# $\tau$ vs. $\pi$
# An art intervention at the crossroads of mathematics and culture

Daniel Caleb Thompson

## Background

The number $\pi$ is defined as the ratio between the circumference of a circle and its diameter and is known to be both irrational and transcendental. It is arguably the only transcendental number that is known to many non-mathematicians and has a great deal of popular appeal. Non-specialists are fascinated by memorizing and calculating digits of $\pi$ and the 14th of March ("3/14" in American date notation) is celebrated as "$\pi$ day" by some.

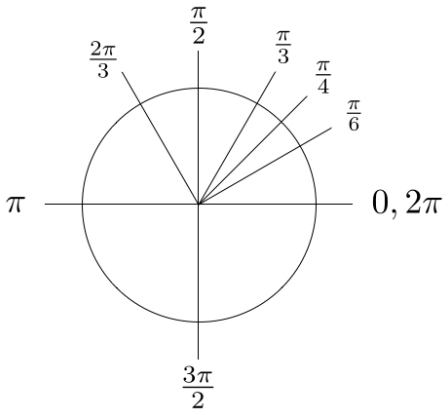
For several years there has been an underground movement spearheaded by Bob Palais, Michael Hartl, Peter Harremoës, Joseph Lindenberg and other people who claim that the ratio between the circumference of a circle and its radius is a more natural number that deserves the popular appeal that $\pi$ is enjoying. This number, the ratio between the circumference and its radius, is called $\tau$, and clearly, $\tau = 2\pi$.

## $\tau$?

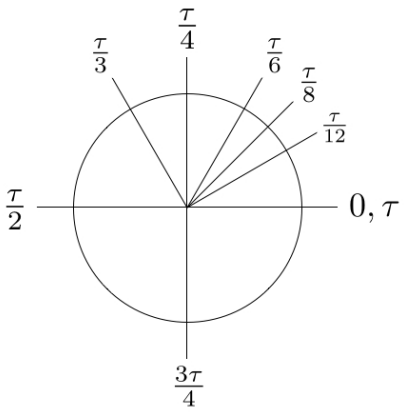
One of the primary arguments made by the "tau-ists" for this paradigm change is based upon the classical definition of a circle: A circle is an Euclidean shape composed of the collection of all points on a plane that are equidistant from a central point. The distance of the points from the centre is the *radius* of the circle. In practice, e.g., when measuring the size of a plumbing pipe, the diameter of the pipe is a value easier to measure with traditional tools like calipers, and the radius is usually determined by measuring the diameter and dividing by 2. However, in pure mathematics, their relation is reversed: the radius is the basic value and the diameter is derived from it by multiplying by 2. This is discussed by Hartl in a discussion about the values of angles in a circle measured in radians,[1] as seen in the diagrams on the next page.

What is immediately obvious is that $\tau$-radians more intuitively and more simply describe a circle's radians. Just think about it: Why is $\frac{1}{4}$ of a circle $\frac{\pi}{2}$ and $\frac{3}{4}$ of a circle $\frac{3}{2}\pi$? Isn't it more obvious to respectively use $\frac{\tau}{4}$ and $\frac{3}{4}\tau$?

[1] Cf. *The Tau Manifesto* by Michael Hartl on `http://tauday.com`.



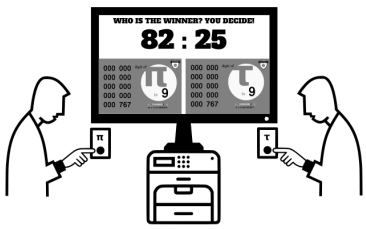

Some special angles, in "$\pi$-radians".




Some special angles, in "$\tau$-radians".

## Intervention

In the lobby of the west wing of the main building of the *Universität Hamburg*, a voting machine will be installed during the conference. This machine is composed of a computer, a laser-printer, a large monitor, two buttons and one coin slot. Two algorithms calculate sequential decimal digits of $\pi$ or $\tau$. As soon as the next digit's value has been calculated, it is registered in a private synchronized block-chain as a proof-of-work so that the algorithms can operate in perpetuity, even after an electricity black-out or device failure. Then the value is shown on the screen.




The installation as a sketch.

The viewer may elect to press one of the two buttons. The system places a vote for either $\pi$ or $\tau$—depending upon which button has been pressed. The vote is then registered on the screen above the respective panes for $\pi$ or $\tau$ and increases the relative value of that circle-constant's blockchain.

If the participant inserts a coin and then presses a button —e.g., for $\tau$—the system will print the screen-half showing the currently displayed $\tau$ value on heavyweight acid-free A3 paper that was previously signed and numbered by the artist. This certificate is a unique proof of ownership of that decimal position in the $\tau$ blockchain. The participant may take the print home with them. Unclaimed digits may be printed by the artist and offered for sale.

Note: If a digit is the same as the digit that came before it, a "Feynman" badge will appear. This badge will also show how often the digit has been repeated. "Feynman" badges multiply the market value of that blockchain member by its face value.

## Algorithms

The computer in the intervention applies a multi-threaded processor-based variation of Simon Plouffe's and Fabrice Bellard's algorithm in C to produce decimal versions of individual digits of $\pi$ or $\tau$ (available on `http://bellard.org`).

This value is then md5sum'd together with the exact decimal position similar to this bash command (as in the above model certificate) and subsequently qr-encoded:

```
$ echo "TAU 767 9" | md5sum | cut -d" " -f1 > "TAU_767.block"
$ cat "TAU_767.block" | qrencode - -o TAU_767.png
```

This is the proof of work that is required for a picoin / taucoin. Analyses of the results and source code will be made available under an open-source license at

`https://denjello.github.io/taupi`.

## Discussion

To be clear, the author is not suggesting we suddenly overturn centuries of practice and switch from $\pi$ to $\tau$. The intervention is intended to be an entertaining way of enabling discussion about the issue. The question which of the two constants is more natural is a matter of convention, not of mathematical substance. A mathematically informed discussion about this conventional decision can be compared to discussions in the past that led to events like switching from the imperial to metric standards of measurement or the Gregorian calendar reform. As opposed to discussions about standards of measurement or calendars, there is no official governing body responsible for the choice of mathematical constants.


A model certificate.

Since $\tau = 2\pi$, all equations involving $\pi$ can easily be converted to equations involving $\tau$ and vice versa. Mathematical operations come at a processing cost, and simplifying equations is in everyone's best interest. Part of the concrete mathematical background of this intervention is to discover which of two similar algorithms is faster: the one calculating the individual digits of $\pi$ or the one calculating the individual digits of $\tau$. Faster algorithms are just better.

By using the notion of blockchain computation as "work", the intervention takes the noble step of challenging infinity and assigning real value to the constituent digits of the artist's favorite shape: a full circle.

Daniel Caleb Thompson was born in Waukesha WI, United States of America. He holds degrees from Cardinal Stritch University in Milwaukee (2000) and Bauhaus-Universität Weimar (2004). He has been affiliated with *Galerie Eigenheim* in Weimar since 2006. Since 2012, he is a member of the *Kuratorium* of the gallery *Loge im Hamburger Gängeviertel*.