Modeling and Simulation Ⅲ

3.6.2024
Sohun

1　Playing Cards that Are Multiples of 3

（１） Experiment overview

Here is a deck of cards.

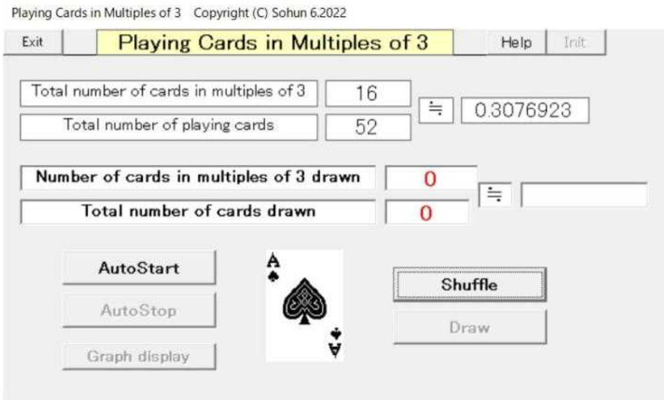
The deck uses 52 playing cards , excluding the two jokers.

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 that 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 exactlly draw 16 cards that are multiples of 3.



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 ÷ 1000 = 0.289 .

The mathematically calculated theoretical probability is 16 ÷ 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 ÷ 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）.

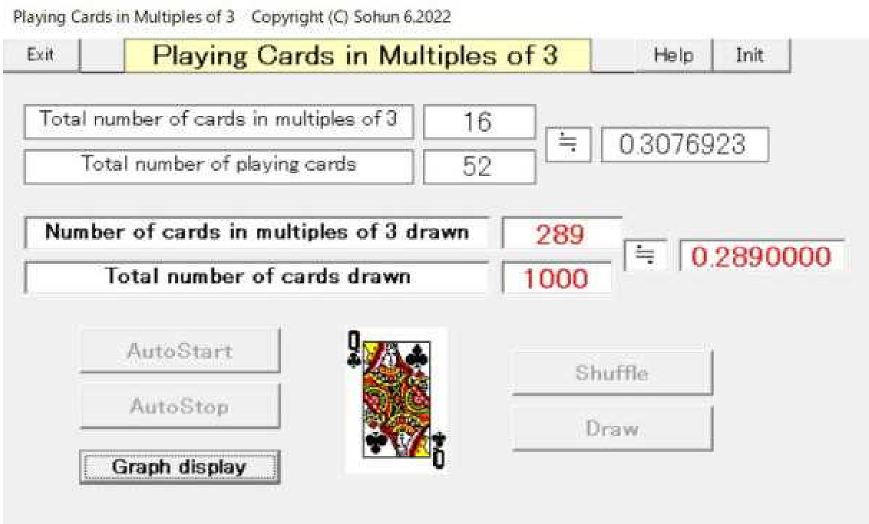
Modeling and Simulation Ⅲ

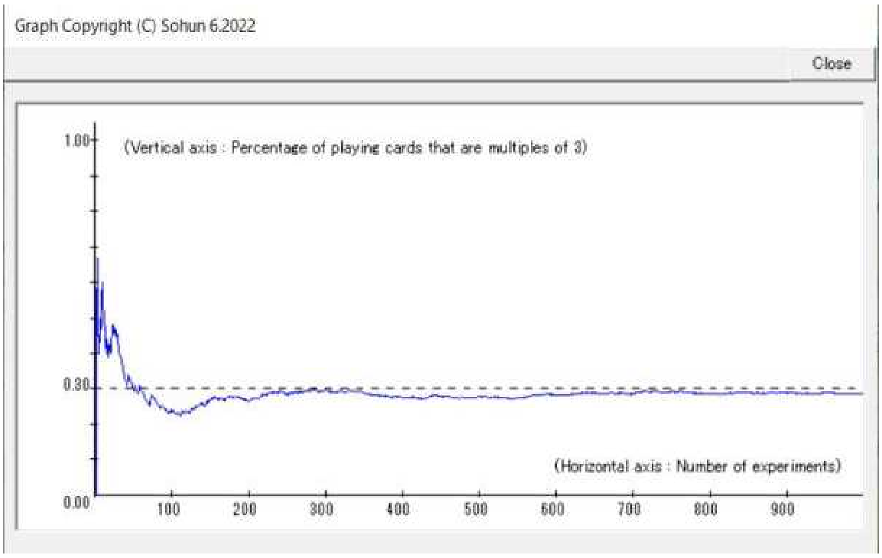
3.6.2024
Sohun

1　Playing Cards that Are Multiples of 3

（２）Experimental result（VB version simulation）

① 1st experiment





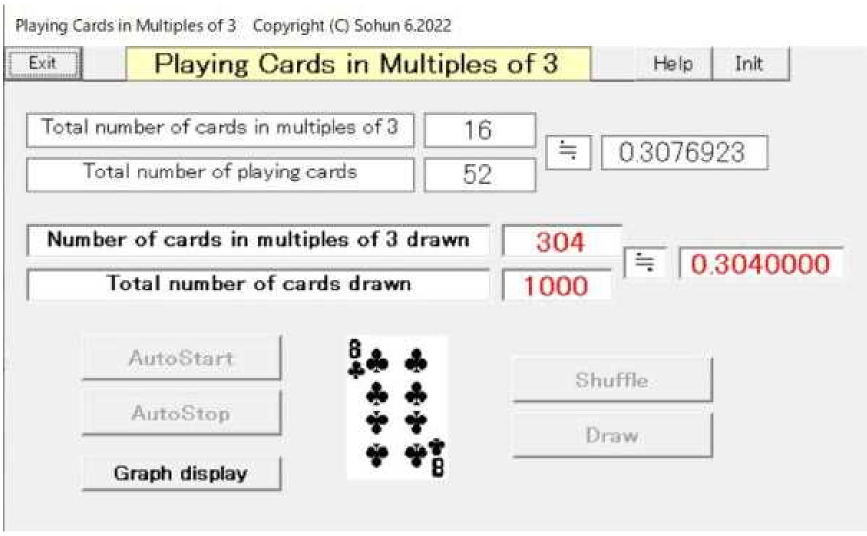
Modeling and Simulation Ⅲ

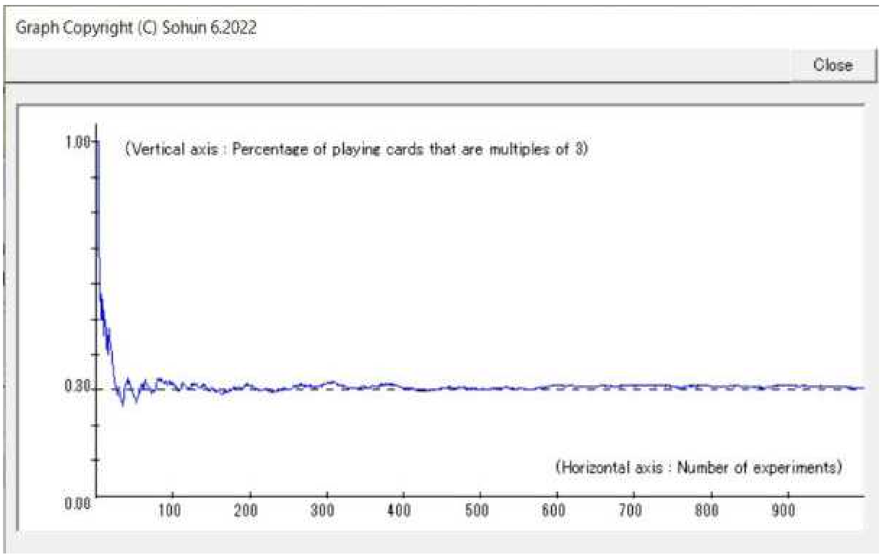
3.6.2024
Sohun

1　Playing Cards that Are Multiples of 3

（２）Experimental result（VB version simulation）

② 2nd experiment





Modeling and Simulation Ⅲ

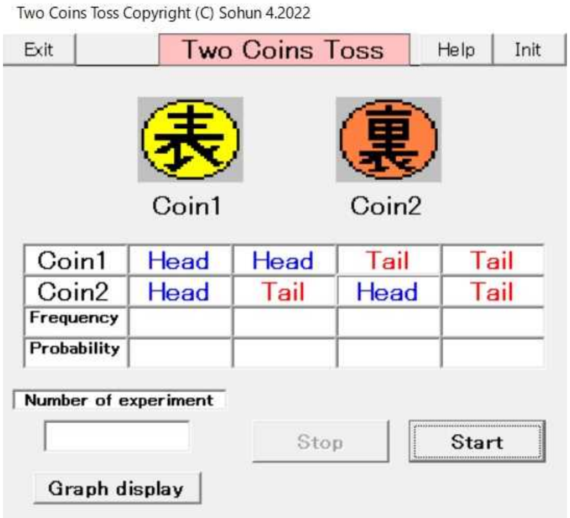
3.8.2024
Sohun

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 coins 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 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 , coins1 and 2 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 , coins 1 and 2 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.

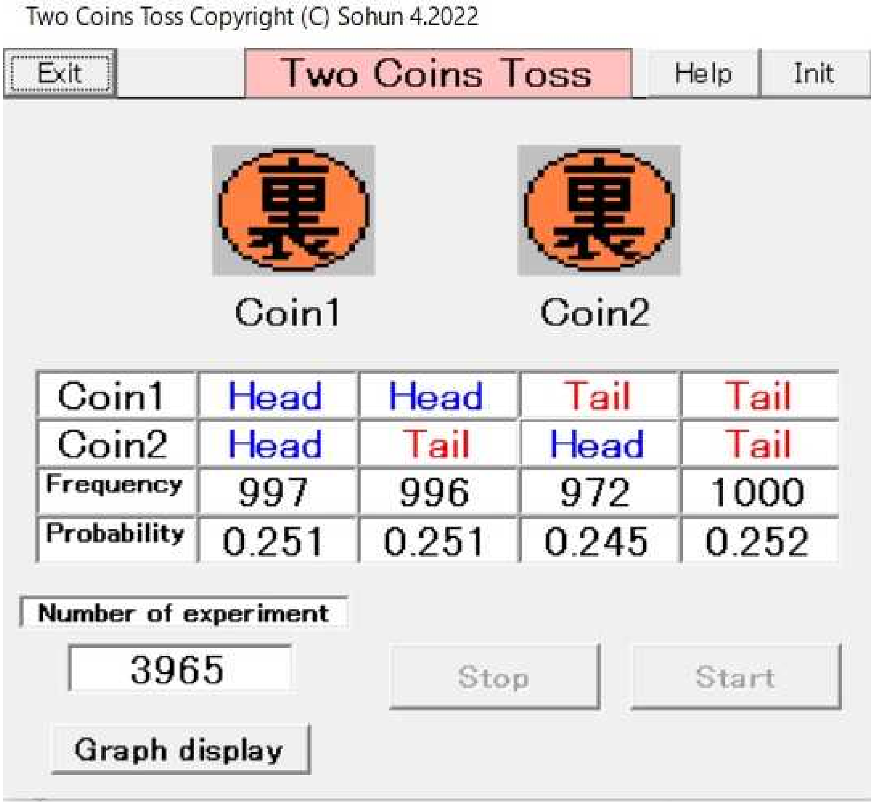
Modeling and Simulation Ⅲ

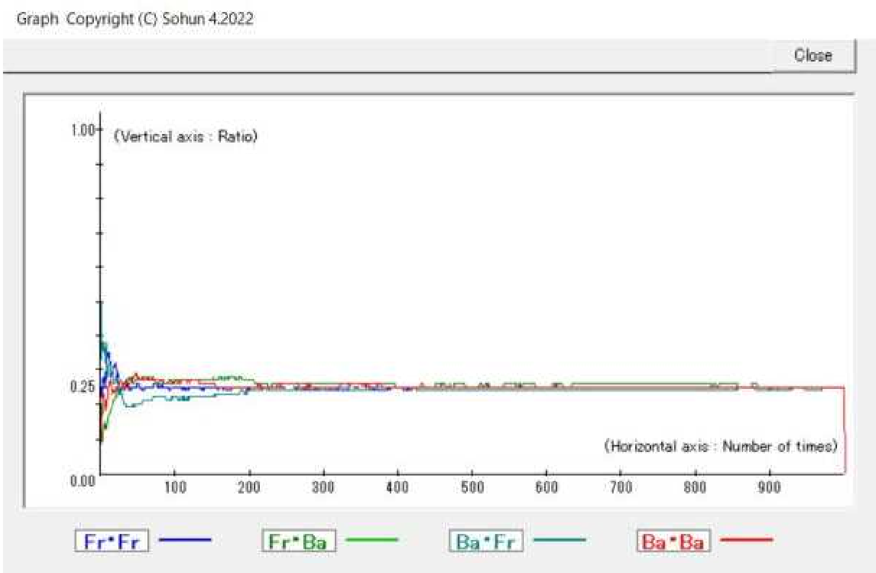
3.8.2024
Sohun

2　Two Coins Toss

（２）Experimental result （VB version simulation）

Experiment ①





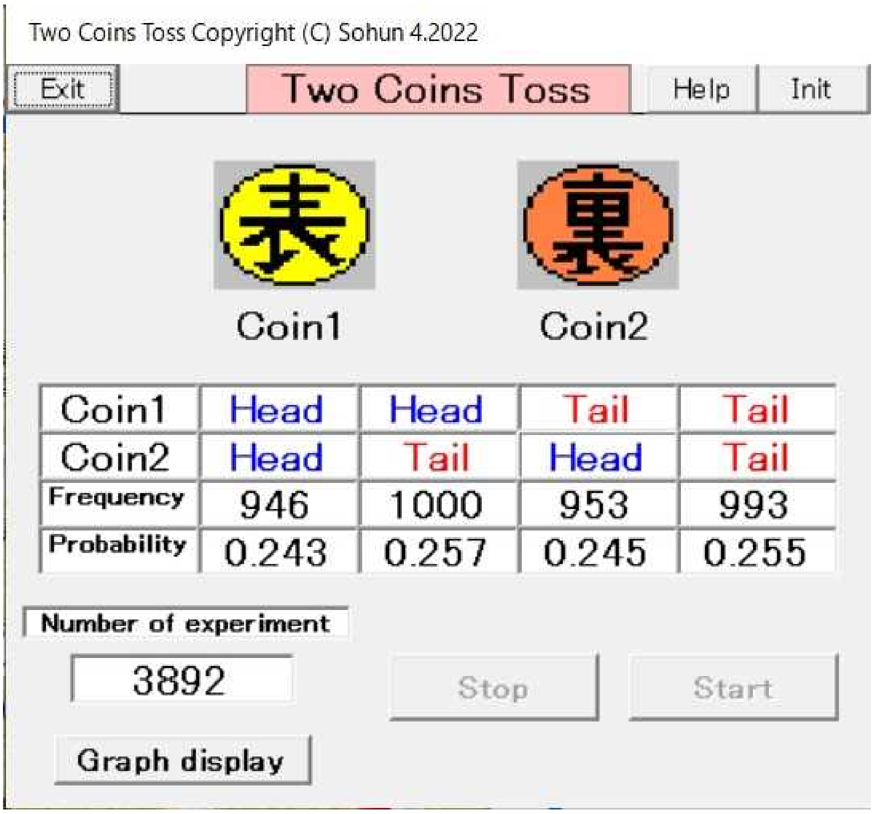
Modeling and Simulation Ⅲ

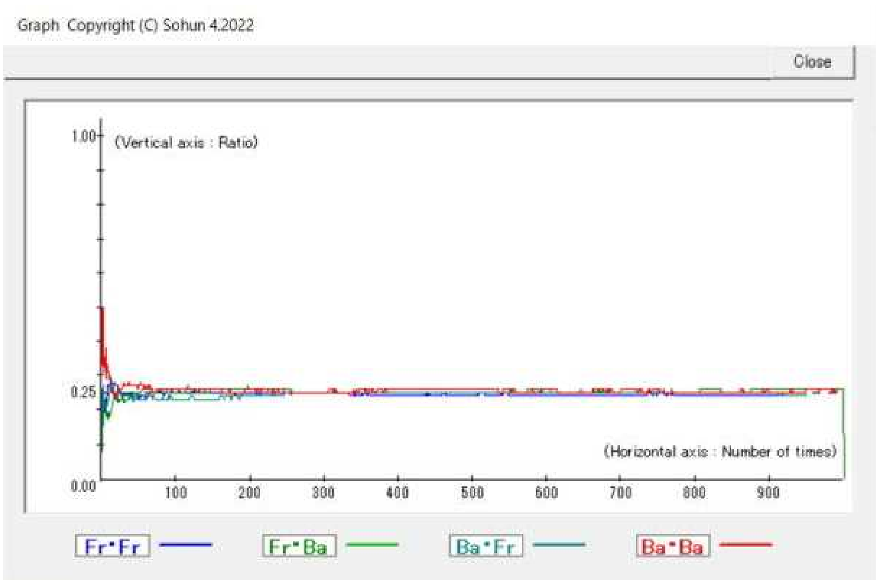
3.8.2024
Sohun

２　Two Coins Toss

（２）Experimental result （VB version simulation）

Experiment ②





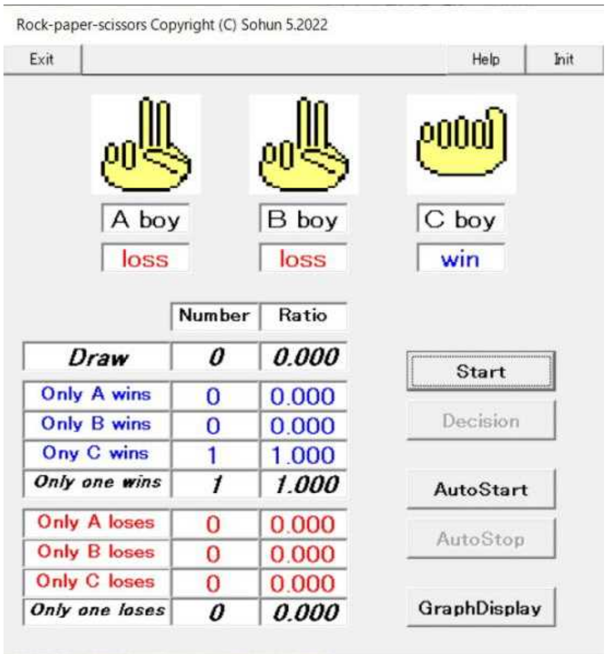
Modeling and Simulation Ⅲ

3.10.2024
Sohun

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/Paper , Scissors/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/Scissor , Scissor/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】

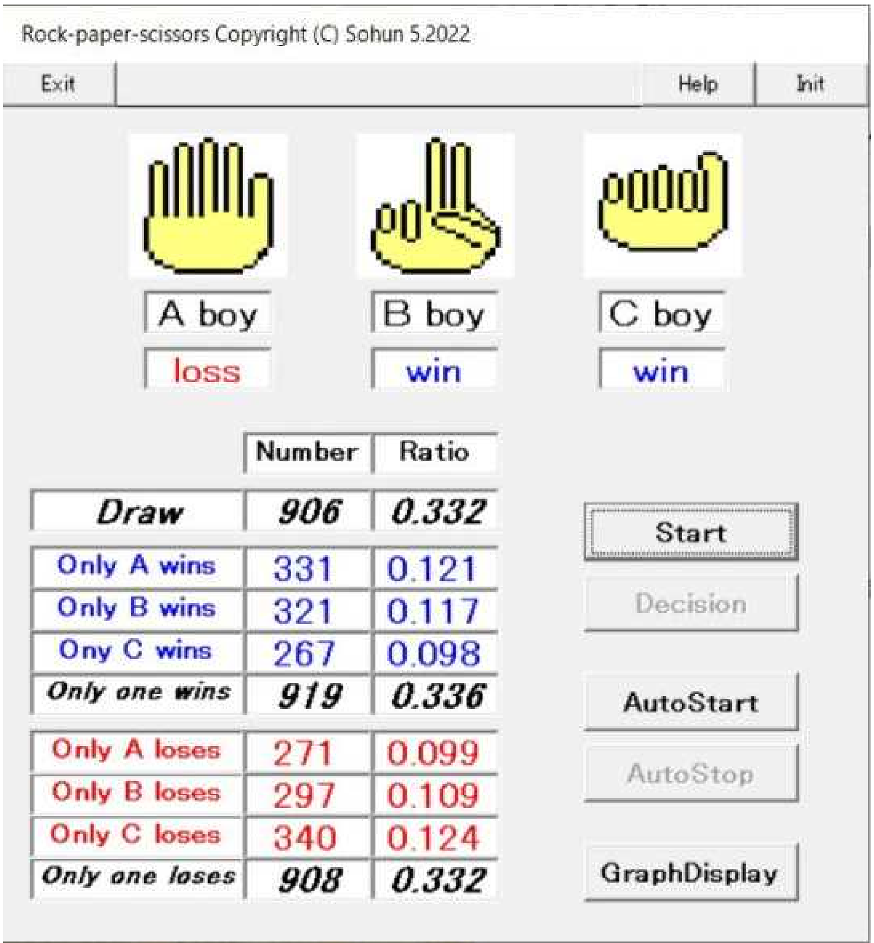
In the experiment , three people A , B , and C played Rock-Paper-Scissors 2733 times. There were 906 draws , and the percentage was 0.332. Only one person wan 919 times , and the percentage was 0.336. Only one person lost 908 times and the percentage was 0.332. The mathematical probability of a draw 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 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.

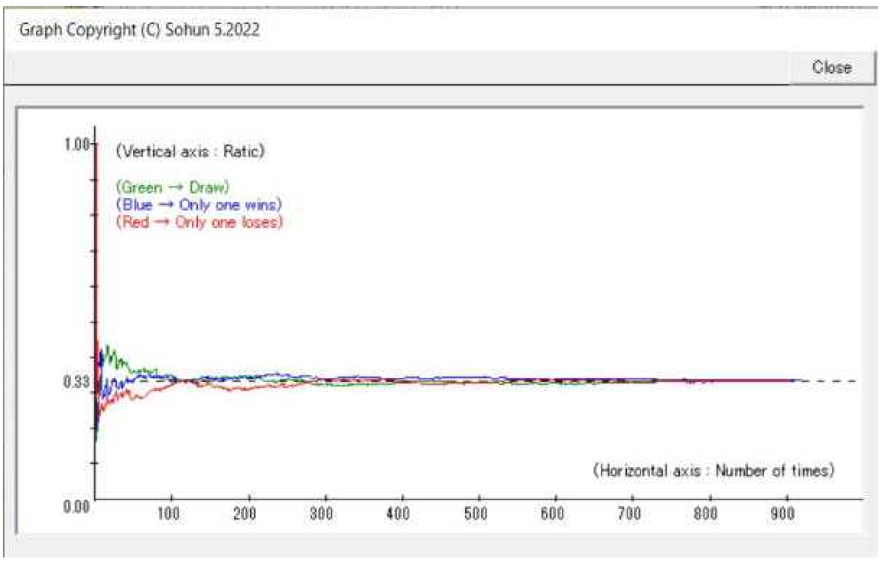
Modeling and Simulation Ⅲ

3.10.2024
Sohun

３　Three People Playing Rock-Paper-Scissors

（２）Experimental result （VB version simulation）





Modeling and Simulation Ⅲ

3.12.2024
Sohun

4 Two Dice with an Odd Product

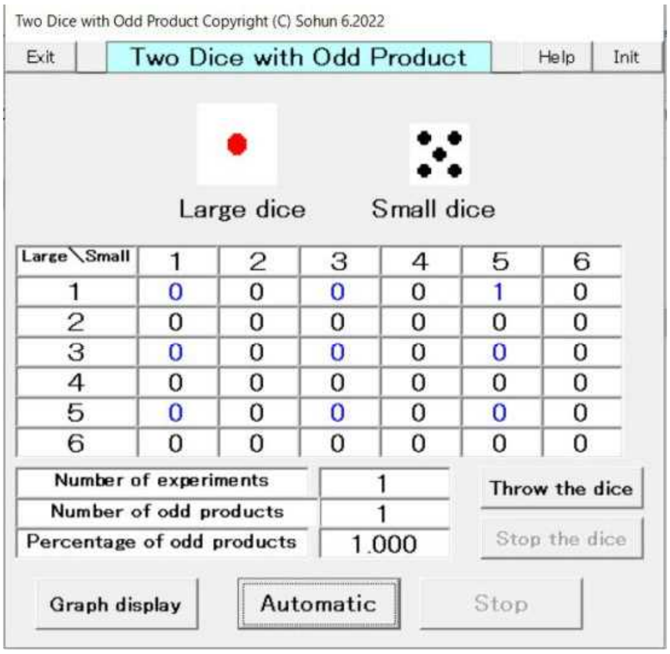
(1) Experiment overview

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 of two large and small dice can be an odd number : 1･1 , 1･3 , 1･5 , 3･1 , 3･3 , 3･5 , 5･1 , 5･3 , and 5･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･1 are 32 times , 1･3 are 32 times , 1･5 are 20 times , 3･1 are 22 times , 3･3 are 28 times , 3･5 are 35 times , 5･1 are 19 times , 5･3 are 20 times , 5･5 are 48 times for a total of 256 times. The ratio of the product of he two dice being an odd number was 0.256.

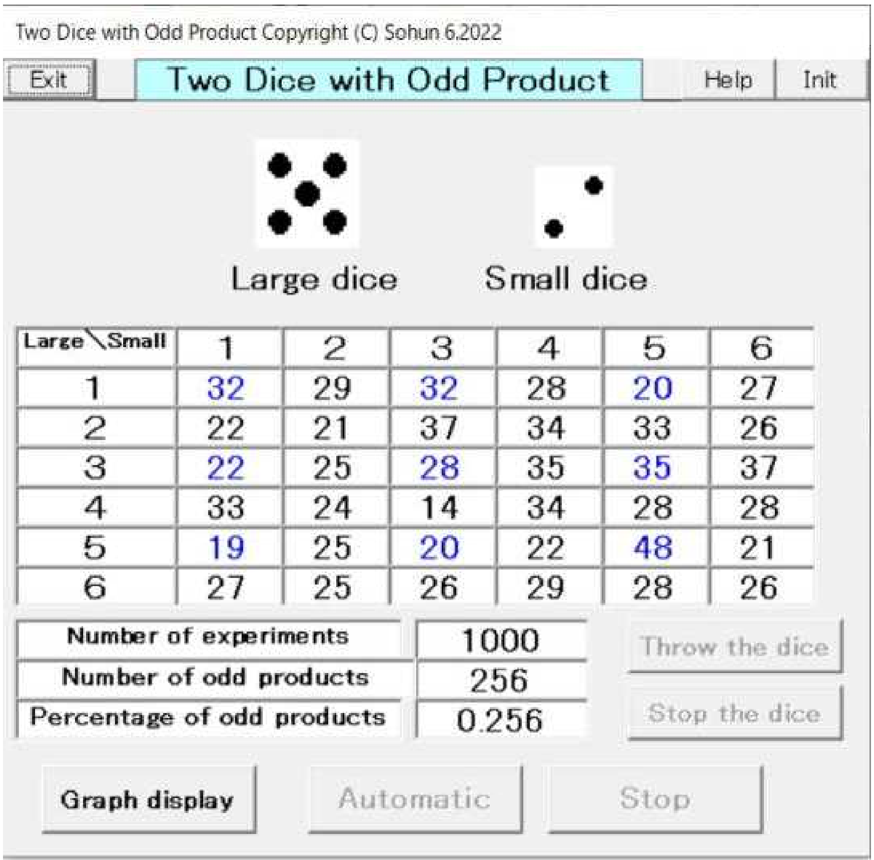
The mathematical probability that the product of two dice will be an odd number is 9/36 (0.25). From the graph of the experimental results , we can see that if you throw two large and small dice at the same time many times , the ratio of the product of the two large and small dice to an odd number approaches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

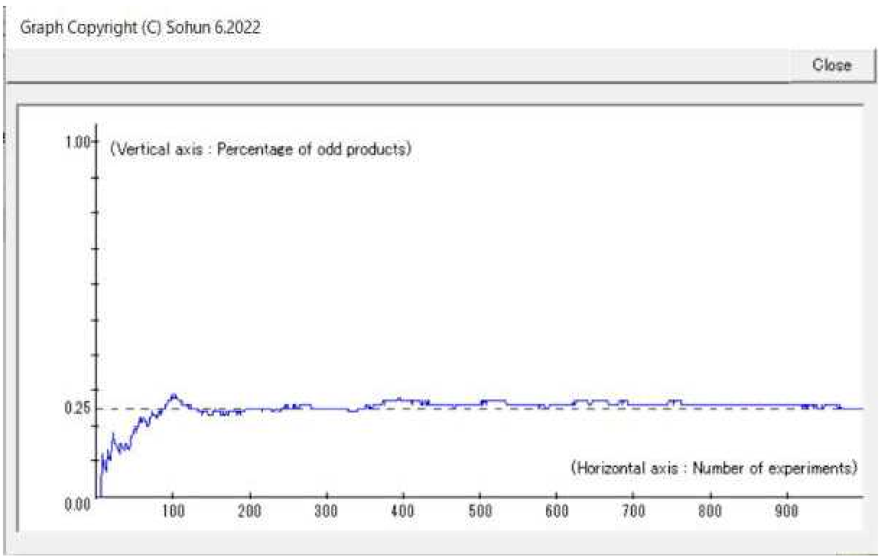
Modeling and Simulation Ⅲ

3.12.2024
Sohun

4　Two Dice with an Odd Product

（２）Experimental result（**VB** version simulation）





Modeling and Simulation Ⅲ

3.13.2024
Sohun

5　Collatz Problem

（１）Experiment overview

Any natural number will do , so if the number is even , divide it by 2 , if it is odd , multiply it by 3 and add 1 , and repeat.

So is it true that no matter what number we start with , it always ends up being 1 ?

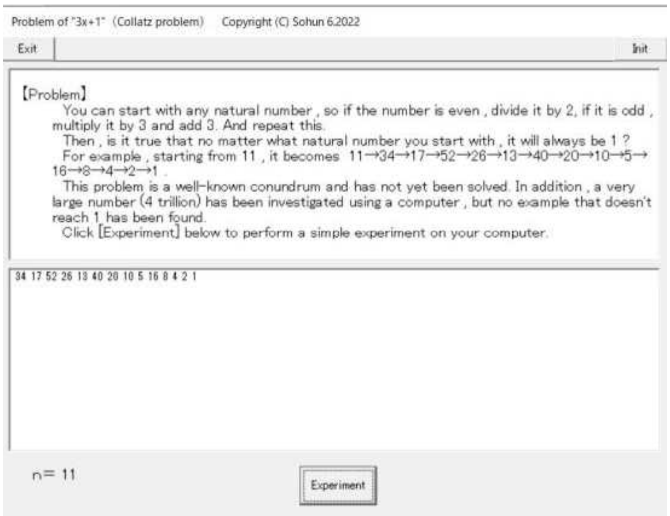
For example , if you start with 11 , 11 → 34 → 17 → 52 → 26 → 13 → 40 → 20 → 10 → 5 → 16 → 8 → 4 → 2 → 1.

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 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
『3x+1 problem 6』

【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→52→26→13→40→20→10→5→16→8→4→2→1.

The 2nd experiment started at 111. 111→334→167→502→251→754→ 377→1132→566→283→850→425→1276→638→319→ 958→479→1438→719→2158→1079→3238→1619→4858→2429→7288→3644→1822→911→2734→1367→ 4102→2051→6154→3077→9232→4616→2308→1154→577→1732→866→433→1300→650→325→976→488→ 244→122→61→184→92→46→23→70→35→106→53→160→80→40→20→10→5→16→8→4→2→1.

The 3rd experiment started at 11111. 11111→･･･→52→26→13→40→20→10→5→16→8→4→2→1.

The 4th experiment started at 1717171. 1717171→･･･→52→26→13→40→20→10→5→16→8→4→2→1.

The 5th experiment started at 9999999. 9999999→･･･→52→26→13→40→20→10→5→16→8→4→2→1.

Modeling and Simulation Ⅲ

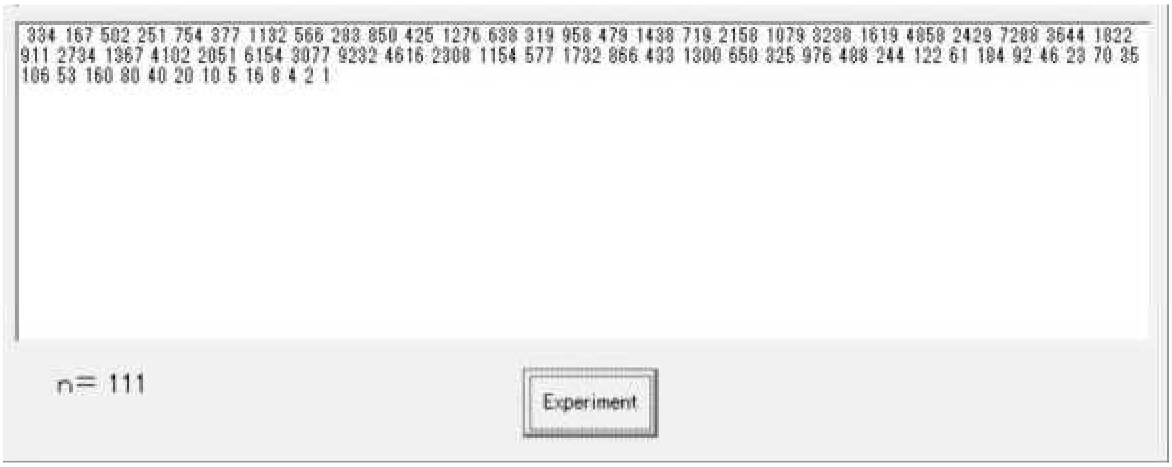
3.13.2024
Sohun

5　Collatz Problem

（２）Experimental result（VB version simulation）

① 1st experiment

② 2nd experiment



Modeling and Simulation Ⅲ

3.13.2024
Sohun

5　Collatz Problem

（２） Experimental result （VB version simulation）

③ 3rd experiment

④ 4th experiment

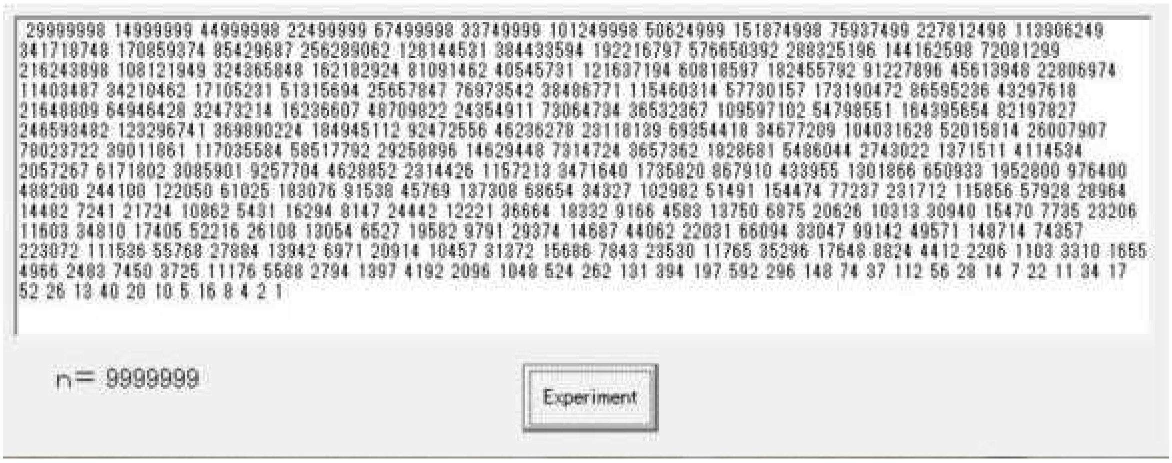
Modeling and Simulation Ⅲ

3.13.2024
Sohun

5　Collatz Problem

（２）Experimental result（**VB** version simulation）

⑤ 5th experiment



Modeling and Simulation Ⅲ

3.17.2024
Sohun

6　Pythagorean Numbers

（１） Experiment overview

Three positive integers (a , b , c) that satisfy the Pythagorean theoream are called Pythagorean triples.

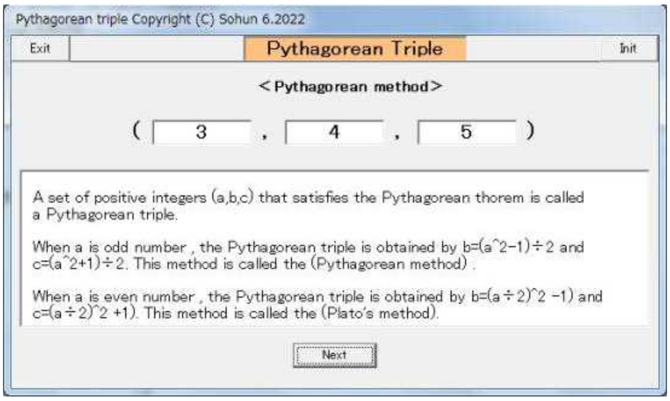
To satisfy the Pythagorean theorem is to satisfy $a^2+b^2=c^2$.

When a is odd, the Pythagorean triples can be found by using

$b=(a^2-1)\div 2$

$c=(a^2+1)\div 2$.

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.

$b=(a\div 2)^2-1=(102\div 2)^2-1=2600$

$c=(a\div 2)^2+1=(102\div 2)^2+1=2602$

$a^2=10404$

$b^2=6760000$

$c^2=6770404$

$a^2+b^2=c^2$ is satisfied.

The 2nd experiment is when a=103. Since a=103 is an odd number. We will use Pythagorean method.

$b=(a^2-1)\div 2=(103^2-1)\div 2=5304$

$c=(a^2+1)\div 2=(103^2+1)\div 2=5305$

$a^2=10609$

$b^2=28132416$

$c^2=28143025$

$a^2+b^2=c^2$ 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.

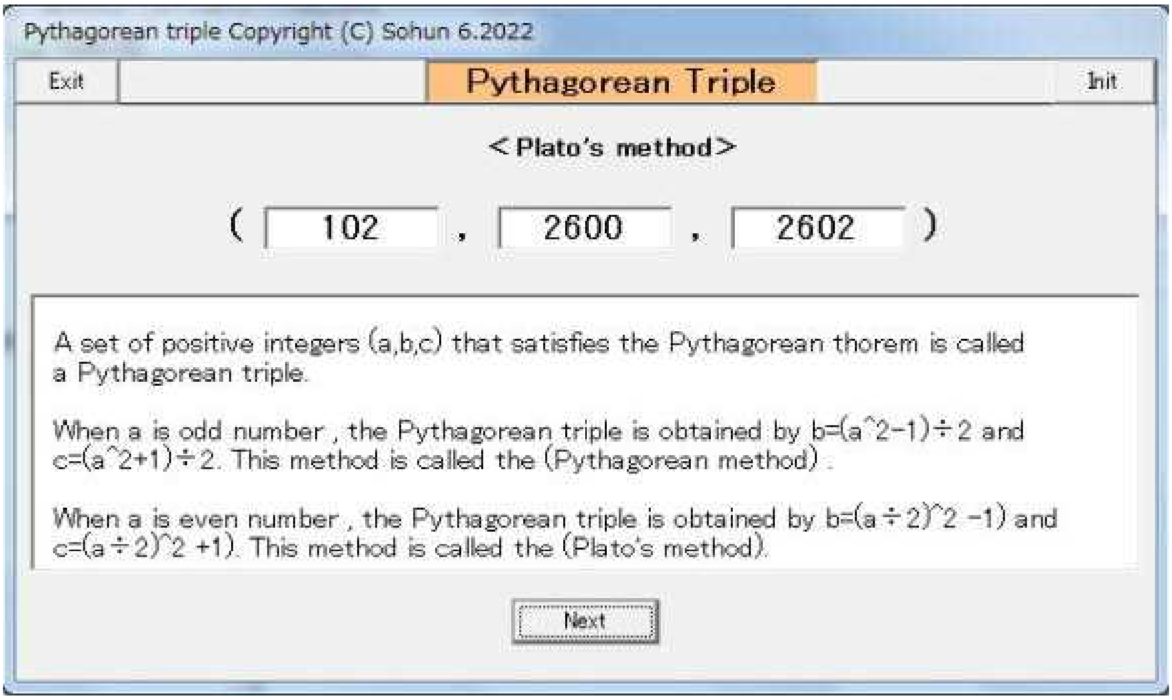
Modeling and Simulation Ⅲ

3.17.2024
Sohun

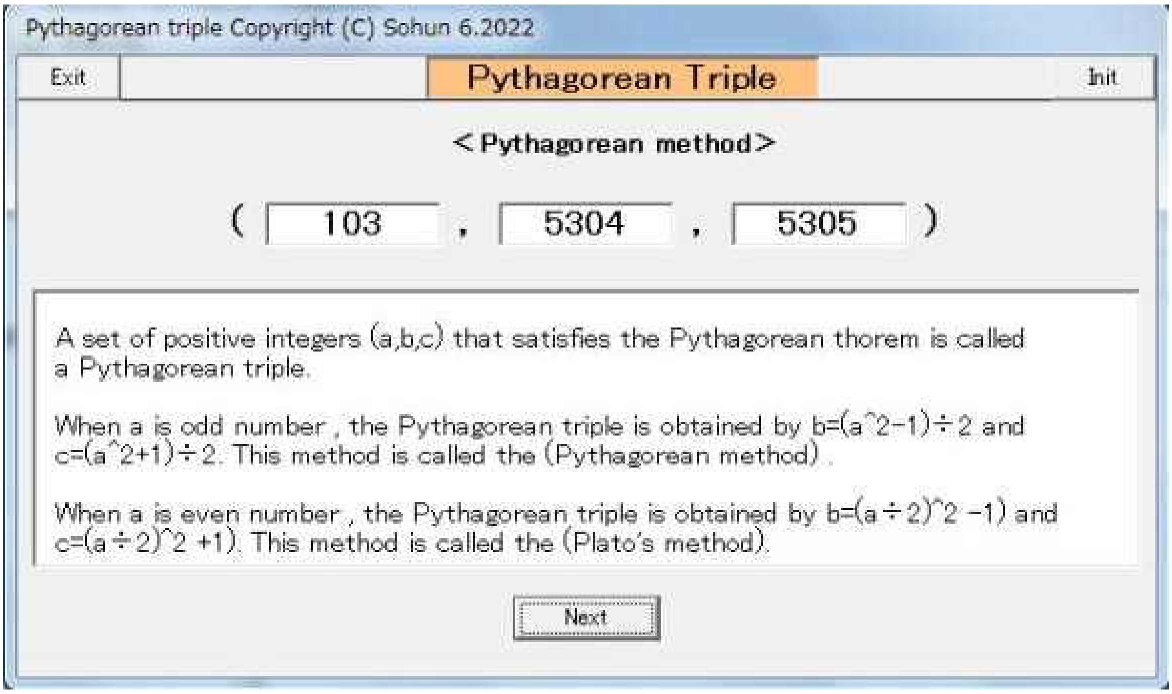
6　Pythagorean Numbers

（2）Experimental result（VB version simulation）

① 1st experiment



② 2nd experiment



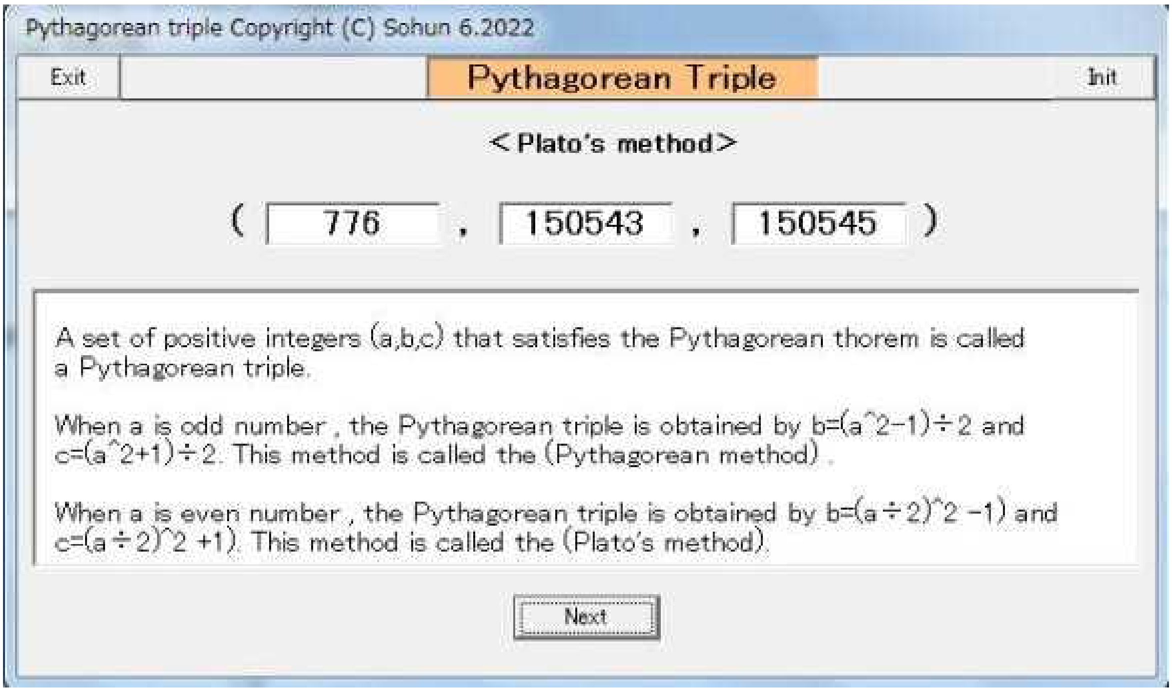
Modeling and Simulation Ⅲ

3.17.2024
Sohun

6　Pythagorean Numbers

（２）Experimental result （VB version simulation）

③ 3rd experiment



④ 4th experiment