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### 1 Playing Cards that Are Multiples of 3

#### (1) Experiment overview

Here is a deck of cards. The deck uses 52 playing cards, excluding the two jokers.

There are four of each of the multiples of 3; spades, clovers, diamonds, and hearts making a total of 16 cards. When you draw a card from this deck of 52 cards, consider the probability that the card is a multiple of 3.

Since 16 of the 52 cards are multiples of 3, mathematically the probability is 16/52. However, in reality, if you draw and put back one at a time, 52 times, it is not guaranteed that you will exactly draw 16 cards that are multiples of 3.

Exit Playing Cards in Multiples of 3 Help Total number of cards in multiples of 3 16 ≒ 0.3076923 Total number of playing cards 52 Number of cards in multiples of 3 drawn 0 **∏** Total number of cards drawn AutoStart Shuffle AutoSton Draw Graph display

Plaving Cards in Multiples of 3 Copyright (C) Sohun 6.2022

So how does this relate to mathematically calculated theoretical pribability of 16/52 ?

(2) Experimental result (VB version simulation)

[Experiment day]

March 6 . 2024

[PC used]

Lavie NX850/N

Software used

Self-made software

[toramp 6]

[Method of operation]

To do this manually, click the [Shuffle] button, then click the [Draw] button.

To do this automatically, click the [AutoStart] button, then click the [AutoStop] button. Clicking the [Graph display] button will display a graph showing the relationship between the total number of cards drawn and the percentage of cards that were multiples of 3.

Click the [Init] button to restart the experiment from the beginning.

[Consideration]

In the 1st experiment, I draw and put back one card at a time 1000 times.

I drew cards that were multiples of three 289 times.

The ratio of drawing a card that is a multiple of 3 is  $289 \div 1000 = 0.289$ .

The mathematically calculated theoretical probability is  $16 \div 52 = 0.3076923$ .

The ratio of drawing a card that is a multiple of 3, 0.289 is close to the mathematically calculated theoretical probability of 0.3076923.

In the 2nd experiment, I draw and put back one card at a time 1000 times, too.

I drew cards that were multiples of three 304 times.

The ratio of drawing a card that is a multiple of 3 is  $304 \div 1000 = 0.304$ .

The ratio of drawing a card that is a multiple of 3, 0.304 is close to the mathematically calculated theoretical probability of 0.3076923.

The graphs for experiments (1) and (2) have the number of cards drawn on the horizontal axis and the percentage of cards drawn that were multiples of 3 at that time on the vertical axis.

The more cards you draw , the closer your chances of drawing a card that is a multiple of 3 become to the mathematically calculated theoretical probability of 16/52 (0.3076923).

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## 1 Playing Cards that Are Multiples of 3

- (2) Experimental result (VB version simulation)
- ① 1st experiment





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## 1 Playing Cards that Are Multiples of 3

(2) Experimental result (VB version simulation)

2 2nd experiment

Playing Ca	rds in Multiple	s of 3	Help	Init
otal number of cards in mu	ultiples of 3 1	5	0.00766	00
Total number of playing	cards 5/	2	0.30765	23
Number of cards in mult	tiples of 3 drawn	304	_	20400
Total number of c	ards drawn	1000	-   -   0	.30400
AutoStart	\$ <b>*</b> *	Shi	offle	1
AutoStop	**	Di	aw.	
Graph display	* * 8			1



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### 2 Two Coins Toss

(1) Experiment overview

Let's toss two coins at the same time and think about how they will come up heads and tails. Let these two coins be coin1 and coin2, respectively. There are four ways to come out : heads and heads, heads and tails, tails and heads, and tails and tails. Mathematically, the probability of each of these four occasions occurring is 1/4. However, in reality, when two coins are tossed four times at the same times, heads and heads, heads and tails, tails and heads, and tails don't necessarily occur once each. So what is the relationship with the theoretical probability of 1/4 calculated mathematically ?

(2) Experimental result (VB version simulation)

[Experiment day]

March 8 . 2024

[PC used]

Lavie NX850/N

[Software used]

Self-made software

[two coins toss 6]

[Method of operation]

[Start] Click the button to start the experiment.

[Stop] Click the button to stop the experiment.

[Graph display] Clicking the button will display a graph showing the relationship between the number of experiments and the proportion of heads and heads , heads and tails , tails and heads , and tails and tails.

[Init] Click the button to restart the experiment from the beginning.

#### [Consideration]

In experiment ①, coin1 and coin2 were tossed simultaneously 3965 times.

Both coin1 and coin2 came up heads 997 times, coin1 came up heads and coin2 came up tails 996 times, coin1 came up tails and coin2 came up heads 972 times, both coin1 and coin2 came up tails 1000 times. Also the percentage of coin1 and coin2 coming up heads is 0.251, the percentage of coin1 coming up heads and coin2 coming up tails is 0.251, the percentage of coin1 coming up tails and coin2 coming up heads is 0.245, and the percentage of coin1 and coin2 coming up tails is 0.252.

In experiment 2, coin1 and coin2 were tossed simultaneously 3892 times.

Both coin1 and coin2 came up heads 946 times, coin1 came up heads and coin2 came up tails 1000 times, coin1 came up tails and coin2 came up heads 953 times, both coin1 and coin2 came up tails 993 times. Also the percentage of coin1 and coin2 coming up heads is 0.243, the percentage of coin1 coming up heads and coin2 coming up tails is 0.257, the percentage of coin1 coming up tails and coin2 coming up heads is 0.245, and the percentage of coin1 and coin2 coming up tails is 0.255.

From the graph , we can see that when the coin1 and coin2 are tossed at the same time , the ratio of heads to heads , heads to tails , tails to heads , and tails to tails approaches 1/4(0.25) as the number of tosses increases.



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#### Two Coins Toss 2

(2) Experimental result (VB version simulation)

### Experiment ①

Exit	Two	Coins 7	loss	Help	Init
		1			
	1		1	1	
	Coin1		Coin2		
Coin1	Head	Head	Tail	Tail	
Coin2	Head	Tail	Head	Tail	
Frequency	Frequency 997		972	1000	)
Probability 0.251		0.251	0.245	0.252	2
Number of e	xperiment				
3965		Sto	p a	Start	
Graph d	ionlaw	-			-





## 2 Two Coins Toss

(2) Experimental result (VB version simulation)

Experiment ②

Two	Coins 7	loss	Help	Ini
	1		1	
Coin1		Coin2		
Head	Head	Tail	Ta	il
Head	Tail	Head	Та	il
946	1000	953	99	3
0.243	0.257	0.245	0.2	55
xperiment				
2	Car		Stor	2
	Coin1 Head 946 0.243	Coin1HeadHeadHeadHeadTail94610000.2430.257	Two Coins TossImage: Coins CoinsImage: Coins CoinsCoin1Coin2HeadHeadHeadHeadHeadTailHead100094610009530.2430.2430.2570.245	Iwo Coins Toss       Help         Image: Coins Toss       Help         Image: Coins Toss       Help         Coin1       Image: Coins Toss         Coin1       Image: Coins Toss         Head       Tail       Tail         Head       Tail       Head       Tail         Head       Tail       Head       Tail         946       1000       953       99         0.243       0.257       0.245       0.257



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### 3 Three People Playing Rock-Paper-Scissors

(1) Experiment overview

Three people A, B, C play Rock-Paper-Scissors once. Draw has 9 ways : for A, B, and C: Rock/Rock/Rock, Paper/Paper , Scissors/Scissors , Rock/Scissors/Paper, Rock/Paper/Scissors, Paper/Scissors/Rock, Paper/Rock/Scissors, Scissors/Rock/Paper, Scissors/Paper/Rock. If A wins alone, there are three ways for A, B, and C: Rock/Scissors/Scissors, Scissors/Paper/Paper, Paper/Rock/Rock. Similarly for B, C, there are three ways in which only one person can win. If A loses alone, there are 3 ways for A, B, and C: Rock/Paper/Paper, Scissors/Rock/Rock, Paper/Scissors/Scissors. Similarly for B, C, there are three ways in which only one person can lose.



In other words , when three people play Rock-Paper-Scissors once , there are a total of

27 ways to play Rock-Paper-Scissors. For example, here are 9 ways to become a draw so the mathematical probability is 9/27, which can be reduced to 1/3 (0.333). However, in reality, if you play Rock-Paper-Scissors three times, there will not be only one draw. So, what is the relationship with the mathematically calculated theoretical probability of a draw of 1/3?

(2) Experimental result (VB version simulation)

[Experiment day]

March 10 . 2024

#### [PC used]

Lavie NX850/N

[Software used]

Self-made software

- [jyanken 6]
- [Method of operation]

If you want to do it manually, click the [Start] button, then click the [Decision] button. If you want to do it automatically, click the [AutoStart] button, then click the [AutoStop] button.

Click the [GraphDisplay] button to display graphs of the percentage for cases where there is a draw, only one person wins, and only one person loses.

Click the [Init] button to restart the experiment from the beginning.

#### [Consideration]

In the experiment, three people A, B, and C played Rock-Paper-Scissors 2733 times. There were 906 draws, and the percentage was 0.332. Only one person wan 919 times, and the percentage was 0.336. Only one person lost 908 times and the percentage was 0.332. The mathematical probability of a draw is 9/27 (0.333). The mathematical probability that only one person wins is 9/27 (0.333). The mathematical probability that only one person wins is 9/27 (0.333). The mathematical probability that only one person loses is 9/27 (0.333). From the graph of the experimental results, we can see that when three people play Rock-Paper-Scissors a lot, the percentage of draws, the percentage of only one player winning, and only one player losing respectively approach 0.33.

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## 3 Three People Playing Rock-Paper-Scissors

(2) Experimental result (VB version simulation)





#### 3.12.2024 Sohun

### 4 Two Dice with an Odd Product

#### (1) Experiment overview

Think about what will happen if you throw two large and small dice at the same time. Let's call two dice large and small, respectively. There are thirty six ways to get the numbers : 1 · 1 , 1 · 2 , 1 · 3 , 1 · 4 , 1 · 5 , 1 · 6 , 2 · 1 , 2 · 2 , 2 · 3 , 2 · 4 , 2 · 5 , 2 · 6 , 3 · 1 , 3 · 2 , 3 · 3 , 3 · 4 , 3 · 5 , 3 · 6 , 4 · 1 , 4 · 2 , 4 · 3 , 4 · 4 , 4 · 5 , 4 · 6 , 5 · 1 , 5 · 2 , 5 · 3 , 5 · 4 , 5 · 5 , 5 · 6 , 6 · 1 , 6 · 2 , 6 · 3 , 6 · 4 , 6 · 5 , and 6 · 6. Also there are nine ways that the product

Also, there are nine ways that the product of two large and small dice can be an odd number :  $1 \cdot 1$ ,  $1 \cdot 3$ ,  $1 \cdot 5$ ,  $3 \cdot 1$ ,  $3 \cdot 3$ ,  $3 \cdot 5$ ,  $5 \cdot 1$ ,  $5 \cdot 3$ , and  $5 \cdot 5$ .

Therefore , mathematically , the probabolity that the product of two large and small dice will be an odd number is 9/36, which is reduced to 1/4 (0.25). However , in reality , if you toss two coins



at the same time four times , it isn't necessarily mean that the product of the two dice will be an odd number only once. So , what is the relationship with the mathematically calculated theoretical probability of 1/4 ?

(2) Experimental result (VB version simulation)

[Experiment day] March 12 . 2024 [PC used] Lavie NX850/N [Software used]

Self-made software

¶two dice 6♪

[Method of operation]

If you want to experiment manually, click the [Throw the dice] button, then click the [Stop the dice] button.

If you want to experiment automatically, click the [Automatic] button, then click the [Stop] button.

Click the [Graph display] button to display a graph showing the relationship between the number of experiments and the ratio of the product of the two dice to an odd number.

Click the [Init] button to restart the experiment from the beginning.

#### [Consideration]

In the experiment, two large and small dice were thrown simultaneously 1000 times. When the product is an odd number, in order of large dice and small dice,  $1 \cdot 1$  are 32 times,  $1 \cdot 3$ are 32 times,  $1 \cdot 5$  are 20 times,  $3 \cdot 1$  are 22 times,  $3 \cdot 3$  are 28 times,  $3 \cdot 5$  are 35 times,  $5 \cdot 1$  are 19 times,  $5 \cdot 3$  are 20 times,  $5 \cdot 5$  are 48 times for a total of 256 times. The ratio of the product of the two dice being an odd number was 0.256.

The mathematical probability that the product of two dice will be an odd number is 9/36 (0.25). From the graph of the experimental results, we can see that if you throw two large and small dice at the same time many times, the ratio of the product of the two large and small dice to an odd number approaches 0.25.

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## 4 Two Dice with an Odd Product

(2) Experimental result (VB version simulation)

Exit	wo Di	ce with	Odd I	Produc	t	Help In	
	Lar	rge dice	:	Small d	ice		
Large Small	1	2	3	4	5	6	
1	32	29	32	28	20	27	
2	22	21	37	34	33	26	
3	22	25	28	35	35	37	
4	33	24	14	34	28	28	
5	19	25	20	22	48	21	
6	27	25	26	29	28	26	
Number of experiments			10	000	Throw	w the dice	
Number of odd products			256				
Percentage of odd products			0.256		Stop	Stop the dice	
Graph dis	play	Auto	omatic	1	Stop	1	



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### 5 Collatz Problem

(1) Experiment overview Problem of "3x+1" (Collatz problem) Copyright (C) Sohun 62022 Exit Init. Any natural number will do, so if the number is even, divide it by 2, if it is odd, [Problem] multiply it by 3 and add 1, and repeat. So is it true that no matter what number we This problem is a well-known conundrum and has not yet been solved. In addition , large number (4 trillion) has been investigated using a computer , but no example th start with, it always ends up being 1? each 1 has been found. Click [Experiment] below to perform a simple experiment on your computer For example, if you start with 11,  $11 \rightarrow$  $34 \rightarrow 17 \rightarrow 52 \rightarrow 26 \rightarrow 13 \rightarrow 40 \rightarrow 20 \rightarrow$ 34 17 52 26 13 40 28 10 5 16 8 4 2 1  $10 \rightarrow 5 \rightarrow 16 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1.$ This problem is a famous conundrum that has not yet been solved. Also, very large numbers (4 trillion) have been investigated using computers. However, no example has been found where n= 11 Experiment it does not become 1. I tried a sample experiment using a computer. (2) Experimental result (VB version simulation) Experiment day March 13. 2024 PC used Lavie NX850/N [Software used] Self-made software  $\begin{bmatrix} 3x+1 \text{ problem } 6 \end{bmatrix}$ Method of operation Click the [Experiment] button. Enter a natural number between 3 and 10,000,000 in half-width characters. Click the [OK] button. Starting with the natural number you input, the display shows how the number is divided by 2 if it is even, or multiplied by 3 and then add by 1 if it is odd, and repeated. Click the [Init] button to restart the experiment from the beginning. [Consideration] The 1st experiment started at 17.  $17 \rightarrow 52 \rightarrow 26 \rightarrow 13 \rightarrow 40 \rightarrow 20 \rightarrow 10 \rightarrow 5 \rightarrow 16 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1$ . The 2nd experiment started at 111. 111  $\rightarrow$  334  $\rightarrow$  167  $\rightarrow$  502  $\rightarrow$  251  $\rightarrow$  754  $\rightarrow$  377  $\rightarrow$  1132  $\rightarrow$  566  $\rightarrow$  $4858 \rightarrow 2429 \rightarrow 7288 \rightarrow 3644 \rightarrow 1822 \rightarrow 911 \rightarrow 2734 \rightarrow 1367 \rightarrow 4102 \rightarrow 2051 \rightarrow 6154 \rightarrow 3077 \rightarrow 9232$  $\rightarrow 4616 \rightarrow 2308 \rightarrow 1154 \rightarrow 577 \rightarrow 1732 \rightarrow 866 \rightarrow 433 \rightarrow 1300 \rightarrow 650 \rightarrow 325 \rightarrow 976 \rightarrow 488 \rightarrow 244 \rightarrow 122 \rightarrow 122 \rightarrow 120 \rightarrow 1200 \rightarrow 120 \rightarrow 120 \rightarrow 12$  $61 \rightarrow 184 \rightarrow 92 \rightarrow 46 \rightarrow 23 \rightarrow 70 \rightarrow 35 \rightarrow 106 \rightarrow 53 \rightarrow 160 \rightarrow 80 \rightarrow 40 \rightarrow 20 \rightarrow 10 \rightarrow 5 \rightarrow 16 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1.$  $\rightarrow 2 \rightarrow 1$ .  $8 \rightarrow 4 \rightarrow 2 \rightarrow 1$ .  $8 \rightarrow 4 \rightarrow 2 \rightarrow 1$ .

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## 5 Collatz Problem

- (2) Experimental result (VB version simulation)
- ① 1st experiment



### 2 2nd experiment



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## 5 Collatz Problem

- (2) Experimental result (VB version simulation)
- ③ 3rd experiment



#### ④ 4th experiment



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### 5 Collatz Problem

- (2) Experimental result (VB version simulation)
- 5 5th experiment

29999998 14999999 44999998 22499999 67499998 33749999 101249998 50624999 151874998 75937499 227812498 113966249 341718748 170859374 85429687 256289062 128144531 384433594 192216797 576650392 288325196 144162598 72081299 216243898 108121949 324385848 162182924 81091462 40546731 121887194 60818597 182455792 91227896 45613948 22806874 1403487 34210462 17105231 51315694 25657847 76973542 38486771 115460314 57730157 173190472 86595236 43297618 21648909 64946428 32473214 16236607 48709822 24354911 73064734 38532367 109597102 54739551 164395654 82197827 246593482 123296741 363890224 184945112 92472556 46236278 23118139 69354418 34677209 104031628 52015814 26007907 79023722 38011661 11703584 58515854 557792 29250996 144529428 2318139 69354418 34677209 104031628 52015814 26007907 79023722 3801161 11703584 585158517792 29250996 144529428 23181839 69354418 34677209 104031628 52015814 26007907 79023722 38011616 11203584 585157792 29250996 144529448 7314724 3857362 1928681 5486044 2743022 1371511 4114534 2057267 6171802 3085901 9267704 4628852 2314426 1157213 3471640 1735820 867910 433955 1301866 650933 1952800 976400 488200 244180 122050 61025 183076 91538 45769 137308 5855 43327 102982 51491 154474 77237 231712 115856 57928 29964 14692 7241 21724 10862 5431 16294 8147 24442 12221 36664 19332 9164 5633 13750 6875 02058 1031 30940 15470 7735 23206 11603 34810 17405 52216 26108 13054 6527 192864 13932 9164 583 13750 6875 020628 1031 30940 15470 7735 23206 11603 34810 17405 52216 10164 1055 6527 1928 971 20914 10457 31372 15686 7843 23530 11765 35296 17648 8824 4412 2206 1103 3310 1655 4956 2403 7450 3725 11176 5588 2794 1397 4192 2096 1048 524 262 131 394 197 592 296 148 74 37 112 56 28 14 7 22 11 34 17 52 26 13 40 29 10 5 16 8 4 2 1 Experiment

### 6 Pythagorean Numbers

Pythagorean triple Copyright (C) Sohun 6.2022 (1) Experiment overview Pythagorean Triple Exit Init Three positive integers (a, b, c) < Pythagorean method> that satisfy the Pythagorean theoream are called Pythagorean triples. ([ 3 4 , [ To satisfy the Pythagorean theorem is to A set of positive integers (a,b,c) that satisfies the Pythagorean thorem is called a Pythagorean triple. satisfy  $a^2+b^2=c^2$ . When a is odd, the Pythagorean triples When a is odd number , the Pythagorean triple is obtained by b=(a^2-1)+2 and c=(a^2+1)+2. This method is called the (Pythagorean method) . can be found by using When a is even number , the Pythagorean triple is obtained by  $b=(a \div 2)^2 - 1$ ) and  $c=(a \div 2)^2 + 1$ ). This method is called the (Plato's method).  $b=(a^2-1) \div 2$  $c=(a^2+1)\div 2$ . Next This method is called the Pythagorean method. When a is even, the Pythagorean triples can be found by using  $b=(a \div 2)^2-1$  $c = (a \div 2)^{2} + 1.$ This method is called Plato's method. (2) Experimental result (VB version simulation) Experiment day March 17. 2024 [PC used] Lavie NX850/N Software used Self-made software [Pythagorean number 6] Method of operation When you click the [Next] button, the value of integer a will increase by 1, and the values of integer b and integer c at that time will be displayed. (In this case, a, b, and c satisfy the Pythagorean theorem  $a^2+b^2=c^2$ ). Click the [Init] button to restart the experiment from a=3. Consideration The 1st experiment is when a=102. Since a=102 is an even number, We will use plato's method.  $b = (a \div 2)^2 - 1 = (102 \div 2)^2 - 1 = 2600$  $c=(a \div 2)^{2}+1=(102 \div 2)^{2}+1=2602$ a<sup>2</sup>=10404  $b^2 = 6760000$  $c^2 = 6770404$  $a^2+b^2=c^2$  is satisfied. The 2nd experiment is when a=103. Since a=103 is an odd number. We will use Pythagorean method.  $b=(a^2-1) \div 2=(103^2-1) \div 2=5304$  $c = (a^2+1) \div 2 = (103^2+1) \div 2 = 5305$ a<sup>2</sup>=10609  $b^2 = 28132416$  $c^2 = 28143025$  $a^2+b^2=c^2$  is satisfied. The 3rd experiment uses Plato's method, and the 4th experiment uses Pythagorean method. In both cases, the Pythagorean theorem  $a^2+b^2=c^2$  is satisfied.

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## 6 Pythagorean Numbers

- (2) Experimental result (VB version simulation)
- ① 1st experiment

Exit		Pythagorean Triple	In
	( 102	< Plato's method>, 2600 , 2602 )	
A set o a Pytha When a c=(a^2+	f positive integers (a, igorean triple. is odd number , the 1)÷2. This method i is even number , the	,b,c) that satisfies the Pythagorean thorem is Pythagorean triple is obtained by b=(a^2-1)÷ is called the (Pythagorean method) e Pythagorean triple is obtained by b=(a÷2)^2	called 2 and 2 -1) and
When a	)^2 +1) This method	is called the (Plato's method)	

### 2 2nd experiment

Exit		Pythagorean Triple	Init
	( 103	< Pythagorean method>	)
A set of a Pytha When a c=(a^2+ When a c=(a ÷ 2	f positive integers (s gorean triple. is odd number , the 1)÷2. This method is even number , th )^2 +1). This metho	a,b,c) that satisfies the Pythagorean thorem Pythagorean triple is obtained by b=(a^2-1 is called the (Pythagorean method) e Pythagorean triple is obtained by b=(a÷2 d is called the (Plato's method).	is called )÷2 and r)^2 −1) and
		Next	

## 6 Pythagorean Numbers

- (2) Experimental result (VB version simulation)
- ③ 3rd experiment

Exit	Pythagorean Triple	Init
	<plato's method=""></plato's>	
	( 776 , 150543 , 150545 )	
A set of po a Pythagon	sitive integers (a,b,c) that satisfies the Pythagorean thorem is ean triple.	called
When a is o c=(a^2+1)÷	xdd number , the Pythagorean triple is obtained by b=(a^2-1)÷ -2. This method is called the (Pythagorean method) .	2 and
When a is e c=(a÷2)^2	even number , the Pythagorean triple is obtained by b=(a÷2)^2 +1). This method is called the (Plato's method).	2 -1) and

### ④ 4th experiment

Pythagorea	n triple Copyright (C) So	hun 6.2022	
Exit		Pythagorean Triple	Init
	( 777	< Pythagorean method> , 301864 , 301865 )	ŀ
A set of a Pytha When a c=(a^2+	f positive integers (a,b gorean triple. is odd number , the F 1)÷2. This method is is even number , the	p,c) that satisfies the Pythagorean thorem i Pythagorean triple is obtained by b=(a^2-1) called the (Pythagorean method) . Pythagorean triple is obtained by b=(a÷2)	s called ÷ 2 and ^2 -1) and
C=(a · 2	/ 2 +17. This method	Next	