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*The author*

### **A place where learning pi is a piece of cake**

By Adrian Apollo

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“Pi Day” is a wonderful new, seriously light-hearted holiday, which is celebrated every year in many Fresno-area math classrooms.

[The Exploratorium](#) science museum in San Francisco is the intellectual epicenter of this new, socio-academic phenomenon, which occurs annually on March 14, simply because of the similarity of that date (3/14) and the value of pi, which begins with the digits 3.14.

Larry Shaw, a long-time staff member of the Exploratorium, created Pi Day in 1988 as a way to make [the mathematical concept “pi”](#) into a more tangible experience for the museum’s young visitors.

Every year the sensory-motor adventure begins at exactly 1:59 p.m. (symbolizing the fourth, fifth, and sixth digits of pi) with Shaw leading a procession of museum visitors to the Pi Shrine, a round brass plaque fixed to the floor on the upper level of the museum. Participants are led to circumambulate the shrine pi number of times, whereupon [“Happy Birthday” is sung in honor of Albert Einstein](#), whose birthday coincidentally falls on March 14.

During [last year’s Pi Day celebration](#), Shasta Berry, 9, a third-grade student from Fresno’s Fancher Creek Elementary School, was selected out of the crowd, along with her classmate and friend, Amanda Vang, 9, to try her hand at spinning and throwing pizza dough into the air.

Shasta didn’t yet understand that [pi is a special ratio](#) that gives us the number of times a circle’s diameter goes around its circumference. But in the meantime, perhaps she has already had an “aha” experience and realized the significance of the circular-shaped apple, cherry and pizza pies that were given out at the festivities.

It was a wild scene, with one adult visitor nearly having his eyeglasses knocked off his face by flying pizza dough, but Shasta and Amanda were exultant during their moment in the pi vortex of fun.

## **Huge cable**

The Golden Gate Bridge is a wonderful place to contemplate the beauty of pi. After the festivities at the museum, I hopped on my bike and made a [Pi Day pilgrimage](#) to its center.

Upon arriving, I reached and pushed up against the huge suspension cable that swoops down over the walkway on the east side. I thought about how movement in the cable causes the towers to sway in response, and how calculating such fluctuations involves pi.

The beautiful panorama that surrounded me brought to mind instances of pi in so many places — in the lengths of the hilly roads of the city, in the pulleys that opened and closed the cell doors on Alcatraz, in the wheels and engines of the hundreds of cars whizzing by behind me.

I saw the shadow of the Bridge’s cables 200 feet below me on the water and thought about how I might use pi in predicting the location of those shadows, given the position of the Bridge relative to the Sun.

According to one convenient standard, [the Sun itself traces out a path in the sky](#) that is exactly pi units long from horizon to horizon.

What better place west of the Mississippi River could there be for contemplating life, art, romance, and how the number pi seems to weave a mysterious and benevolent thread through the warp and woof of our hearts and souls?

Later, on my way home, driving through Los Banos, a luminous peach-colored moon peeked out from behind some dark-blue clouds. It looked strangely near, as if it were hanging low over the town just down the way. With memories of the Sun, the Bridge and its shadow still in mind from

the afternoon, I couldn't help but think about the integrated nature of the universe and how all things are related.

I thought about Leonhard Euler, who, back in the 1700s, discovered the deeply rich nature of the tapestry of some of mathematics' most abstract methods — ideas profound enough to cause tears to well up in the eyes of a math major with a romantic view of the world. The Babylonians might have first discovered pi, but it was Euler who truly found pi's place in mathematics' overall scheme.

Then I laughed at myself for having memorized 46 digits of pi [when I was 14 years old](#), “just in case” I got stranded somewhere in the universe and needed to be able to find my way home. And yes, I still remember those digits.

For some of us, celebrating the joy of pi brings back the wispy and fond memories of first making its acquaintance, a fondness that can only be conveyed in the sparkle of a gleam in the eye.

[End commentary]



## § Apollo's Pi FAQs:

**Q:** Were there any other famous mathematicians or scientists born on March 14th, other than Einstein?

Answer: Yes. The Polish mathematician [Wacław Sierpiński](#) was born on March 14, 1882, which happened to be a year of major importance for research on the mathematical constant pi and also for the field of geometry. [In that year](#), the mathematician Ferdinand von Lindemann [proved](#) that pi is a “[transcendental](#)” number. (Hat tip to [Simon Plouffe](#).)

**Q:** Would it make more sense to celebrate a “Tau Day” on June 28th, instead of Pi Day on March 14th?

Answer: No, not really. The fact that people in some countries express the 14th day of the third month of the year as “3/14” (instead of “14/3”) is an issue of convention (not to mention the fact that our base-10 numbering system is also based on convention, as well as the division of the calendar into 12 months, etc.). The premise behind the attempt to create “tau” as a mathematical constant to replace pi is that “tau” is supposedly more sensible to use *without regard to convention* (more natural, more practical, etc.), but then to turn around and say that because of those arguments that it somehow makes more sense to celebrate June 28th instead of March 14th is to fall into the trap of undercutting one's own argument, because the month/day order in the

expression “6/28” is itself an issue of convention (not to mention the fact that there is nothing natural about associating a mathematical constant with a date on the calendar).

**Q:** Would it be more natural and more practical to use “tau” instead of pi?

**Answer:** The question presupposes a false choice. It’s not really an either-or question, because each “way” is natural in some respects, but not in other respects. Pi is more natural if you’re talking about a circle that has *already been created* (or disk, technically) and you are comparing its *diameter* with its circumference. Tau would be more natural if you’re talking about a circle that you’re *in the process of creating* (by using a radius and swinging one end of the radius all the way around while keeping the other end stationary) and you then compare the length of the *radius* with that circle’s circumference. The diameter goes around the circle pi times (3.14... times), while the radius goes around the circle “tau” times, or 2pi number of times (6.28... times). If you’re dealing with a circular object that already exists, then it would take an extra step to find the length of the radius (you would have to cut the diameter into two equal parts), and so it’s more “natural” or practical to use pi in that situation to measure the circumference. If you are starting with a long, straight object (such as a popsicle stick, a ruler or a meter stick) that you use to trace out a circle (by fastening one end to the ground or table and swinging the other end around), then it would take an extra step to figure out the length of the diameter, but since you already have the radius at hand, it would be more “natural” or practical to use “tau” in that situation to measure the circumference. So since the question presupposes a false choice, it’s not really a valid question.

**Q:** Isn’t there more to the issue than that?

**Answer:** Yes, if your definition of “practicality” is expanded to include the (very important) issues of language, culture and communication, then pi is much more “practical” to use than tau, because pi has already been established in the language of mathematics and in the culture of mathematicians. Even *if* it made more sense to use tau in terms of overall considerations of naturalness (which is something that hasn’t been demonstrated), insisting that tau be used instead of pi would be something akin to claiming that everyone should learn Esperanto. It represents a philosophically naïve approach that doesn’t properly take into account the more fundamental issues. The fact that “ $2\pi$ ” appears in many equations is hardly reason enough to claim that tau should be used in the place of that expression, since mathematicians can easily treat “ $2\pi$ ” as a single linguistic entity when needed, cognitively. That in itself is a non-issue. So there really is no compelling reason to switch over to using tau instead of pi.

**Q:** What about in terms of pedagogy? Wouldn't it be better to teach the concept of tau to students first, instead of pi?

Answer: No, not at all, and this is not even a close call. The fact that we humans see and interact with the world from the perspective of “bilateral symmetry” (due to the human body being structured that way) means that it is more effective, pedagogically, for students to learn the rectangular coordinate system (i.e., the Cartesian coordinate system) before they learn the polar coordinate system. This means that it is easier to deal with arcs instead of full circles, because (small and medium-sized) arcs can be described as functions within the rectangular coordinate system. Additionally, the length of the most basic form of an arc that can be described as a function in the rectangular system is pi units, not tau units (as I pointed out in my Pi Day article, above, when I mentioned the part about looking from “[horizon to horizon](#)”). So the claim made by tauists that it would be easier, pedagogically, for students to use tau and fractions of tau to handle radians, instead of using pi and fractions of pi, falls flat. In fact, using fractions of pi works nicely when we think of the unit-semicircle as being more basic than the full circle in the context of the rectangular coordinate system. (An angle of measure  $\pi/2$  radians is one-half the size of an angle of  $\pi$  radians, an angle of measure  $\pi/3$  radians is one-third the size of an angle of  $\pi$  radians, an angle of measure  $\pi/4$  radians is one-fourth the size of an angle of  $\pi$  radians, an angle of measure  $3\pi/2$  radians is one-and-a-half times the size of an angle of  $\pi$  radians, etc.)

**Q:** What do you mean that the bilateral symmetry of the human body leads to rectangular coordinates being easier to use? Isn't the polar coordinate system symmetric also, bilaterally?

Answer: If humans had only one eye, one arm, one leg and the musculature of the human body made bodily rotation a more basic maneuver than moving forward and backward and left and right, then in that case the polar coordinate system would be easier for humans to use and it would make more sense pedagogically to teach students to use polar coordinates first before teaching the rectangular coordinate system. For those types of intelligent organisms (if they exist somewhere in the universe, whose bodies are structured with rotational symmetry, which is technically called “radial symmetry” in biology), then perhaps it might make more sense for them to express the number of radians being referred to by using tau (along with fractional multipliers) instead of pi, since it would be easier for them to think of the full circle as being more basic in the context of polar coordinates than the semicircle, and perhaps make more sense for them to be taught the concept of “tau” first, instead of pi.

**Q:** So you don't think that it's better to use  $\tau$ -radians instead of  $\pi$ -radians?

Answer: There's no such thing as “ $\tau$ -radians” or “ $\pi$ -radians”. That's a misnomer. The number of radians being referred to remains the same regardless of how that number is expressed. One radian is still one radian and two radians is still two radians, regardless of whether or not we choose to divide the unit circle into fractions of  $\pi$  or fractions of  $\tau$ . A “radian” is a *unit* of angular measurement. The *number* of radians being talked about in a situation is something else. To

confuse the two different notions would be like confusing the “three” in the expression “three cookies” with “cookies” in that expression.

**Q:** So are you saying that you don’t believe that tau is a good concept to use at all in the classroom?

**Answer:** If the kids bring up the topic themselves, I would be reluctant to curb their enthusiasm. In this case it becomes an issue of psychology in terms of fostering motivation among your students. Or if you as a teacher honestly think it’s a good topic for a lesson plan, then I wouldn’t want to throw a wet blanket on your prerogative to teach as you see fit. However, if it’s debate you’re looking for, I think it would be more interesting and better for the kids in the long run to have a forensic competition on the topic of “[pi vs. e](#)”, or something similar.

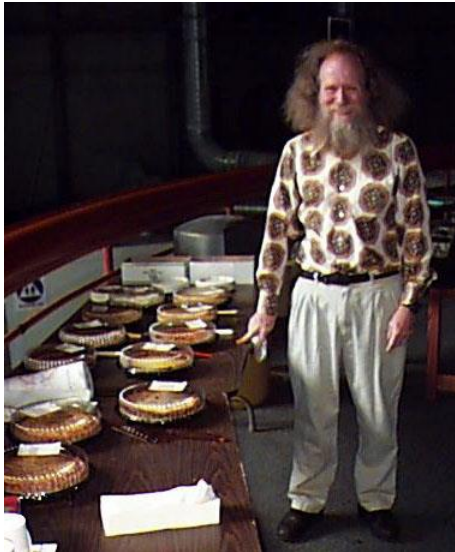
**Q:** What is the reason for Pi Day’s success? How did it become so popular?

**Answer:** Its popularity grew organically, because of the fortuitous confluence of social forces that existed in the Exploratorium science museum in San Francisco where it was created in 1988. First came the fun idea of associating the date with the number and having a reason for an annual celebration. The camaraderie existing among the staff members helped to “jump start” the new tradition. The context of the science museum being a teaching institution gave the holiday a serious rationale to underlie its light-hearted aspects, which probably accounted for its growth in popularity as the idea spread around to schools when math teachers who happened to visit the Exploratorium on Pi Day learned about it and began celebrating it with their students.

**Q:** I have a great idea for a new math holiday. How can I get it started?

**Answer:** Be patient. You need to find a social context where you can attract enthusiastic supporters who will want to return to celebrate it again the next year. Merely spreading the idea around on the Internet is not enough, as the lack of success of the idea of an “E Day” shows (for [the natural number e](#), annually on February 7th in the US or the 2nd of July in other countries). Personally, I love [the idea of “E Day.”](#) and hope it eventually catches on, but so far no socially organic situation has presented itself that would cause it to actually be “born.”

[Q](#): Who really came up with the idea of Pi Day?



Larry Shaw, the Prince of Pi

Answer: Physicist/astronomer Larry Shaw, a technical curator at the Exploratorium Science museum in San Francisco, came up with the basic framework for Pi Day in 1988 while on a staff retreat at the Asilomar Conference Grounds in Pacific Grove, California, after discussing the *The Hitchhiker's Guide to the Galaxy* with two other staff members (who did contribute some elements to the initial, expanded version of Pi Day, but choose to keep a low profile). [A prior conversation](#) that he had with a musician/mathematician friend, [Jim Horton](#), in 1983 provided the initial inspiration. As shown by his contemporaneous notes, the first Pi Day was held as a public event at the Exploratorium at its prior location near Chrissy Field on Monday, March 14, 1988. At the time of the second Pi Day celebration in 1989, Larry's youngest daughter Sara (now a veterinarian), noticed that Albert Einstein's birthday fell on Pi Day, and the tradition of singing happy birthday to Einstein on Pi Day was added on. Known widely as the "Prince of Pi" — a kind of an ex-flower-child-turned-cool-intellectual-Santa figure — Shaw follows in the footsteps of other [colorful characters and celebrities in San Francisco's history](#), and contributes to local lore by leading the [Pi Procession](#) and [mingling freely with the public](#) during the annual Pi Day festivities.

[Q](#): When you say that the proponents of using tau are being philosophically naïve and you use the analogy of people being pressured to learn Esperanto, how does that square with [your own admiration for the work of Anthony P. Morse?](#)

Answer: It's true that Morse developed a unique mathematical notation that was difficult for some people to learn. There was a standing joke among his students that they were having to learn "Morse code," but they understood the intention of his research. His notation was

experimental in the sense that its main purpose was to create a system of expression that would help to tease out new explanations (conceptual integrations) and techniques to be used with previously posed problems and perhaps provide the conceptual machinery that could take things to a new level in some instances. He titled his magnum opus: *A Theory of Sets*. He didn't call it "*The Theory of Sets*". His purpose was not to go around telling people that they were doing it all wrong and that everyone should convert to using his special notational system. Morse did a postdoc at the Institute for Advanced Study for two years where he could have had discussions with von Neumann, Gödel or even Einstein on issues in the philosophy of mathematics. When you operate on the cutting edge at such a high level, your "discourse community" shrinks down to a very small size and all bets are off as to predicting what type of conceptual tools might provide what is needed to achieve a major breakthrough. Considerations of exactly how one's work might eventually be interpreted and communicated to wider and wider social-scientific networks are important but are secondary in such a scenario, and that type of work is often carried out by other people (such as, for example, what Minkowski did for Einstein). This is a completely different situation than the "pi vs. tau" (pseudo-)controversy, which involves areas of mathematics that are intended to be understood by the layperson and used in everyday life.

**Q:** What do you think about Vi Hart's math videos?

Answer: Her video titled "[How I Feel About Logarithms](#)" is brilliant. She didn't include a discussion of [why a negative times a negative is a positive](#) in it, in fundamental terms, but that wasn't really the main purpose of that video. The brilliance of her logarithm video more than makes up for the misguidedness of her pi/tau video. Her explanation of multiplication (and exponentiation) is very correct, and she's even got [Keith Devlin](#) beat on that one. Bravo. I sincerely hope that her math videos don't veer off in the wrong direction, philosophically, as her career progresses. I'm not sure how she feels about her famous pi/tau video today, but I for one am familiar with the sense of chagrin that results after having released [something](#) that I've done an about-face on in the meantime and strongly disagree with now. In her other pi video where she claims that "Pi is a number, not a process" — that is incorrect. It's another example of a claim that presupposes a false choice. Pi is actually a number *and* a process. The topic of how mathematicians use the term "number" is a deep one that requires some pretty extensive grounding in the philosophy of math to understand.

**Q:** What do you think of Michael Hartl's tau advocacy?

Answer: It's a sign of societal health when dissenting views are seen making the rounds within a "free marketplace of ideas." In his lecture that is posted on YouTube, he mentioned that it was Google's Pi Day doodle in 2010 that propelled him into his tau advocacy. That seems to indicate a fairly severe misreading on his part as to the true meaning of Pi Day. Pi Day has nothing at all to do with pi fetishization. The part of Pi Day that might *seem* like fetishization on the surface is actually due to [Pi Day's origins as a light-hearted gag](#). The point of the joke is to have fun and set aside a little time to think about what is *really* important, which is pi's relationship to other



mathematical constants and the place of pi and those other constants within mathematics as a whole. This is an important issue that Larry himself stressed when I interviewed him in 2007. Shortly after I interviewed him, the Exploratorium had a special event in honor of the 300th anniversary of Leonhard Euler's birth, which illustrates this point. (See also: [this webpage](#), or also: [this article](#).)

The only actual fetishization that seems to be going on is the tau fetishization of the tauists. The tau fetishization seems to be indicated by their use (i.e., misappropriation) of the yin-yang symbol. Tau advocacy might make a *little* more sense if perhaps the tauists fancied themselves as being instigators of an upcoming paradigm shift within mathematics (which is what Hartl seems to be aiming for when he says his tau advocacy is intended as a "social hack"), but if they thought such a paradigm shift were needed, then the pi/tau pseudo-controversy is not going to take them there. In that sense, the proposal to replace pi with tau is really "dead on arrival." It's kind of fun to think about it a little bit, as way of sharpening one's analytical skills in dissecting a misguided idea, but that's about all. [Hartl's comment](#), made to one journalist, that he perceives himself as being someone who is "skewering a sacred cow," lends support to my interpretation that he is completely misreading the intent of Pi Day and what it's all about. Hartl now identifies himself as having a commercial motive, which in itself is not a deal-breaker for amateur math or science enthusiasts who are evaluating his claims, but it does show that he may have a vested interest in his attempt to create a new holiday. That kind of thing doesn't go over too well with the American public. In any event, the [spectacular success](#) of the new Pi Day/Einstein celebrations in Princeton, New Jersey pretty much proves that Pi Day is "where it's at," so to speak, and that Hartl's Tau Day proposal has pretty much flopped.

**Q:** What do you mean by "fetishization"?

Answer: "Fetishizing" in this context means: placing undue stress or importance on something. In other words,  $\pi$  and  $2\pi$  and  $3\pi$ , etc., are all equally important. In fact, staff members at the Exploratorium have already been celebrating June 28th every year (calling it "2pi Day," not to mention the fact that Larry Shaw's online nickname is "[Larry2pi](#)"), and joke about wanting to celebrate "3pi Day" on "September 42nd." If you want to give  $2\pi$  a special name and call it " $\tau$ ", then please go ahead if you think that would be helpful in some way. But if you're going to say that one way of writing an equation is "right" and an alternate way is "wrong," then it is incumbent upon you to articulate a clear standard as to why the concepts of "right" and "wrong" would apply. This is exactly what the tauists have not done, their protestations to the contrary. They seem to be wanting to hang their hat, ultimately, on the idea of compactness of expression, but the way that this *might* prove important is if there was some kind of domino effect to where switching  $2\pi$  to a single symbol would engender a chain reaction in form on multiple layers of expression, or demonstrate some equally potent effect of some similar kind. As one mathematician told [The Telegraph](#) of Calcutta, India: "The only benefit I see is that you could write one symbol (tau) instead of two symbols (2pi) and save on ink — nothing more than that."

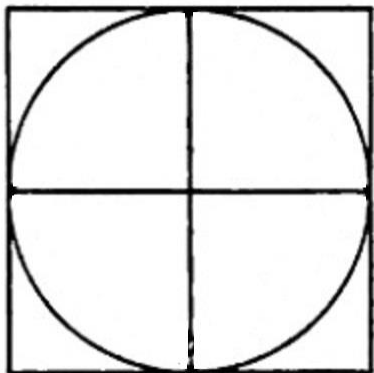
**Q:** But I just saw an article about Tau Day posted in the “Science Now” section of the LATimes.com website. Doesn't that lend credibility to the idea of Tau Day?

Answer: No, not really. The *LA Times* has been steadily losing its credibility since 2007, when it was taken over by [Sam Zell](#).

**Q:** What about Bob Palais' 2001 article titled “Pi Is Wrong!”?

Answer: It's not a research article. Bob Palais doesn't list it as a research article in his online CV, but rather lists it as a “publication.” It's actually an opinion piece (not a research article), and is clearly labeled as such in the publication in which it appeared. A disclaimer was included by the publisher that states: “The Opinion column offers mathematicians the opportunity to write about any issue of interest to the international mathematical community. Disagreement and controversy are welcome. The views and opinions expressed here, however, are exclusively those of the author, and neither the publisher nor the editor-in-chief endorses or accepts responsibility for them.” Bob Palais, of the University of Utah (who wrote the “Pi Is Wrong!” opinion piece) is not to be confused with *Richard S. Palais*, who did his Ph.D. at Harvard and did a postdoc and was a member at the Institute for Advanced Study in Princeton. Those are two different people. Bob Palais lists his doctoral degree in the following way on his CV: “Ph. D. in Mathematics, University of California, Berkeley, Princeton University, 1985-6” — but he graduated with his Ph.D. from UC Berkeley, not Princeton.

**Q:** In case my students ask, can you give me an easy explanation as to why the tau proposal is misguided?



Answer: Yes, just show them an illustration of a circle with radius  $r$  inscribed inside a square with a side length of  $2r$  and draw two lines that each cut the square in half, vertically and horizontally. (See also: [this article](#) and [this worksheet](#).) Point out how the area of the large square

is the same as the area of the four smaller squares whose sides match the radius in length. Show them how if we set the radius equal to one, then the area of the circle is pi and the area of the square is 4 and point out how they can visibly see the relationship between pi (3.14...) and the area of the square (4). This shows that, contrary to the tau proponents' claims, there is indeed a direct relationship between the radius of a circle and pi: *Pi is equal to the number of times that a square whose side is the length of a circle's radius can fit inside the circle.* This is, in fact, how [my math teacher in junior high](#) explained it to me. This is quite simple and quite clear, yet the idea of *the ratio of the circumference of a circle to the length of its diameter* is even simpler, so that's probably why pi was defined that way rather than this way. The idea of *the ratio of the circumference of a circle to the length of its radius* ("tau") is actually not simpler, because you need to count six times around, instead of three.

**Q:** How did you get so good at this?

Answer: I grew up on pi.

Send your pi-queries to: [thinkonaut@gmail.com](mailto:thinkonaut@gmail.com)



(FAQs updated: September 11, 2014)

### **§ Apollo's Pi Links:**

[http://www.exploratorium.edu/pi/history\\_of\\_pi](http://www.exploratorium.edu/pi/history_of_pi)

<http://tinyurl.com/pi-day-2014-brief-clip>

<http://tinyurl.com/pi-procession-2014>

[http://www.huffingtonpost.com/david-h-bailey/pi-day-314-14\\_b\\_4851011.html](http://www.huffingtonpost.com/david-h-bailey/pi-day-314-14_b_4851011.html)

<http://www.carma.newcastle.edu.au/jon/piday-14.pdf>

<http://www.davidhbailey.com/pi>

<http://tinyurl.com/a-history-of-pi>

<http://tinyurl.com/a-history-of-mathematics-p-158>

<http://tinyurl.com/a-history-of-mathematics-p-224>

<http://tinyurl.com/the-mountains-of-pi>

<http://unihedron.com/projects/pi/pi.pdf>

<http://eulerarchive.maa.org>

[http://www-groups.dcs.st-and.ac.uk/~history/HistTopics/Pi\\_through\\_the\\_ages.html](http://www-groups.dcs.st-and.ac.uk/~history/HistTopics/Pi_through_the_ages.html)

<http://www.thepimanifesto.com>

[http://www.123greetings.com/events/pi\\_day](http://www.123greetings.com/events/pi_day)

<http://tinyurl.com/charlie-brown-and-pi>

<http://shirt.woot.com/offers/reflections-on-pi>

<http://tinyurl.com/google-ngram-1988-to-2008>

[http://www.greenwickschools.org/uploaded/faculty/lori\\_mulligan/Mono\\_Pi\\_ly.pdf](http://www.greenwickschools.org/uploaded/faculty/lori_mulligan/Mono_Pi_ly.pdf)

<http://teachpi.org/stories/pi-goes-to-washington>

[http://www.telegraphindia.com/1110630/jsp/nation/story\\_14178997.jsp](http://www.telegraphindia.com/1110630/jsp/nation/story_14178997.jsp)

<http://tinyurl.com/pi-day-1996>

<http://tinyurl.com/pi-approximation-day>

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