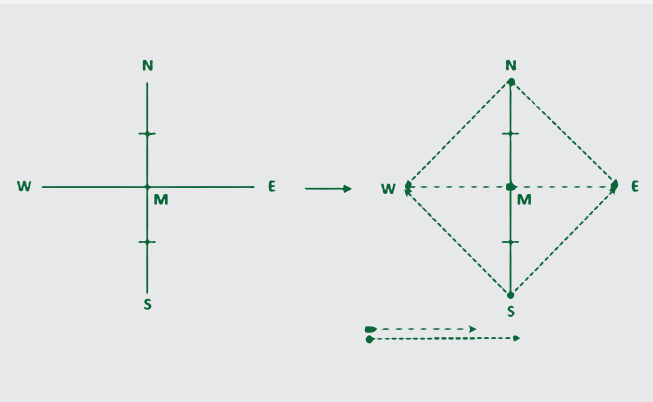


Figure 5 Using the city pillar to determine the cardinal directions

Now we'd need two lengths of rope, one the same length as PQ, the other the length of XP (the first being longer). To determine true east, we would need to fix one end of the longer rope at N and one end of the shorter one at M, then pull the free ends east of M. The spot (E) where the two lengths of rope met on the ground would point to true east. We could then use the same method to determine West with WM=XP and WN=PQ, making sure that W, M and E form a straight line and NE=ES=SW=WN.

Next, we'd mark a spot, H, east of N, with MH=NE and NH=ME, then place I west of S, with IM=WS and IS=WM. I, M, H must form a straight line and IS=IW=HN=HE=ME.

Then we'd mark a spot, J, west of N and another spot, K, east of S, making sure J, M, K form a straight line and JN=JW=KE=KS=ME (see Figure 6).

J, N, H should form a straight line, and so should K, S, I and I, W, J. Once this was achieved, we'd have a square, JHIK, which could be used to determine where the city wall and city moat should be built. If the square JHIK we helped create was deemed too small, we could help the builders expand it as shown, step by step, in Figure 6.

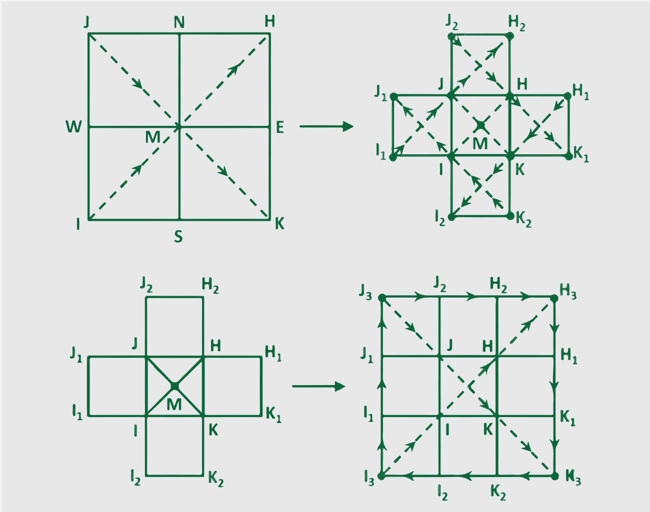


Figure 6 How the original square could be expanded to the desired size

So, by applying basic geometry knowledge, we could have helped Chiang Mai's founders build a perfectly square city (see Figure 7) without the aid of Pythagorean Triples.

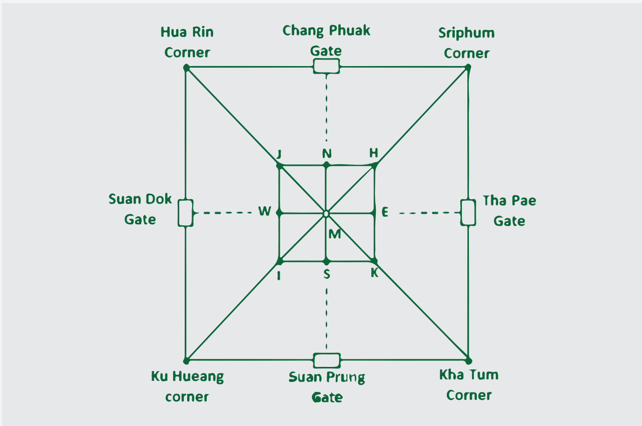
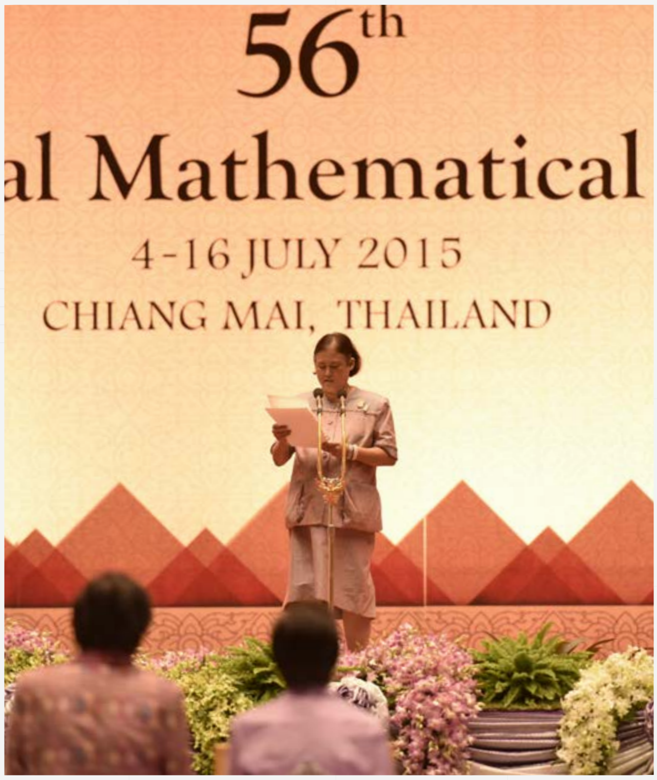


Figure 7 A rough plan of Chiang Mai's Old City

If you have an alternative theory on how the city of Chiang Mai could have been built, share it with us via email to IMO2015newsletter@gmail.com). A prize awaits the person with the most plausible theory.

(This article is adapted from a Thai-language paper titled "How Chiang Mai's City Pillar Could Have Replaced Pythagoras' Theorem" by the late Assoc. Prof. Smai Yodindra, a long-time faculty member at Chiang Mai University's Department of Mathematics.)

IMO POST 2015 NEWS



A Beautiful Welcome

To celebrate the official opening of IMO 2015 and welcome all participants to Chiang Mai, dancers from CMU's Lanna Club performed 4 dances of the north, including a traditional Sword Dance, traditional Martial Art Dance, Dance of the Bird-Woman and Mythical Deer and Flag Dance. Lanna Club President Jessada Panyafoo said: "We are honored and excited to have an opportunity to present a welcome performance for IMO 2015 participants. We are very happy to show Lanna's beautiful cultural heritage to our international visitors. On behalf of the people of Chiang Mai, we would like to extend a warm welcome to all and wish all contestants success." At 7.30 am, representatives of Chiang Mai University's student body, dressed in their full dress uniform, formed lines in front of CMU Convention Center to await the arrival of HRH Princess Maha Chakri Sirindhorn. A staunch supporter of math and science education in Thailand, Her Royal Highness graciously presided over the opening ceremony.

At 8 am, participants from around the world gathered in front of the convention center to see a welcome performance. Attendees from several countries donned their national dress for the occasion, a reflection of the IMO's international and multicultural character. Nigeria's Adewale Roland Tunde Solarin (above right) was resplendent in his robe of beautifully patterned fabric. The Ghanaian team (above left) also turned heads in their colorful graphic prints.

IMO 2015 OFFICIAL OPENING

Observers from Mahidol University, one of the largest public research universities in Thailand, posed for photos in front of CMU Convention Center, where the opening ceremony was about to begin.

Contestants, team leaders, jury members and observers had their first lunch together in a cheerful atmosphere. Thai food and international buffets were available, with desserts and fruits to round out the meal. Trying Thai food for the first time, a Belarus contestant commented that Thai and Belarusian cuisines are quite different from each other. “Thai food is very spicy and rice is the main staple, whereas potatoes are the Belarusian staple,” he said. “My teammates and I like Thai food and my favorite Thai dish so far is steamed rice.” A Swiss contestant commented that Thai food is flavorful and uses a wide variety of ingredients. The Swiss team’s favorite dishes at the lunch included Tom Kha Gai (coconut chicken soup), Tom Yum Goong (spicy prawn soup) and all seafood dishes. Contestants spent the afternoon of July 9 enjoying a variety of activities. Some played chess while others opted for Go, card games or mini foosball. The ping-pong table also attracted a fair share of contestants who needed to work out the last kinks from their long flights or simply wanted to get some exercise. We hope you all had a great day!

After the opening ceremony, participants moved to Lotus Pang Suan Kaew Hotel for lunch. A member of Team Turkey (in dark blue shirt) had his first encounter with the rambutan, a native fruit of Southeast Asia.

PLEASE JOIN US IN WELCOMING FORMER MATH OLYMPIAN PROF. RAVI VAKIL, WHO WILL GIVE A TALK ON JULY 14, 2015

A Professor of Mathematics and the Robert K. Packard University Fellow at Stanford University, Prof. Vakil is an algebraic geometer whose research work encompasses enumerative geometry, topology, Gromov-Witten theory and classical algebraic geometry.

He is the recipient of many awards and honors including the Dean's Award for Distinguished Teaching, the American Mathematical Society Centennial Fellowship, the Coxeter-James Prize from the Canadian Mathematical Society, the André-Aisenstadt Prize, the Terman fellowship, a Sloan Research Fellowship, the NSF CAREER grant, and the Presidential Early Career Award for Scientists and Engineers.

As a high school student, he won an IMO silver medal and two gold medals (once with a perfect score) in 1986, 1987 and 1988, respectively. As an undergraduate at the University of Toronto, he was a four-time Putnam Fellow, the top award in the US/Canadian undergraduate competition. He received his Ph.D. from Harvard University and taught at Princeton and MIT before moving to Stanford.

Prof. Vakil helped found the website Mathoverflow and serves on its Board of Directors, where his unofficial title is "Godfather". He works extensively with talented younger mathematicians at all levels, from middle school through to recent PhDs.

ANNOUNCING THE IMO 2015

FRIENDSHIP PRIZE!

IMO 2015 brings together participants from around the world. To encourage everyone to get to know each other, we hereby invite all to nominate your favorite new friend for **THE FIRST-EVER FRIENDSHIP PRIZE.** Each participant can nominate 1 person, the only condition being that your nominee **CANNOT BE YOUR OWN TEAMMATE.** The person who receives the most votes will be our Friendship Prize Winner. We also have prizes for 3 lucky voters (to be decided by a lucky draw). Nominate your favorite new friend by email to IMO2015newsletter@gmail.com by July 13. Be sure to include your nominee's name and country. The list of winners will be published in the July 15 Issue.

If you have an announcement to make, we'll be happy to print it. It can be about a program of study, an important day in your country, or anything else that you think will be of interest to other readers. Email your announcement to IMO2015newsletter@gmail.com. We reserve the right to edit your submission for length and style.

HAPPY BIRTHDAY

Given Name: Pedro Henrique
Family Name: Sacramento de Oliveira
Country: Brazil (BRA)
Date of Birth: 11/07/1999
IMO role: Contestant

Given Name: Petar
Family Name: Orlić
Country: Croatia (HRV)
Date of Birth: 11/07/1998
IMO role: Contestant

Given Name: Sujin
Family Name: Khomrutai
Country: Thailand (THA)
Date of Birth: 11/07/1977
IMO role: Observer A

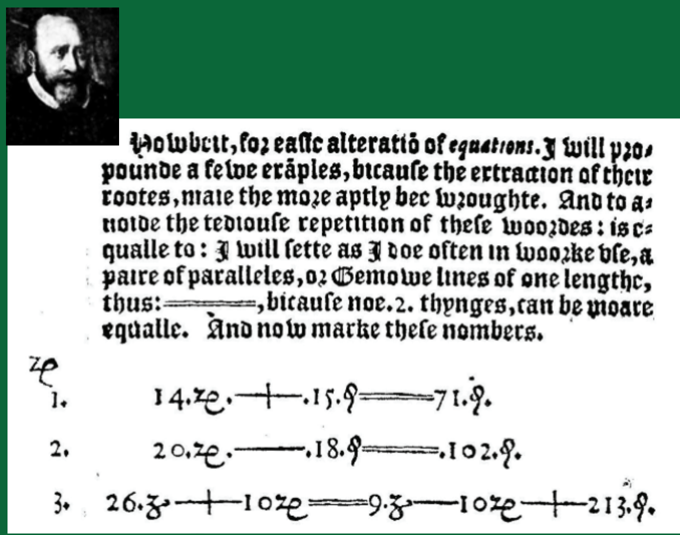
MATH CARTOON

WE ARE ON THE WEB, TWITTER AND FACEBOOK!

To get the latest IMO 2015 news and updates, go to our WEBSITE: HTTP://WWW.IMO2015.ORG/
follow us on TWITTER: HTTPS://TWITTER.COM/IMO2015THAILAND
or Like us on FACEBOOK: HTTPS://WWW.FACEBOOK.COM/IMO2015CHIANGMAITHAILAND

WHERE DID THE EQUAL SIGN COME FROM?

The equal symbol ('=') was first invented in 1557 by Welsh doctor and mathematician Robert Recorde. Recorde used the symbol in his 1557 book "The Whetstone of Witte" to avoid repeating the phrase "is equal to," which he had used almost 200 times.



Howbeit, for easie alteratiõ of equations. I will propounde a fewe exãples, bicause the extraction of their rootes, maie the more aptly bee wroughte. And to auoide the tediouse repetition of these woordes: is equalle to: I will sette as I doe often in woorke vse, a paire of paralleles, or Gemowe lines of one lengthe, thus: =====, bicause noe. 2. thynges, can be moare equalle. And now marke these nombers.

1. 14.ꝛ. + .15.ℨ ===== 71.ℨ.
2. 20.ꝛ. —— .18.ℨ ===== .102.ℨ.
3. 26.ʒ + 10ꝛ ===== 9.ʒ —— 10ꝛ + 213.ℨ.

(http://www-groups.dcs.st-and.ac.uk/~history/Bookpages/Recorde4.jpeg)

The first use of the symbol was in an equation 14x+15=71. You can see that the original design of the symbol was much longer than the one that we use now.

Recorde also explained his design of the "Gemowe lines" (meaning twin lines) in the book:

… to avoid the tedious repetition of these words: "is equal to", I will set (as I do often in work use) a pair of parallels, or Gemowe lines, of one length (thus =), because no two things can be more equal.

The symbol '=' was not immediately popular, however. The symbol ||, and æ (or œ), from the Latin word aequalis (meaning "uniform", "identical", or "equal") were widely used into the 1700s.

References:
Professor Stewart's Hoard of Mathematical Treasures
http://www.wired.com/2014/10/invention-equals-sign/
http://www-history.mcs.st-and.ac.uk/Biographies/Recorde.html

QUOTE FROM GREAT MATHEMATICIANS #3

"To those who ask what the infinitely small quantity in mathematics is, we answer that it is actually zero. Hence there are not so many mysteries hidden in this concept as they are usually believed to be."

Leonhard Euler (1707-1783), Regarded as one of the greatest mathematicians who ever lived, he made important discoveries in many fields, from infinitesimal calculus to graph theory, and introduced much of the modern mathematical terminology and notation.

MATH IS FUN

Find the sum of the first 35 terms of an Arithmetic Progression whose third term is 7 and seventh term is two more than thrice of its third term.

Email your answer to imo2015newsletter@gmail.com.
You'll be eligible to win a fabulous prize!

MATHEMATICS IN EVERYDAY LIFE

THE WORLD’S RICHEST MATHEMATICIANS
THE WORLD’S RICHEST MATHEMATICIANS

This “multiple-choice question” has been floating around on the internet:

Which of the following is the most different from the others?
(A) A Ph.D in mathematical biology
(B) A Ph.D in theoretical mathematics
(C) A Ph.D in statistics
(D) A large pepperoni pizza
Answer: (B) The other three can all feed a family of four.

This joke went viral because it is based on a stereotype that many have of mathematicians as people who can barely eke out a living. But is there any truth to it? Well, in every profession, there are people who do well financially and people who do less well. Mathematics is no exception. The good news for aspiring mathematicians is that there are people with mathematics background who have done extremely well. In fact, some of them have even joined the billionaires’ club!

James Simons

Net worth: $14 billion
No. 76 on Forbes’ 2015 “World's Billionaires" list
Simons received his B.S. in mathematics from MIT and his Ph.D. from the University of California, Berkeley. He is a former department chairman and professor of mathematics at the State University of New York at Stony Brook. In 1982, he founded Renaissance Technologies, a private hedge fund management company based in New York with over $22 billion in assets under management.

David Cheriton

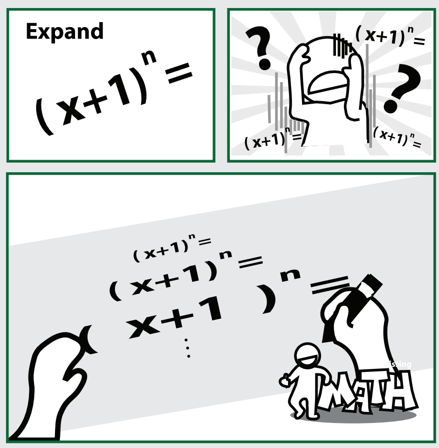
Net worth: $1.7 billion *(Wiki puts his net worth at $3.3 billion as of Sept. 2014)*
No. 2 on therichest.com’ “5 richest professors in the world” list
After receiving his Ph.D. from the University of Waterloo, Canada, Cheriton worked for 3 years as an assistant professor at the University of British Columbia before joining Stanford’s computer science faculty. A decade after he moved to Stanford, he co-founded Granite Systems, a gigabit Ethernet production company, which was bought by Cisco Systems in 1996. Two years later, he met Stanford students Sergey Brin and Larry Page and became one of Google’s first investors, writing the pair a $100,000 check. He also co-founded companies like Arastra (Ethernet switches production company) and Kealia.

Simons and Cheriton earned the bulk of their wealth through smart investments. There are many others who became wealthy thanks to their math skills but don’t call themselves mathematicians. Some are engineers, others are Wall Street analysts, and yet others are company CEOs.

Now you must be wondering if there are any mathematicians who got rich from their mathematical work. The answer is, there are, one of the most famous ones being the late Prof. James Stewart, a long-time faculty member and professor emeritus at Canada’s McMaster University. Stewart authored a series of calculus textbooks, some of which are standard university textbooks in many countries. He left behind Integral House in Toronto, which was built in the early 2000s at the cost of $32 million.

AGENDA | DAY 3, SATURDAY JULY 11

LEADERS		DEPUTY LEADERS		CONTESTANTS	
6:00 am	Breakfast	7:00 am	Breakfast	7:00 am	Breakfast
7:30 am	Depart for Q&A session	9:00 am	Move for Coordination	9:00 am-1.30 pm	Contest (Paper II)
9:00 am	Q&A session				
12:00 am	Lunch	12:00 am	Lunch	1:30 pm	Lunch
5:30 pm	Dinner	5:30 pm	Dinner	5:30 pm	Dinner
8:30-10:00 pm	Scripts of first contest day hand out				



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