Indiana's Squared Circle

Revealed yet rational values for π nearly became law in an Indiana bill proposed by a country doctor in 1897.

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In 1897 the Indiana state legislature considered House Bill No. 246 — "a bill for an act introducing a new mathematical truth" — which proclaimed a new way of squaring the circle with an accompanying declaration of a new value of π. This amazing story was first fully documented in 1935 by W. E. Edington in a paper [**2**] that gives a valid account of the legislative action. Upon its introduction in the House, the bill was initially sent to the Committee on Swamp Lands; in the Senate it first went to the Temperance Committee. The Education Committee was called into the picture, and, upon the advice of the State Superintendent of Public Instruction, supported the bill. While the House passed the bill unanimously without even waiting for its third reading, as required by the state constitution, the Senate finally voted to postpone action on the bill indefinitely. Fortunately for the people of Indiana, the "indefinitely" still continues!

The author of the bill was E. J. Goodwin, M.D., of Solitude, Posey County, Indiana. It was presented to the House by representative Taylor I. Record, who was to admit that he really knew nothing about the merits of the bill, but had introduced it at the request of the country doctor who had been practicing in Posey County for nearly 20 years. (Goodwin at that time was at least 68 years old — possibly 72.)

The bill (see box) appears to propose two different values for π, first the value 4, and then 3.2. The 3.2 value is readily obtained by inverting the "five-fourths to four" ratio which itself is irresistible if one accepts two of Goodwin's assumptions. He speaks of them as "revealed"; although they are mathematically false, as approximations they are not too bad. Goodwin states that the ratio of chord to arc of ninety degrees is as seven to eight (FIGURE 1) and the ratio of diagonal to side of a square is as ten to seven. Hence, for a quadrant of 8 we have a circumference of 32 and a diameter of 10; the ratio 10/32 yields a ratio of 5/4 to 4.

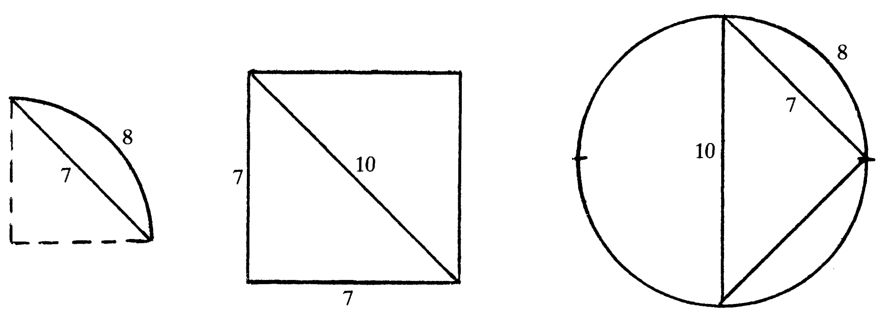

FIGURE 1.

The value of 4 is deduced from the proportion stated in Section 1. Since an "equilateral rectangle" is simply a square, this proportion is Area of circle: Quadrant^2 = Area of Square: Side^2. Since the right side reduces immediately to 1, we appear to have $\pi r^2 = (2\pi r/4)^2$ or $\pi = 4$.

House Bill No. 246, Indiana, 1897

A bill for an act introducing a new mathematical truth and offered as a contribution to education to be used only by the State of Indiana free of cost by paying any royalties whatever on the same, provided it is accepted and adopted by the official action of the legislature of 1897.

Section 1. Be it enacted by the General Assembly of the State of Indiana: It has been found that a circular area is to the square on a line equal to the quadrant of the circumference, as the area of an equilateral rectangle is to the square on one side. The diameter employed as the linear unit according to the present rule in computing the circle's area is entirely wrong, as it represents the circle's area one and one-fifth times the area of a square whose perimeter is equal to the circumference of the circle. This is because one-fifth of the diameter fails to be represented four times in the circle's circumference. For example: if we multiply the perimeter of a square by one-fourth of any line one-fifth greater than one side, we can in like manner make the square's area to appear one fifth greater than the fact, as is done by taking the diameter for the linear unit instead of the quadrant of the circle's circumference.

Section 2. It is impossible to compute the area of a circle on the diameter as the linear unit without trespassing upon the area outside of the circle to the extent of including one-fifth more area than is contained within the circle's circumference, because the square on the diameter produces the side of a square which equals nine when the arc of ninety degrees equals eight. By taking the quadrant of the circle's circumference for the linear unit, we fulfill the requirements of both quadrature and rectification of the circle's circumference. Furthermore, it has revealed the ratio of the chord and arc of ninety degrees, which is as seven to eight, and also the ratio of the diagonal and one side of a square which is as ten to seven, disclosing the fourth important fact, that the ratio of the diameter and circumference is as five-fourths to four; and because of these facts and the further fact that the rule in present use fails to work both ways, mathematically, it should be discarded as wholly wanting and misleading in its practical applications.

Section 3. In further proof of the value of the author's proposed contribution to education, and offered as a gift to the State of Indiana, is the fact of his solutions of the trisection of the angle, duplication of the cube and quadrature of the circle having been already accepted as contributions to science by the American Mathematical Monthly, the leading exponent of mathematical thought in this country. And be it remembered that these noted problems had been long since given up by scientific bodies as unsolvable mysteries and above man's ability to comprehend.

Some clarification can be obtained from Goodwin's contribution to the July 1894 issue of the *American Mathematical Monthly.* (This issue was only number 7 of volume 1 of an infant journal published independently by its two editors, B. F. Finkel and J. M. Colaw. The Mathematical Association of America, which today publishes the MONTHLY as one of its official journals, did not come into existence until 1915.) In the "Queries and Information" section, Goodwin's "contribution to science" reads as follows:

QUADRATURE OF THE CIRCLE

By EDWARD J. GOODWIN, Solitude, Indiana

Published by the request of the author.

A circular area is equal to the square on a line equal to the quadrant of the circumference; and the area of a square is equal to the area of the circle whose circumference is equal to the perimeter of the square.

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To quadrate the circle is to find the side of a square whose perimeter equals that of the given circle; rectification of the circle requires to find a right line equal to the circumference of the given circle. The square of a line equal to the arc of 90° fulfills both of the said requirements.

Goodwin's original (copyrighted!) premise was that a given "perimeter" defines the same area whether related in form to a circle or to a square. This is stated so clearly here and in a number of his other writings, prior to 1897, that one wonders why it was not so given in the bill itself. Perhaps the "protection of the copyright" was thought to be involved — but the proportion initially given in the bill actually says the same thing. The contribution states incorrectly the quadrature problem — which is to find the side of a square whose *area* (not perimeter) equals that of the given circle. At no place in any of Goodwin's writings is there any reference to the historical context of the classical quadrature problem of finding such a side by a geometrical construction using only compass and straightedge.

Returning to the bill itself, we find a phrase repeated a number of times which at first seems to make little sense: "The diameter employed as the linear unit according to the present rule in computing the circle's area is entirely wrong...". For many mathematical neophytes, an area is something found by multiplying two lengths together. To find the area of a circle, Goodwin apparently assumed that one of the lengths should be the quadrant of the circle. Correct mathematics says: $A = \pi r^2 = (2\pi r/2)\cdot r = (C/2)\cdot(d/2) = (C/4)d$. Hence the true area is indeed $(C/4)d$, and the diameter is "the linear unit". But for Dr. Goodwin the area was $(C/4)\cdot(C/4)$.

In Section 2 Goodwin points out another bit of evidence for the "incorrectness" of the rule in present use: "... because the square on the diameter produces the side of a square which equals nine when the arc of ninety degrees equals eight". In the MONTHLY note, as well as in a number of other references, Goodwin states his case in much more dramatic terms. "It is not mathematically consistent that it should take the side of a square whose perimeter equals that of a greater circle to measure the space contained within the limits of a less circle. Were this true, it would require a piece of tire iron 18 feet to bind a wagon wheel 16 feet in circumference".

Goodwin's reasoning on the 18 foot rim for a 16 foot wagon wheel is a bit tricky, but it goes like this: Consider a circle of circumference 16. Goodwin assigns it first the diameter of 5.0929 (which is correct, based on $\pi = 3.1416$). This leads to an area for the circle, "by the rule in use", of 20.3716 (i.e., 1/4 of 16 times the diameter). Hence, if a square has this same area, the square's side would be $\sqrt{20.3716}$, which is 4.51^+. Now the circle with quadrant 4.51 has a circumference of 18^+, and so "it would require a piece of tire iron 18 feet to bind a wagon wheel 16 feet in circumference". For Goodwin it is the "rule in use" which has led, incorrectly, to this false conclusion — since *his* rule is correct!

Goodwin's ultimate prescription for finding the area of a circle was to multiply the diameter by 3.2, then take a fourth of this (the quadrant), and finally to square this. To find the volume of a sphere (given elsewhere, but not in the bill), find the quadrant of the circle (sphere) and then cube it. This is good reasoning by analogy, if not good mathematics.

One might well wonder how results based on such reasoning could appear in a journal devoted to advanced mathematics. As noted before, the MONTHLY was in its first year of publication and the editors/publishers were both looking for material and promoting interest in the publication. On the other hand, the notation "by request of the author", is very seldom found with other contributions in these early years. Albert A. Bennett, in speaking of the MONTHLY before it was taken over by the Association, refers to "the largely rustic quality of early issues" **[1]**. Insight into the policies of the editors can be obtained by noting a large running debate on the validity of non-Euclidean geometry in early issues of the journal. In November 1895, Editor Finkel wrote: "Dr. (John N.) Lyle may be regarded as the greatest Anti-Non-Euclidean Geometer in America, and he has furnished many papers for publication in the MONTHLY. These we shall publish as our space permits. *Truth* has nothing to fear at the hands of any one, and if the Non-Euclidean doctrine is true, Dr. Lyle's papers will only aid in establishing it.... The editors of the MONTHLY belong to the Non-Euclidean school of thought".

No rebuttal or ciriticism of Goodwin's contributions ever appeared in the MONTHLY. But in December 1895, David Eugene Smith contributed an article, "Historical Survey of the Attempts at the Computation and Construction of π", which was actually a translation from Felix Klein's *Vorträge über ausgewählte Fragen der Elementargeometrie*; this of course included reference to Lindemann's proof of the transcendence of π.

When interviewed by a reporter for the Indianapolis *Sun* immediately after his proposal had been adopted unanimously by the House, Goodwin confessed that he had never devoted much time to mathematics, and only since 1888 had he thought about the circumference of the circle. The reporter noted that in Goodwin's room in Indianapolis were "his pamphlets on the relativity of relations, etc., etc., solving problems of life and the universe that have made the sages of all times scratch their heads until they became bald. 'If I were to say that the discoveries are revelations to me, they wouldn't believe it. This is an age of unbelief. Do you know it?'" [7].

Goodwin's original interests were in the combination of science-philosophy-religion that was not uncommon in those days. He published at least three versions of a monograph entitled *A New Physical Truth* in 1884, 1885, and 1892. The last version bore the title *Universal Inequality is the Law of All Creation.* Its major thesis was his One Law of the Universe: "All change depends on an inequality in the adjustment of forces whereby particles and aggregates compress to and repel from centres while acting in lines least resisting" [4]. In the third version (but not in the earlier two) we find several pages devoted to the quadrature of the circle. The mathematical material is essentially a preliminary version of that presented in the MONTHLY and in the bill itself.

Towards the end of the booklet we find the following autobiographical comment:

> During the first week in March, 1888, the author was supernaturally taught the exact measure of the circle, just as he had been taught three years before, the "Scheme of Universal Creation". These revelations were due in fulfillment of Scriptural statements and promises. Mathematicians second to none in this country, frankly admit that no authority in the science of numbers can tell how the ratio was discovered.... To assert that my experience differs from that of any other man, is, to say the least, a declaration of no common import.... All knowledge is revealed directly or indirectly, and the truths hereby presented are direct revelations and are due in confirmation of scriptural promises.

In this regard, it should be stated that Goodwin's contribution is by no means unique. One can easily document stories of half-a-dozen persons in England, Germany, and the United States who similarly received "divine revelations" of the true value of the circumference-diameter ratio — none of which was 3.14159....

While Goodwin at first felt his revelations concerning the circle were primarily to substantiate his "physical truth" concerning Universal Inequality as the Law of all Creation, as time went on he devoted more and more attention to the quadrature problem. His solution was copyrighted in England as well as in the United States. He corresponded with professors at the National Observatory in Washington, D.C., and was convinced that he had convinced the astronomers there of the truth of his results. He called upon the officers of the Smithsonian Institution to award prizes of $10,000 each (which he would supply) to any scientist who proved able to find an exception to the statement of his new physical truth, or to any mathematician who proved able to ascertain the means whereby the new ratio was found. He attempted to give a lecture-demonstration of his work at the 1893 World's Fair in Chicago.

Knowledge of these activities, all of which occurred prior to the legislative action of 1897, gives some insight into the dilemma confronting these legislators. It seems evident that nearly all of the legislators were completely unknowledgeable about the underlying mathematics and the import of the bill. We now know that almost immediately an Indianapolis daily paper exposed the absurdity of the bill by giving a brief resume of the history of π, including reference to the Rhind Papyrus, Archimedes, Huygens, Lambert, Lindemann, and Weierstrass. The only drawback was that the newspaper was *Der Tägliche Telegraph* [8] which was published entirely in German! On the other hand, the recognition that Goodwin had obtained in prior years seemed authoritative to some, particularly to members of the various committees with which he apparently met. Indicative of this feeling is an editorial which appeared in the Indianapolis *Journal* [6] after the bill was postponed, which illustrates how easily misinterpretations of earlier misunderstandings can become magnified.

Some newspapers have been airing their supposed wit over a bill introduced in the Legislature to recognize a new mathematical discovery or solution of the problem of squaring the circle, made by Dr. Goodwin, of Posey County. It may not be the function of a Legislature to endorse such discoveries, but the average editor will not gain much by trying to make fun of a discovery that has been endorsed by the *American Mathematical Journal*; approved by the professors of the National Astronomical Observatory of Washington, including Professor Hall, who discovered the moons of Mars; declared absolutely perfect by professors at Ann Arbor and Johns Hopkins Universities; and copyrighted as original in seven countries of Europe. The average editor is hardly well enough versed in high mathematics to attempt to down such an array of authorities as that. Dr. Goodwin's discovery is as genuine as that of Newton or Galileo, and it will endure, whether the Legislature endorses it or not.

There were a number of factors which combined to cause the indefinite postponement of the bill. Editorial ridicule in various newspapers, out-of-state as well as local, undoubtedly played a role. The opportune appearance and "coaching" of Purdue mathematician C. A. Waldo **[11]** must have influenced a few of the legislators; however, his claim that "it was probably (this) alone" that prevented its adoption simply is not supported in any other account.

The final report on the bill given by the Indianapolis *Journal* (February 13, 1897) is probably the most valid overall assessment of the Senate's action:

Although the bill was not acted on favorably, no one who spoke against it intimated that there was anything wrong with the theories it advances. All of the senators who spoke on the bill admitted that they were ignorant of the merits of the proposition. It was simply regarded as not being a subject for legislation.

We conclude this look at Goodwin's life and thought by quoting his obituary from the New Harmony, Indiana *Times*, June 27, 1902. It summarizes his entire life rather well:

End of a Man Who Wanted to Benefit the World

Dr. E. J. Goodwin died at his home in Springfield Sunday, aged 77 years. He had been in feeble health for some time, and death came at the end of a long season of illness. Dr. Goodwin was no ordinary man, and those meeting him never failed to be inspired by this fact. He was of distinguished appearance and came from Virginia where he received an excellent education. He has devoted the last years of his life in an endeavor to have the government recognize and include in its schools at West Point and Annapolis his method of squaring the circle. He wrote a book on his system and it was commented on largely and received many favorable notices from professors of mathematics.

He felt that he had a great invention and wished the world to have the benefit of it. In years to come Dr. Goodwin's plan for measuring the heavens may receive the approbation which was untiringly sought by its originator.

As years went on and he saw the child of his genius still unreceived by the scientific world, he became broken with disappointment, although he never lost hope and trusted that before his end came he would see the world awakened to the greatness of his plan and taste for a moment the sweetness of success. He was doomed to disappointment, and in the peaceful confines of village life the tragedy of a fruitless ambition was enacted.

There is always the human element in mathematics, whether the mathematics is right or wrong!

References

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