Ratio of Area of Circle and r² is π

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Abstract: In this paper, some geometrical figures based on the formula (17 – 8√3) r² are shown. It is also demonstrated how much area is formed inside and outside the circle by subtracting and comparing the border areas of these figures.

Keywords: *Geometric Proof of pi, Value of pi, Simple pi.*

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I. INTRODUCTION

The value of π (pi) has been found digitally up to 300 trillion digits as 3.14159…. Using this value, the area of a circle is calculated. However, this value is only approximate, though accepted worldwide. Hence, it is said even today that the area of a circle cannot be determined exactly.

The methods used to find the value 3.14159… such as series expansion, polygonal approximation, mathematical and trigonometric methods etc. can never yield an exact value. Therefore, instead of using those methods, I studied another geometric method to find how an exact value could be obtained.

The paper demonstrates the derivation of a rectangular area equivalent to the circular area. Some equations are also given there, whose results cannot be exactly matched with the true exact value. There are infinitely many such equations, a few of which are shown in this paper.

To find the value of π, consider the ratio of the $\pi r^2 / r^2$. It is known that the area of the twelve-sided polygon inside the circle is $3r^2$. The portion of the circle beyond that polygon is therefore $(\pi - 3) r^2$. Hence, a focus was laid on studying this extra portion, where these portions were added, $(\pi - 3) r^2 + (4 - \pi) r^2$ their sum is $1r^2$. The real question is how the values of $(\pi - 3) r^2$ and $(4 - \pi) r^2$ are determined. It is found that their sum alone needs to be taken, and it is not necessary to calculate each separately this is shown in this paper.

To find the area of the circle, a special experimental method was used. In this method, several parts of the circle were separated in order to try to determine the circle's area. However, due to the many different shapes that can be formed from the circle's area, it becomes quite difficult to calculate accurately.

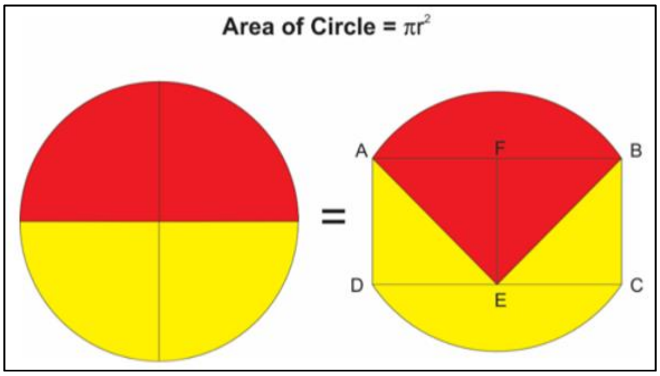

Fig 1 Both the Colours Indicated in the Figure have the Same Areas

Seg AE = √2 , an angle of AEB 90 º

Area of red part = $(\sqrt{2}r \times \sqrt{2}r \times \pi)/ 4$

The area indicated in red color = area indicated in yellow colour.

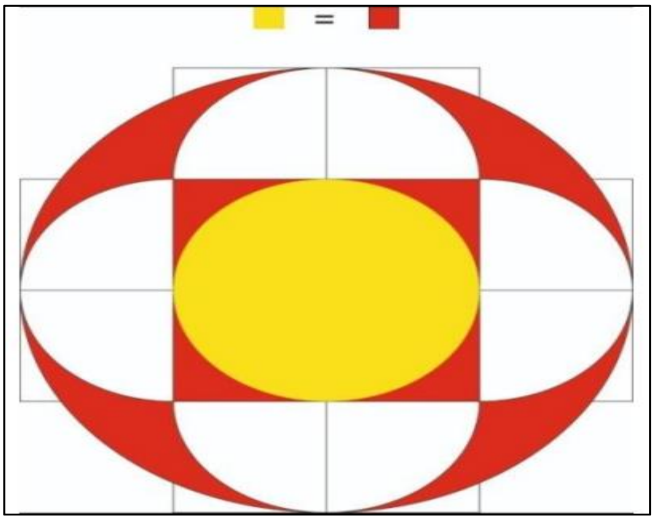

Fig 2 Shows that the Red Colored Part has Area of πr^2

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For the circle of radius 2r, the area will be $(2r \times 2r \times \pi) = 4\pi r^2$

In above circle white part $2\pi r^2$ + yellow part πr^2

$= 3\pi r^2$

$(4\pi r^2 - 3\pi r^2) = \pi r^2$ red part

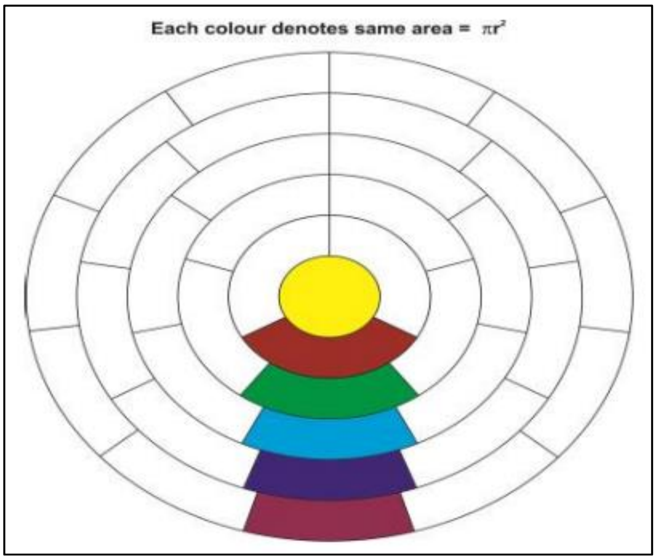

Fig 3 Shows that Each Color Area of πr^2

Any circle radius =1r, 1r+1r, 2r+1r, …..

Area of circle $(1r)^2 \times \pi$

Area of circle $(2r)^2 \times \pi = 4\pi r^2$, $(4\pi r^2 - \pi r^2) = 3\pi r^2$

$= 3\pi r^2/3 = \pi r^2$ in the same way

Area of circle $(6r)^2 \times \pi = 36\pi r^2$, $(36\pi r^2 - 25\pi r^2)$

$= 11\pi r^2$

$= 11\pi r^2/11 = \pi r^2$

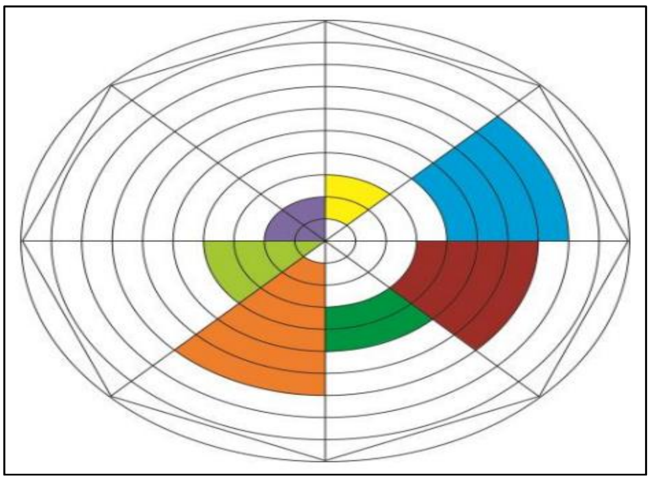

Fig 4 Shows that if the Circle is Divided into 8 parts Each Color Area is… πr^2

Consider the circles as indicated in the figure4 having radius as 1r, 1r+1r, 2r+1r, …...

Consider the following example:

- Area of this color $[(8 \times 8)\pi r^2 - (4 \times 4)\pi r^2]/8$

$= (64\pi r^2 - 16\pi r^2)/8 = 6\pi r^2$

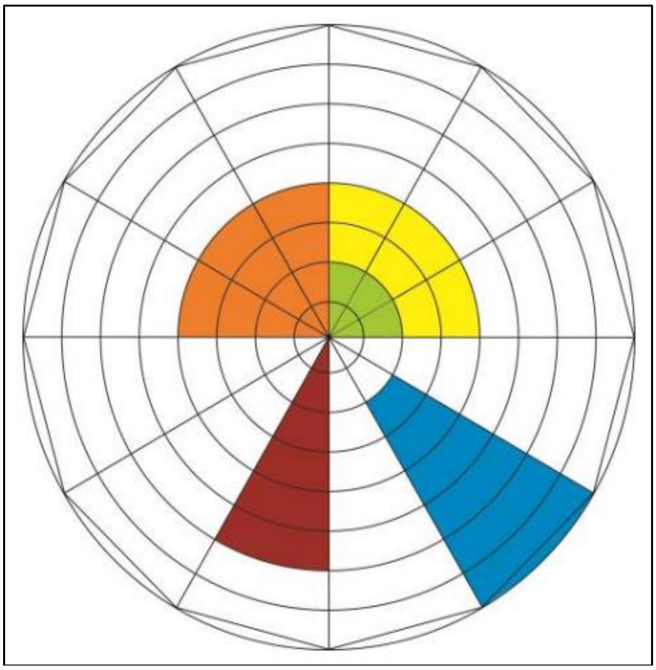

Fig 5 Shows that if the Circle is Divided into 12 Parts Each Color Area is… πr^2

For example:

- Area of this color $[(8 \times 8)\pi r^2 - (2 \times 2)\pi r^2]/12$

$= (64\pi r^2 - 4\pi r^2)/12 = 5\pi r^2$

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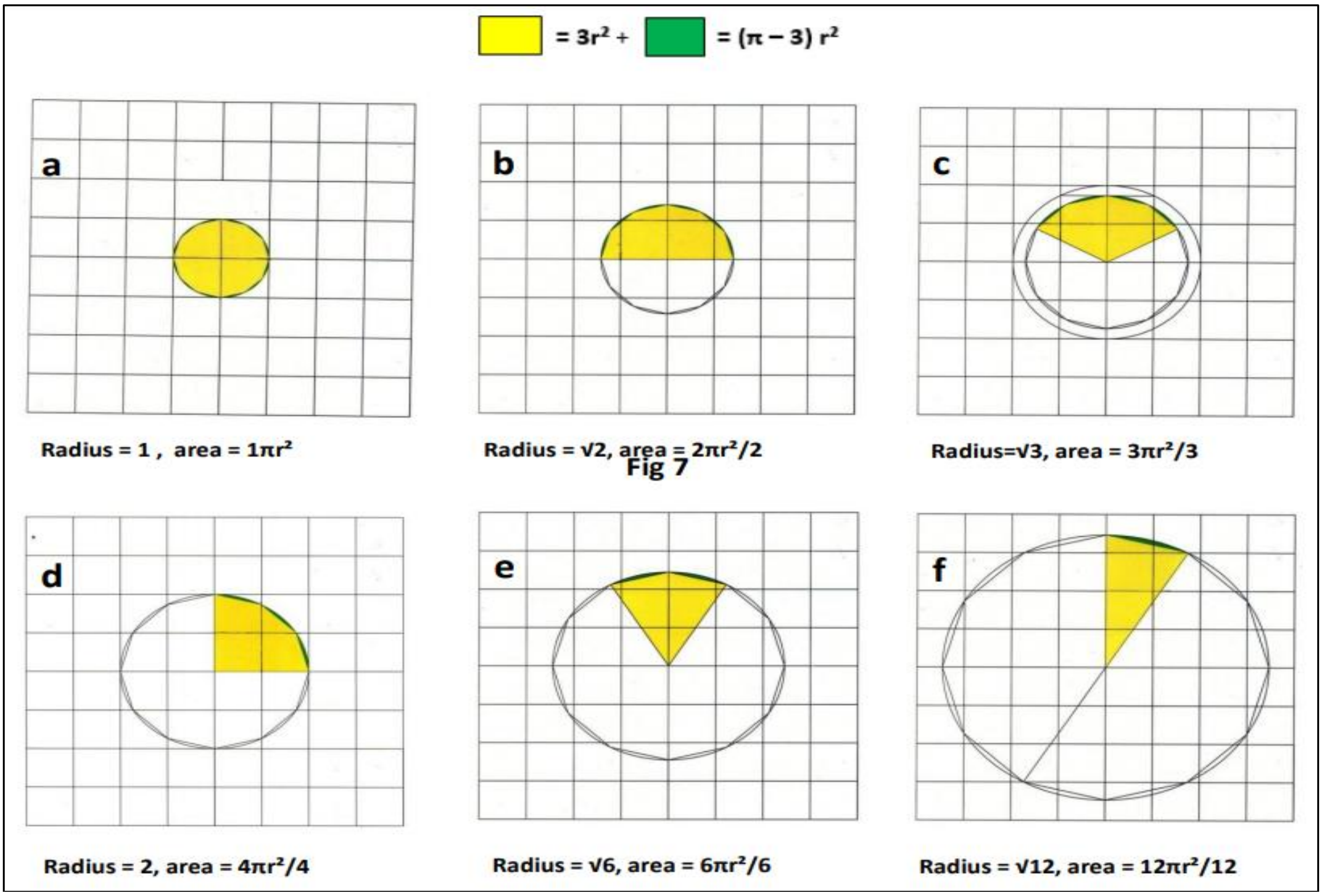

Fig 6 Area of Circle with Different Radii

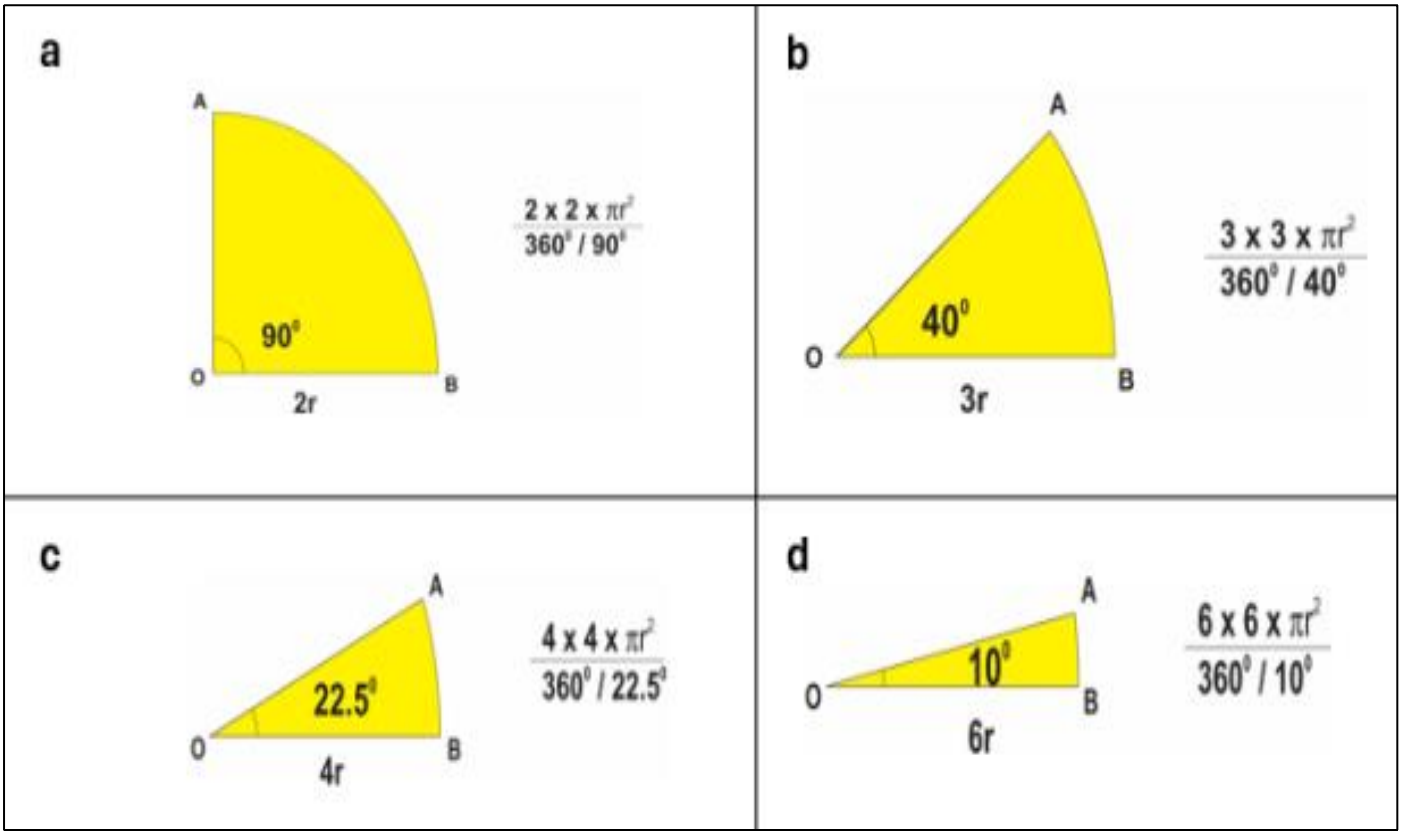

Fig 7 Variable Radius and Corresponding Angles Indicating the Same Area of πr^2

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Area of $(17 - 8\sqrt{3})\ r^2$		geometry figures
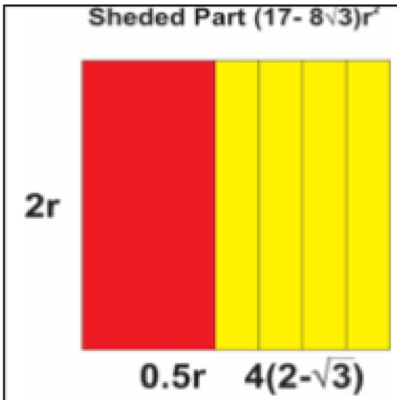	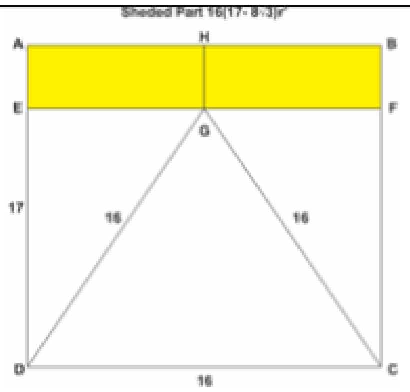	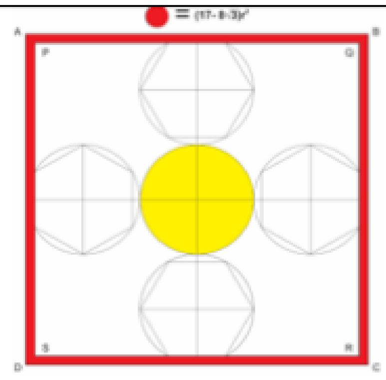
Fig 8	Fig 9	Fig 10
Area of above fig. $4(2 - \sqrt{3}r) + 0.5r$ $= (8.5r - 4\sqrt{3}) \times 2r$ $= (17 - 8\sqrt{3})r^2$	Above rectangle A,B,C,D $= (17 \times 16)$ Triangle C,D,G side 16 Then height($8\sqrt{3}$) Length G,H = $(17 - 8\sqrt{3})$ Area of yellow part $= 16(17 - 8\sqrt{3})r^2$	Side of square ABCD = 6r Area of square ABCD = $36r^2$ Side of square PQRS = $6r - (2 - \sqrt{3})r$ $=(4 + \sqrt{3})r$ Area of square PQRS = $(4 + \sqrt{3}r)^2$ $= (19 + 8\sqrt{3})r^2$ Area of shaded part $= 36r^2 - (19 + 8\sqrt{3})r^2$ $= (17 - 8\sqrt{3})r^2$

Fig 8 Area of whole rectangle = $(17-8\sqrt{3})\ r^2$
Fig 9 Area of rectangle AEFB = $16\ (17-8\sqrt{3})\ r^2$
Fig 10 Area of red shaded part = $(17-8\sqrt{3})\ r^2$

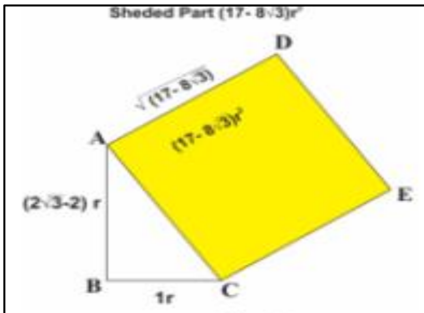	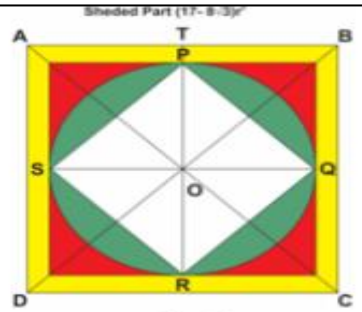	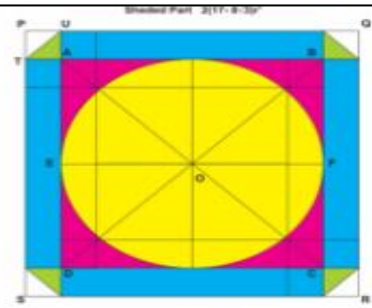
Fig 11	Fig 12	Fig 13
Sides of right angle triangle $(2\sqrt{3} - 2)$ & 1 Then diagonal $\sqrt{(17 - 8\sqrt{3})}$ $[\sqrt{(17 - 8\sqrt{3})}]^2$ $= (17 - 8\sqrt{3})$ side^2	Side of square ABCD $= 2r + (2 - \sqrt{3})r$ Area of square ABCD = $(4 - \sqrt{3}r)^2$ $= (19 - 8\sqrt{3})r^2$ Side of square PQRS = $\sqrt{2}r$ Area of square PQRS = $2r^2$ Area of shaded part $= (19 - 8\sqrt{3})r^2 - 2r^2$ $= (17 - 8\sqrt{3})r^2$	Side of square PQRS $= 2r + 2(2 - \sqrt{3})r$ Area of square PQRS = $(6 - 2\sqrt{3}r)^2$ $= (48 - 24\sqrt{3})r^2$ Side of triangle PUT = $(2 - \sqrt{3}r)$ Area of triangle PUT $= (2 - \sqrt{3}r)^2/2 = (7 - 4\sqrt{3})\ r^2/2$ Area of 4 triangle = $4(7 - 4\sqrt{3})$ $r^2/2 = (14 - 8\sqrt{3})\ r^2$ Area of shaded part $= (48 - 24\sqrt{3})r^2 - (14 - 8\sqrt{3})\ r^2$

Fig 11 Area of Square = $(17-8\sqrt{3})$ (Side)^2
Fig 12 Total Area of Yellow, Red and Green Colored Part = $(17-8\sqrt{3})\ r^2$
Fig 13 Total Area of Yellow, Red, Blue and Green Colored Part = $2(17-8\sqrt{3})\ r^2$

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Let x, y, z be any numbers to solve the examples below

Area of inscribed dodecagon (x) + Area of circumscribed (y square + z hexagon + [2x + 2.5z + (8y + z)/3] dodecagon)

$= (3x + 4y + 4z) \times (17 - 8\sqrt{3})\ r^2$

For example: x = 7, y = 8, z = 23

(Area of 7 inscribed dodecagons) + Area of circumscribed (8 square 23 hexagon) + [2(7) + 2.5(23) + (64 + 23)/3] = (14 + 57.5 + 29 = 100.5) dodecagon}

= 3(7) + 4(8) + 4(23)

= (21 + 32 + 92)

$= 145 \times (17 - 8\sqrt{3})\ r^2$

$= 7(3r^2) + 8(4r^2) + 23(2\sqrt{3})\ r^2 + [(100.5)12(2 - \sqrt{3})]\ r^2$

$= 21r^2 + 32r^2 + (46\sqrt{3})\ r^2 + (2412 - 1206\sqrt{3})\ r^2$

$= (2465 - 1160\sqrt{3})\ r^2$

$= 145(17 - 8\sqrt{3})\ r^2$

One more example x = 35, y = 13, z = 67

(Area of 35 inscribed dodecagons) + Area of circumscribed (13 square + 67 hexagon) + {Area of [2(35) + 2.5(67) + (104 + 67)/3] = (70 + 167.5 + 57) 294.5 circumscribed dodecagon}

= 3(35) + 4(13) + 4(67)

$= 425 \times (17 - 8\sqrt{3})\ r^2$

$= 35(3r^2) + 13(4r^2) + 67(2\sqrt{3})\ r^2 + 294.5\ [12(2 - \sqrt{3})]\ r^2$

$= 105r^2 + 52r^2 + (134\sqrt{3})\ r^2 + (7068 - 3534\sqrt{3})\ r^2$

$= (7225 - 3400\sqrt{3})\ r^2$

$= 425(17 - 8\sqrt{3})\ r^2$

Let x, y, z be any numbers to solve the examples below

Area of [inscribed dodecagons (x) + circumscribed squares (y) + (0.75z – 0.5y) circumscribed hexagons] + area of [2x + 1.25y + 2.125 z] circumscribed dodecagons

$= (3x + 2y + 3z) \times (17 - 8\sqrt{3})\ r^2$

For example: x = 7, y = 12, z = 32

= (Area of 7 inscribed dodecagons) + (area of 12 circumscribed squares) + (area of [0.75(32) – 0.5(12)] 18 circumscribed hexagons) + {Area of [2(7) + 1.25(12) + 2.125(32)] = (14 + 15 + 68) 97 circumscribed dodecagons}

= 3(7) + 2(12) + 3(32)

$= 141 \times (17 - 8\sqrt{3})\ r^2$

$= 7(3r^2) + 12(4r^2) + 18(2\sqrt{3})\ r^2 + 97[12(2 - \sqrt{3})]\ r^2$

$= 21r^2 + 48r^2 + (36\sqrt{3})\ r^2 + (2328 - 1164\sqrt{3})\ r^2$

$= (2397 - 1128\sqrt{3})\ r^2$

$= 141(17 - 8\sqrt{3})\ r^2$

For example: x = 18, y = 5, z = 13

= (Area of 18 inscribed dodecagons) + (area of 5 circumscribed square) + (area of [0.75(13) – 0.5(5)] 7.25 circumscribed hexagon) + {Area of [2(18) + 1.25(5) + 2.125(13)] = (36 + 6.25 + 27.625) 69.875 circumscribed dodecagon}

= 3(18) + 2(5) + 3(13)

$= 103 \times (17 - 8\sqrt{3})\ r^2$

$= 18(3r^2) + 5(4r^2) + 7.25(2\sqrt{3})\ r^2 + 69.875[12(2 - \sqrt{3})]\ r^2$

$= 54r^2 + 20r^2 + (14.5\sqrt{3})\ r^2 + (1677 – 838.5\sqrt{3})\ r^2$

$= (1751 - 824\sqrt{3})\ r^2$

$= 103(17 - 8\sqrt{3})\ r^2$

Note: x, y, z are any numbers

(Area of 9x inscribed dodecagon) + (area of 9y circumscribed square) + (area of 6(z – y) circumscribed hexagon) + area of [18x + 7y + 17z] circumscribed dodecagon

$= (27x + 12y + 24z) \times (17 - 8\sqrt{3})\ r^2$

For example: x = 13, y = 25, z = 41

= (Area of 9(13) inscribed dodecagons) + (area of 9(25) circumscribed square) + (area of 6(41 - 25) 96 circumscribed hexagon) + {Area of [18(13) + 7(25) + 17(41)] = (234 + 175 + 697) 1106 circumscribed dodecagon}

= 27(13) + 12(25) + 24(41) = 1635

$= 1635 \times (17 - 8\sqrt{3})\ r^2$

$= 117(3r^2) + 225(4r^2) + 96(2\sqrt{3})\ r^2 + 1106[12(2 - \sqrt{3})]\ r^2$

$= 351r^2 + 900r^2 + (192\sqrt{3})\ r^2 + (26544 - 13272\sqrt{3})\ r^2$

$= (27795 - 13080\sqrt{3})\ r^2$

$= 1635(17 - 8\sqrt{3})\ r^2$

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For example: x = 1, y = 2, z = 3

= (Area of 9(1) inscribed dodecagons) + (area of 9(2) circumscribed square) + (area of [6(3) – 6(2)] 6 circumscribed hexagon) + {Area of [18(1) + 7(2) + 17(3)] = (18 + 14 + 51) 83 circumscribed dodecagon}

= 27(1) + 12(2) + 24(3) = 123

$= 123 \times (17 - 8\sqrt{3})\, r^2$

$= 9(3r^2) + 18(4r^2) + 6(2\sqrt{3})\, r^2 + 83[12(2 - \sqrt{3})]\, r^2$

$= 27r^2 + 72r^2 + (12\sqrt{3})\, r^2 + (1992 - 996\sqrt{3})\, r^2$

$= (2091 - 984\sqrt{3})\, r^2$

$= 123(17 - 8\sqrt{3})\, r^2$

Note: x, y, z any numbers

(Area of 5x inscribed dodecagon) + (area of 5y circumscribed square) + (area of (6z + 2y) circumscribed hexagon)

+ Area of [10x + 19y + 17z] circumscribed dodecagon

$= (15x + 28y + 24z) \times (17 - 8\sqrt{3})\, r^2$

For example: x = 3, y = 5, z = 1

= (Area of 5(3) inscribed dodecagons) + (area of 5(5) circumscribed square) + (area of [6(1) + 2(5)] circumscribed hexagon) + {Area of [10(3) + 19(5) + 17(1)] = (30 + 95 + 17) 142 circumscribed dodecagon}

= 15(3) + 28(5) + 24(1)

$= 209 \times (17 - 8\sqrt{3})\, r^2$

$= 15(3r^2) + 25(4r^2) + 16(2\sqrt{3})\, r^2 + 142[12(2 - \sqrt{3})]\, r^2$

$= 45r^2 + 100r^2 + (32\sqrt{3})\, r^2 + (3408 - 1704\sqrt{3})\, r^2$

$= (3553 - 1672\sqrt{3})\, r^2$

$= 209(17 - 8\sqrt{3})\, r^2$

Table 1 A Regular Polygon was Inscribed or Circumscribed in the Circle and a Square, and a Regular Polygon was Circumscribed the Circle, the Result Obtained Each Time was (**17** – 8√3) r²………

S. R. No.	**(Inscribed Dodecagon**	**+ Circumscribed Square**	**+ Circumscribed Hexagon**	**+ Circumscribed Dodecagon)**	**= Total = …(17 - 8√3) r²**
1	(3	-4	2	1)	= 1(17 - 8√3) r²
2	(-5	2	2	1)	= 1(17 - 8√3) r²
3	(2	1	-2	1)	= 2(17 - 8√3) r²
4	(6	-2	-2	1)	= 2(17 - 8√3) r²
5	(-1	-2	4	4)	= 5(17 - 8√3) r²
6	(3	1	-2	3)	= 5(17 - 8√3) r²
7	(-2	3	[redacted]	4)	= 6(17 - 8√3) r²
8	(1	5	-4	4)	= 7(17 - 8√3) r²
9	(4	1	-2	5)	= 8(17 - 8√3) r²
10	(-1	3	[redacted]	6)	= 9(17 - 8√3) r²
11	(2	5	-4	6)	= 10(17 - 8√3) r²
12	(5	1	-2	7)	= 11(17 - 8√3) r²
13	(1	-2	4	8)	= 11(17 - 8√3) r²
14	(-4	[redacted]	6	9)	= 12(17 - 8√3) r²
15	(-1	8	-4	8)	= 13(17 - 8√3) r²
16	(3	-1	2	9)	= 13(17 - 8√3) r²
17	(-2	1	4	10)	= 14(17 - 8√3) r²
18	(6	1	-2	9)	= 14(17 - 8√3) r²
19	(5	6	-6	9)	= 15(17 - 8√3) r²
20	(4	5	-4	10)	= 16(17 - 8√3) r²
21	(-1	1	4	12)	= 17(17 - 8√3) r²
22	(3	4	-2	11)	= 17(17 - 8√3) r²
23	(-2	6	[redacted]	12)	= 18(17 - 8√3) r²
24	(1	2	2	13)	= 19(17 - 8√3) r²
25	(5	5	-4	12)	= 19(17 - 8√3) r²
26	(4	4	-2	13)	= 20(17 - 8√3) r²
27	(3	9	-6	13)	= 21(17 - 8√3) r²
28	(2	2	2	15)	= 22(17 - 8√3) r²
29	(1	1	4	16)	= 23(17 - 8√3) r²
30	(4	3	[redacted]	16)	= 24(17 - 8√3) r²

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31	(3	2	2	17)	= 25(17 - 8√3) r²
32	(2	1	4	18)	= 26(17 - 8√3) r²
33	(5	3	[redacted]	18)	= 27(17 - 8√3) r²
34	[redacted]	(5	2	19)	= 28(17 - 8√3) r²
35	(7	-2	4	20)	= 29(17 - 8√3) r²
36	(2	12	-6	19)	= 30(17 - 8√3) r²
37	(1	5	2	21)	= 31(17 - 8√3) r²
38	(4	1	4	22)	= 32(17 - 8√3) r²
39	(-1	3	6	23)	= 33(17 - 8√3) r²
40	(2	5	2	23)	= 34(17 - 8√3) r²
41	(1	4	4	24)	= 35(17 - 8√3) r²
42	[redacted]	(3	6	25)	= 36(17 - 8√3) r²
43	(-1	2	8	26)	= 37(17 - 8√3) r²
44	(2	-2	10	27)	= 38(17 - 8√3) r²
45	(1	3	6	27)	= 39(17 - 8√3) r²
46	(4	5	2	27)	= 40(17 - 8√3) r²
47	(3	-2	10	29)	= 41(17 - 8√3) r²
48	(2	3	6	29)	= 42(17 - 8√3) r²
49	(3	2	-4	1)	= 1(17 - 8√3) r²
50	[redacted]	(-1	2	3)	= 4(17 - 8√3) r²
51	[redacted]	(17	-16)	[redacted]	= 4(17 - 8√3) r²

II. CONCLUSION

Using these values, a square equivalent to the area of a circle can be determined, and vice versa from any square, the circle of equal area can also be derived.

- The newly derived value of π has successfully resolved several previously unsolved mathematical problems.
- This value of π is an exact representation in contrast to the currently accepted approximate value of π.
- A segment of this newly derived value of π can be geometrically constructed.
- Using this value of π squaring the circle is possible.
- It also establishes that it is possible to draw a circle with area represented as whole number.

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