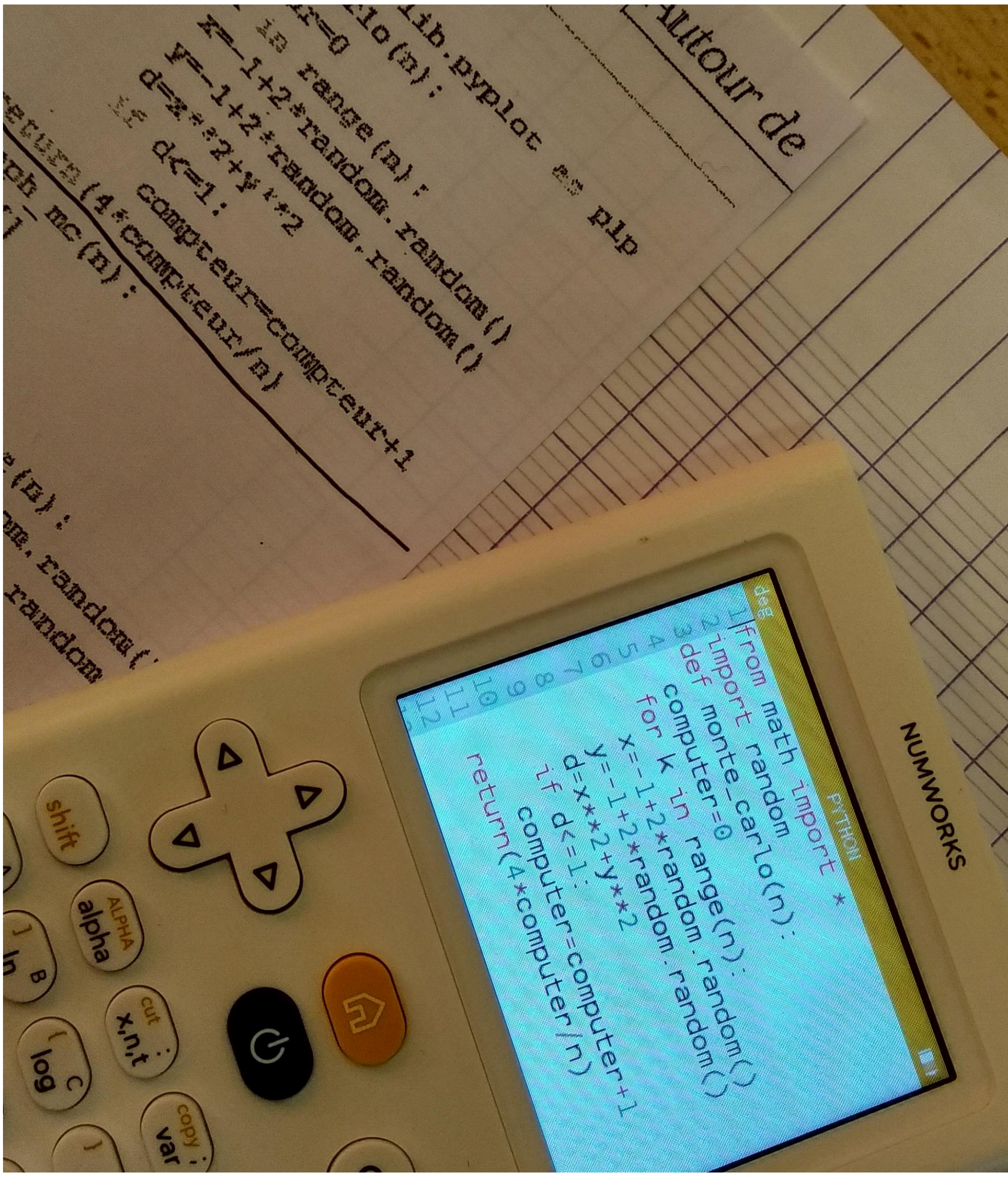
Here you can see a picture of our material.

OPINION:
We like this experiment because it's interesant and different.

CALCULATING PI

MATERIAL:
We used a pizza box covered with transparent plastic. Inside, there were 500 grains of rice and a circle drawed.
PROCEDURE:
We shook the box and then we counted the number of grains outside the circle. We subtract this number to 500, to know the number of grains inside the circle.
We used the next formula:
nº of grains inside the circle/nº of total grains.

The result was PI because if you divide the area of a circle by the area of a square, it's the same as PI/4.



How to calculate PI using different methods?

The approximation of PI.

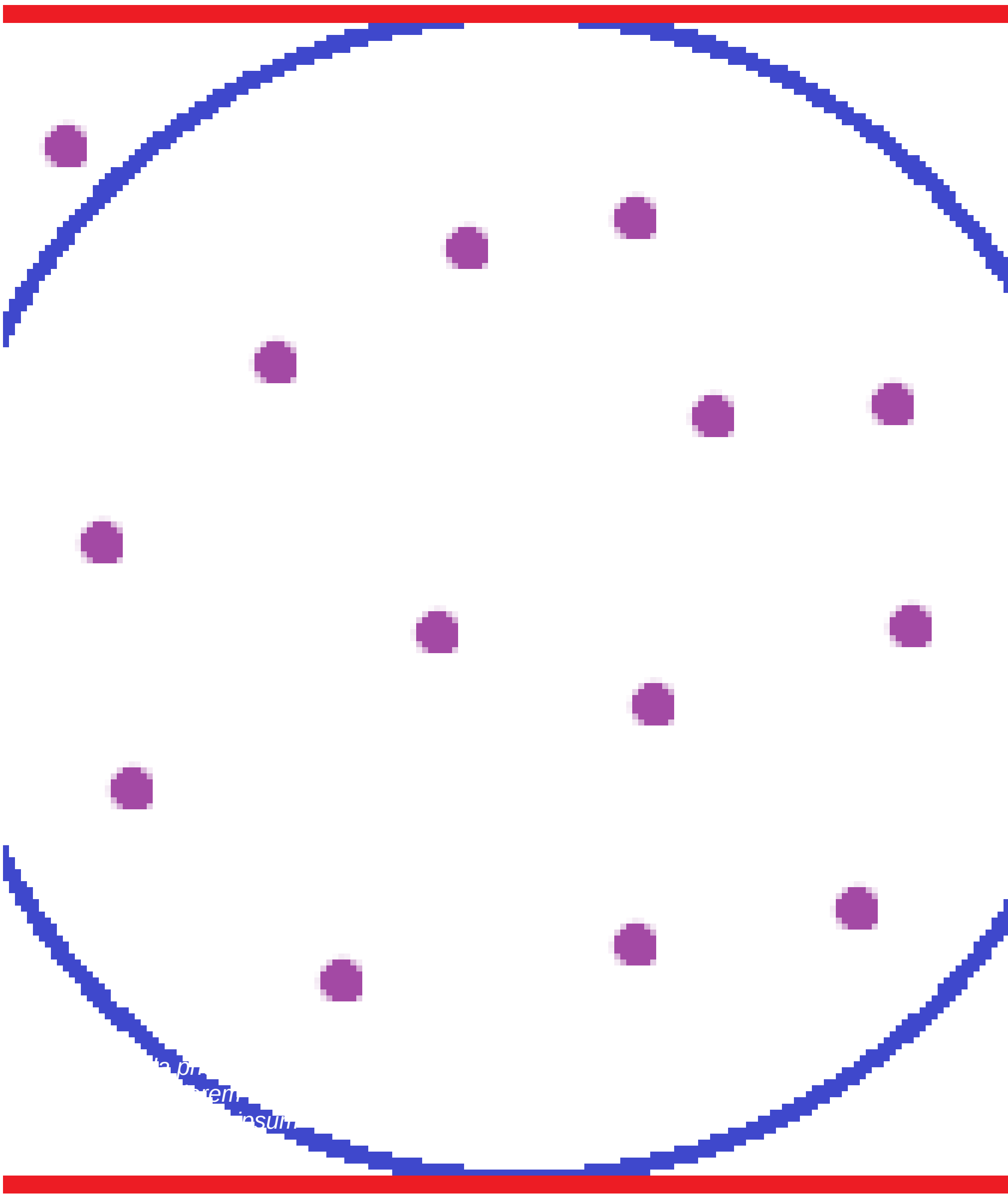
To calculate the approximation of PI we used different means of calculation. We used a box in which was drawn a square and in which was drawn a circle, then we threw seeds and we then did a calculation: the number of seeds in the circle divided by the total number of seeds.

After that we have with our calculators created a python program to make roughly the same manipulation as with the seeds but thanks to a program (see image)

Paul CAMBILLET

Monte Carlo Method

The term Monte-Carlo method designates a family of algorithmic methods aimed at calculating a numerical value



You may know that the digits of pi look random You can actually approximate the area of any circle using random points in a method called the Montecarlo method. The principle of this method uses something called "sampling" which works as follows: Say you want to find the number of people in a country who are female. You don't have time to check every single person so instead you take a random sample of people, say 10% of the population, and check only those. You find that 40% of the people in this sample are female so you generalize this percentage to the whole population and say that approximately 40% of the country is female. If the sample was random, this would be a reasonable approximation and this sort of thing is done all the time in surveys.

HISTORY

An early variant of the Monte Carlo method can be seen in the Buffon's needle experiment, in which π can be estimated by dropping needles on a floor made of parallel and equidistant strips. In the 1930s, Enrico Fermi first experimented with the Monte Carlo method while studying neutron diffusion, but did not publish anything on it.

APPROXIMATING π : MONTE CARLO METHOD.

Approximating π using the Monte Carlo Method ?

π can be found by generating randomly points on a square and counting the proportion that lies inside an inscribed circle into this square.
The probability of a point landing in the circle is proportional to the relative areas of the circle and the square.

The instructions to Monte Carlo Method are :
- Calculate the area of a square.
- Calculate the radius of the inscribed circle.
- Calulate the area of the circle.
- Divide the area of the circle by the area of the square.
- Multiply this number by 4.
- Repeat steps with different side lenghts.
- We always find π.

In class we select approximately 100 grains of rice and throw into the circle. We count the number of grains outside the circle and subtract this number from the total number of grains. This calculation gives the number of grains inside the circle and we divide this number by the total number of grains. Then we multiply this result by 4.

Our exemple : We take 300 grains of rice and 225 grains are inside the circle. We divide 225 by 300 and we find 0.75. We multiply by 4 this result and we get 3. Three is an approximation value of π.

We test a python program, this program can simulate the approximation of π using a number of grains of rice.

We found this experience in class was very good, because its was very interesting and now we can approximat π with grains of rice.

Picture of the experiment

« Its was a great experience ! »

Students from Institut Lemonnier, France. (Years 2019-2020)

Anatole CLOS, Clément REPEL, Corentin ANFRAY

Approximating π with the Monte Carlo method.

The problem is: to find easily an approximation of π with simple calculations ?

The spanish method is the following : generate random points on a square and count the proportion that lies into this square inside an inscribed circle. The probability of a point landing in the circle is proportional to the relative areas of the circle and the square.

Experiment :
Firstly, we draw a square with side length 28 cm and its inscribed circle on our copybook. Then, we take 100 grains of rice, throw them on the square, and we count the number of grains inside the circle and outside the circle. Then, we repeat with 200 grains and 300 grains.

Calculations :
First, we calculated the area of the square : 28*28=784 ; and the area of the circle : 2*pi*14²=615.752

The quotient of the area of the cirlce/area square is equal to 0.785 Multiply by 4 we find 3.14 ! It means that if we multiply the quotient grains circle/grains square by 4 we will find Pi.
Experiment 1 with 100 grains, we got 76 grains inside the circle and 24 inside the square. Therefore 76/100=0.76 then 0.76*4=3.04
Experiment 2 with 200 grains, gives 156 grains inside the circle and 44 grains inside the square. Therefore 156/200=0.78 and 0.78*4=3.12 that's close !

Programming :

Thanks to the python program we can randomly simulate the number π. The program breaks down in this way : we start by importing from python the math module and the random module. Then define the function (monte_carlo) which takes as variable "n" and initialize "counter" to 0. Then for k from 0 to n-1 we remove 1 then we add 2*random to x then y, d corresponds to x squared + y squared. If d <=1 we add 1 to the variable counter. Finally we return 4* counter/ n to give a number of π.

The team throwing the rice.

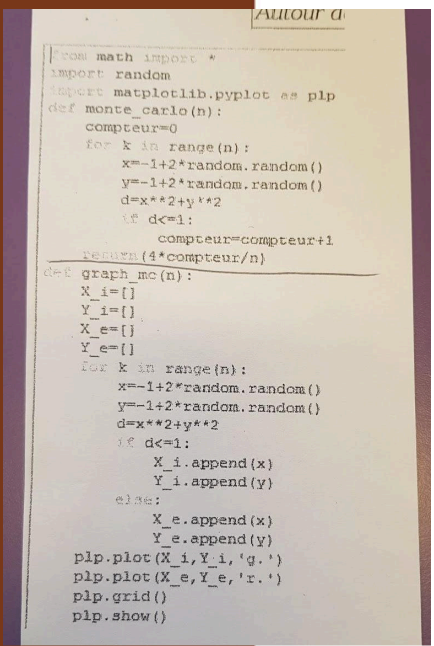
The square and its inscribed circle with rice.

Louis GALLIENNE - Nathan FERET - Thibauld FROUSSART - Anatole FORTIN - french student aged 17

The Monte Carlo method

We belong to a project in our high school which consists in some activities made in group around the mathematics, this is called the etwinning project with spanish and swedish students.

Together we all participated to the same activity which was we droped some rice into a box which had a paper inside with a circle and a square drawn on it showing different zone and we had to give the percentage of rice that fell in which zone of the paper (In the square or in the circle).
Check the photo below.



Autour d

```python
from math import *
import random
import matplotlib.pyplot as plp
def monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+1
    return(4*compteur/n)
def graph_mc(n):
    X_i=[]
    Y_i=[]
    X_e=[]
    Y_e=[]
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            X_i.append(x)
            Y_i.append(y)
        else:
            X_e.append(x)
            Y_e.append(y)
plp.plot(X_i,Y_i,'g.')
plp.plot(X_e,Y_e,'r.')
plp.grid()
plp.show()
```

A Python program

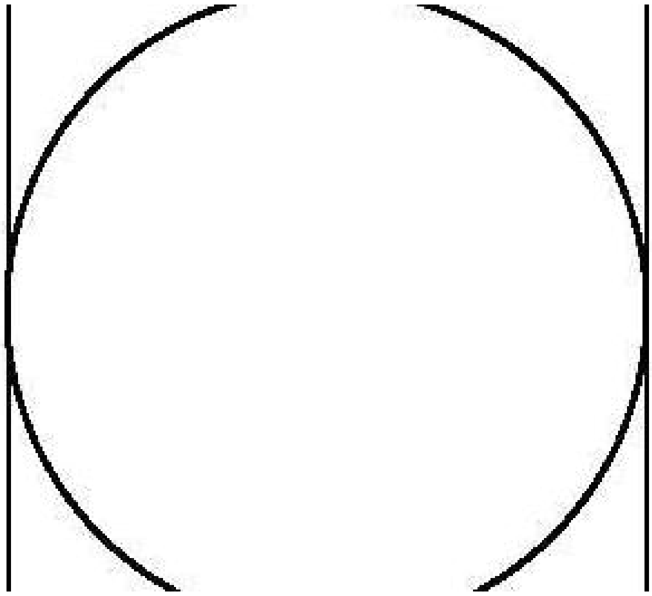
Photo from the dropping rice experiment

The programm of the left photo is in Python, a language of programmation very used and this one is made

This program determine where a rice grain can fall in a graph b determinating 2 factors, the X axis and the Y axis. those 2 valors determine the placement very precisely.

The monte Carlo Method

How can we calculate using How can we calculate π using

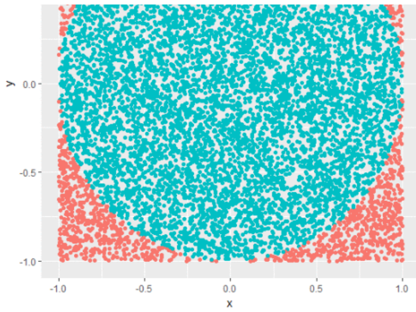


Circle inside a square

The goal is to calculate π.

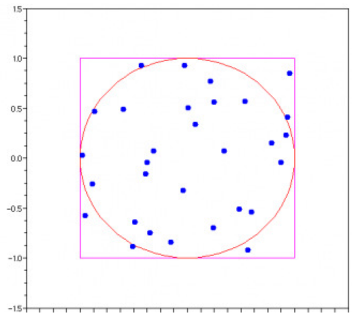
We need to draw a square and a circle inscribed then the square. Take a random point in the square and in the circle with different technics. And it's time to calculate π, count the number of points in the square and the number of points in the circle. The calculation is dividing the number of points inside the circle by the number of points inside the square including the circle and multiplie the quotien by 4. The more there are points, more the result nearest to the value of π.

We thinks this method to calculate π it's good but for the most specific value we need to do very lot of points.



In order to use this method we use a cardboard box where we put a sheet of paper with square and a circle inside the square. Then we use rice to throw randomly in the box. Then we count the number of rice in the circle and in the square. Finally we calcule the aproximate value of π by divinding, number of rice in the circle by the number of rice in the square and in the circle multiplie by 4.

Our results are 40 rice in the circle and 46 rice in the square including the circle. Our result of approximate value of π it's 3.48.



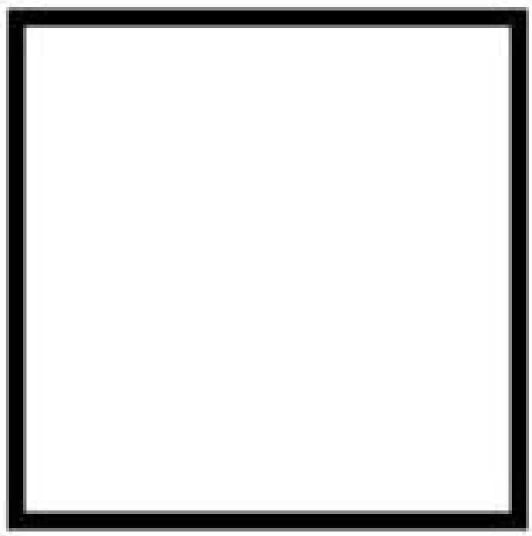
The Python program to calculate π with the Mont Carlo method.

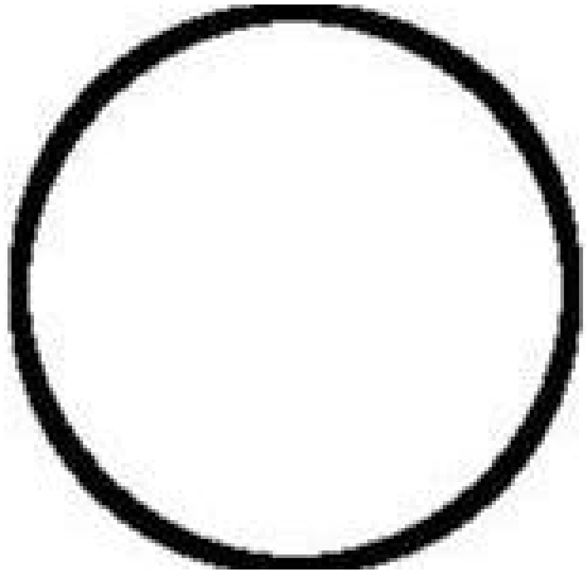
```
from math import *
import random
import matplotlib.pyplot to plp
def monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+1
    return(4*compteur/n)
```

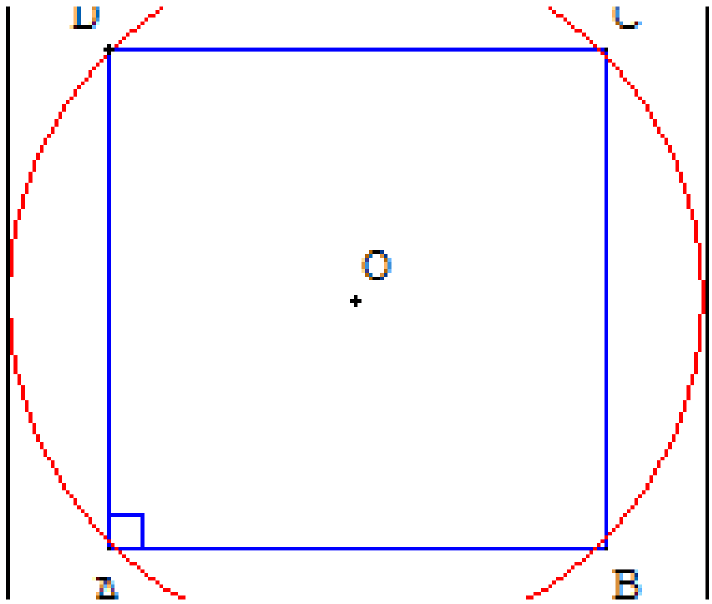
The Python program

This program calculate π with the Monte Carlo method.

The user chooses the number of points "n" and the program calculates the approximation of π with the command "random" to choose random the position of the point. The program returns the experimental value of π.







Let's uss introduce a method to experiment an aproximate value of pi.You make a square of 28cm. You make a circlewith the radiaus are equal to 14cm. After the square and the circle make you can select 100 grainsand throw rice.You count the number of them outside the circle.

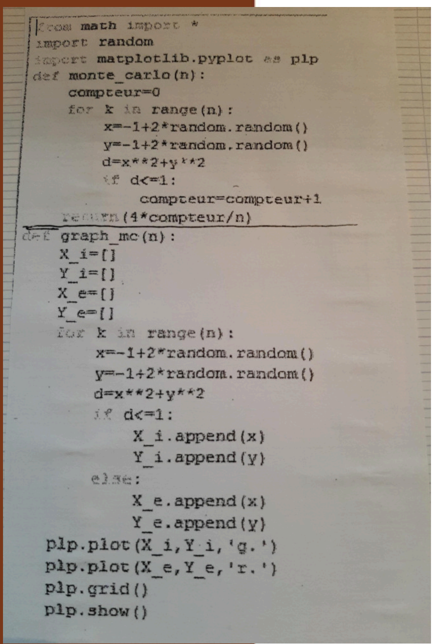
My team find the number 4.2.My team throw 52 rices, he have 42 rices in the circle and 10rices outside the circle.Then we have dividide 42/ 10 and the result are 4.2.It's not a good result because it's too for to 3.14 the number pi

The experiment in the class was very interesant and sympatic.Légendes des 4 photo Nemo

You dividide the number of grains inside the circle by the number of grains inside the square

Monte Carlo Method

We are going to explain to you in what consist the Monte Carlo Method.



```
from math import *
import random
import matplotlib.pyplot as plp
def monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+1
    return(4*compteur/n)
def graph_mc(n):
    X_i=[]
    Y_i=[]
    X_e=[]
    Y_e=[]
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            X_i.append(x)
            Y_i.append(y)
        else:
            X_e.append(x)
            Y_e.append(y)
    plp.plot(X_i,Y_i,'g.')
    plp.plot(X_e,Y_e,'r.')
    plp.grid()
    plp.show()
```

Program on the Monte Carlo method in Python:
This program consists in reproducing the Monte Carlo Method on a machine. This program takes into account two variables to which are added random results after each round (n).

This method consists in calculating the number of objects launched in a circle of various sizes. The result at the end of each experiment is never similar to the previous one. This method therefore has a random result all the time. It is therefore impossible to predict the final result.

For example, in a circle of area 616cm², there were 83 grains of rice over 100.

This project is done with a German and Spanish high school.

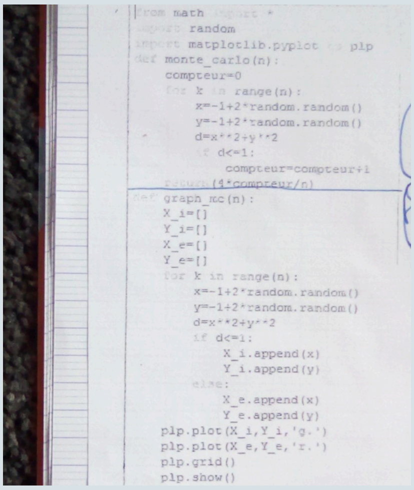
We ara not very satisfied with this method because for us it isn't reliable because we never get a precise result, it is by chance.

Test of the method seen in class with a circle and grains of rice.

The Monte Carlo method

The program

Now let's make a program to avoid repeating the steps below :

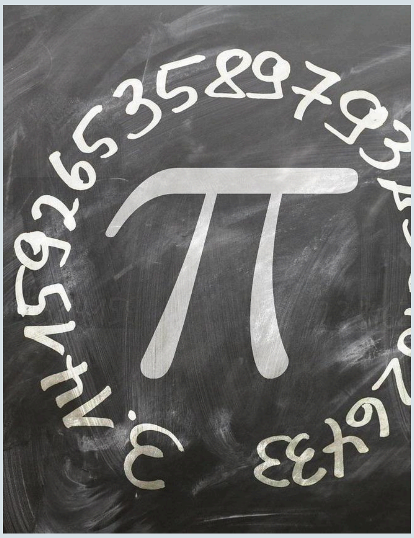


```
from math import *
import random
import matplotlib.pyplot as plp
def monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+1
    return (4*compteur/n)
def graph_mc(n):
    X_i=[]
    Y_i=[]
    X_e=[]
    Y_e=[]
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            X_i.append(x)
            Y_i.append(y)
        else:
            X_e.append(x)
            Y_e.append(y)
    plp.plot(X_i,Y_i,'g.')
    plp.plot(X_e,Y_e,'r.')
    plp.grid()
    plp.show()
```

The progam

Mi comment to the Monte Carlo method

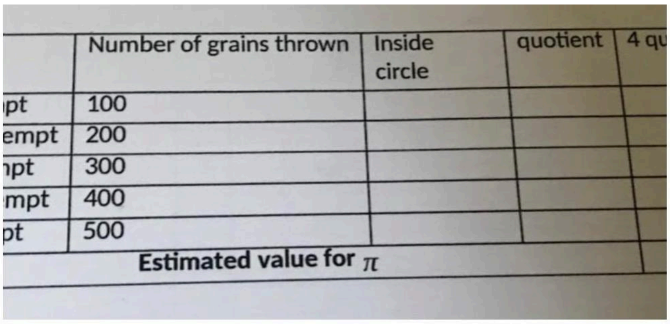
The Monte Carlo method is good for understand the fonction of the number π but is not very sur because there are a Margin of error



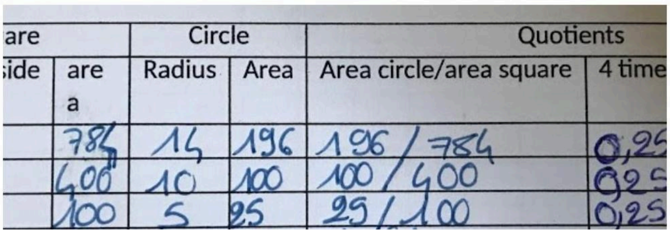
π

to find the value of π we doing an experience with rice to find value of π we use the figure and we take to area of circle divided by the area of square and multiply the discussion by for this function we give the number π

the Monte-Carlo method is interesting because it allows us to better understand how to find the number π but also to understand its functionality



	Number of grains thrown	Inside circle	quotient	4 qu
pt	100			
empt	200			
npt	300			
mpt	400			
pt	500			
	Estimated value for π			



are		Circle		Quotients	
side	are a	Radius	Area	Area circle/area square	4 time
	784	14	196	196 / 784	0,25
	400	10	100	100 / 400	0,25
	100	5	25	25 / 100	0,25

above we can see the table which is used to classify the results of the calculations with the area of the circle and the square below we can see the table that served to classify the results of the Monte Carlo method

The experiment in classe

Experiment :

In this experiment, we use rice, we count the nuber of rice grains inside the circle and the total number of rice grains inside the square. Calculation step below:

step 1: Calculate the area of square of side length 28 cm.

Step 2 Calculate the radius of the circle inscribed to this square

Step 3 : Calculate the area of this circle

Step 4 : Divide the area of this circle by this area of square.

Step 5 : Multiply this number by 4. We obtain ....

Step 6 : Then, we repeat steps 1,2,3,4,5 with other lengths and obtains............

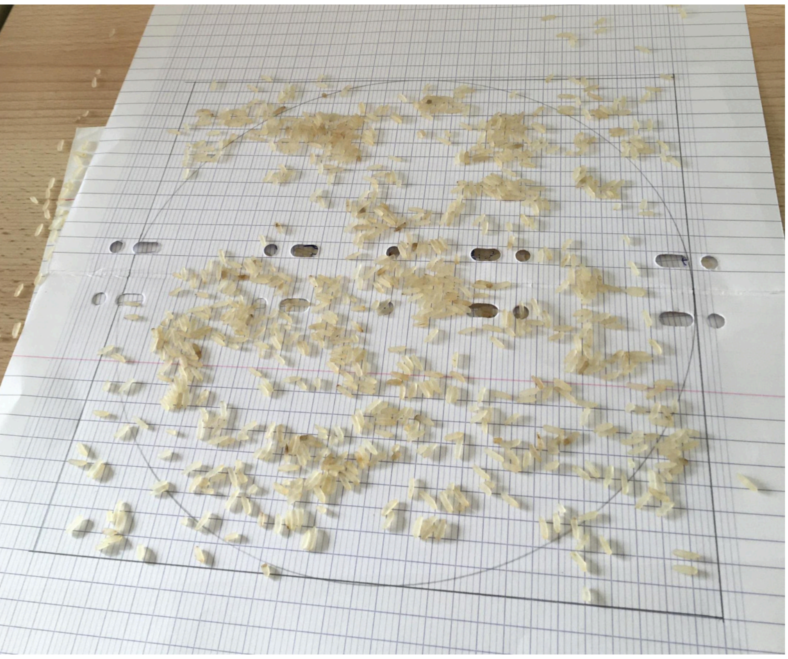
Step 7 : you can see the results in the table "La tu mets la photo du tableau"

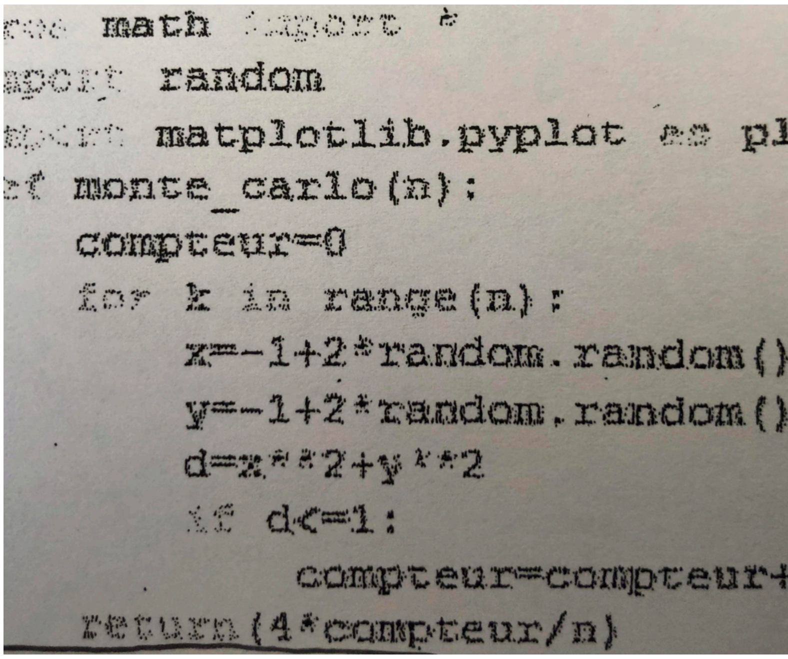
Now let's experiment with rice:

Step 8 : Take 100 grains of rice or 100 beans and drop them at the top center of the circle of about 30 centimeters

Step 9 : Once done, count the grains that are outside the circle so in the square normally Step10 : Now place for calculations: Divide the number of grains inside the circle by the number of grains inside the square.

Step 11 : then try the previous steps again with more grains





```
rom math import *
mport random
mport matplotlib.pyplot as pl
ef monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+
    return(4*compteur/n)
```

The monte carlo method is used to find a value of π. The goal of this method is about throwing rice grains in a circle.

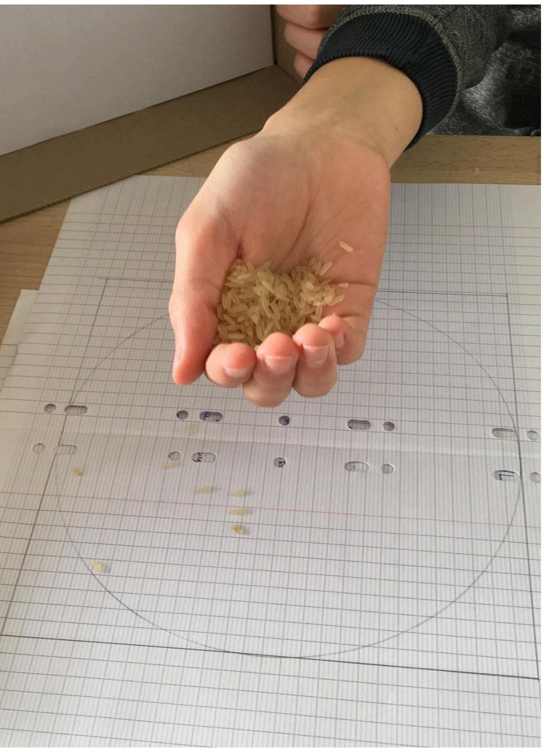
the algorithme create a variable called monte carlo. (n) is a total rice grains number selected by someone an executed by a camputer. This simulated the experiment by a camputer.

accordind to the assignment paper from spain, π can be found by generating random points on a square and counting the proportion of areas that lies inside an inscribed circle to a square.

In class, we experiment the Monte Carlo Method. We throw 100 rice grains. In a box with a one circle inside a square, we pour rice and then count the number of grains that lie in the circle and those in the square. Finally, we calculate the following number of rice grains inside the circle over total rice grains. we find approximately 3.32

The result is approaching π when we divide the area of the circle by the area of the square. So it's like π over four.

Rice throw picture



> the result obtained does not correspond to pi, but it approaches it. So the method is good but not precise

Finding π in an unusual way using the Monte-Carlo method

In class

We draw a large square and its inscribed circle on a A4 sheet of paper. Then, we throw rice on the square, we count the number of rice grains inside the circle and the total number of rice thrown in the square.

Throwing rice grains in class.

Programming

Python algorithm

This algorithm simulates the Monte-Carlo method throwing a larger number of rice grains. The programming allows to obtain an experiment result closer to π.

```python
from math import *
import random
import matplotlib.pyplot as plp
def monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+1
    return(4*compteur/n)
```

The number π is now essential in many fields of activity, in mathematics, in architecture and industry... But how can we approach this number that we use so often. There is a method to approximate π, the one we use is the Monte-Carlo method.

We will see how we use this method, first with rice, then using of a computer. The principle of the Monte-Carlo method is to generate random points or thrawn rice on a square and to count the proportion of rice grains that lies in its inscribed circle.

Square		Circle		Quotients	
Lenght of the side	Area	Radius	Area	Area circle/ area square	4 times this quotient
5	25	2.5	6.25π	π/4	π
20	400	10	100π	π/4	π
x	x^2	X/2	$(x/2)^2$ * π	π/4	π

Relations between a square and its inscribed circle with π.

Number of grains thrown	Inside circle	Quotient	4 times this quotient
691	581	581/691	3.36324
		Estimate value for π	3.36324

Our experiment results.

Explaination of calculations

The relation between the area of a square and its inscibed circle is π. The first spreadsheet proves that the method works since the result is π. The second spreadsheet gives our results of the experiment. There were 691 grains in the square and 581 grains in the inscribed circle.

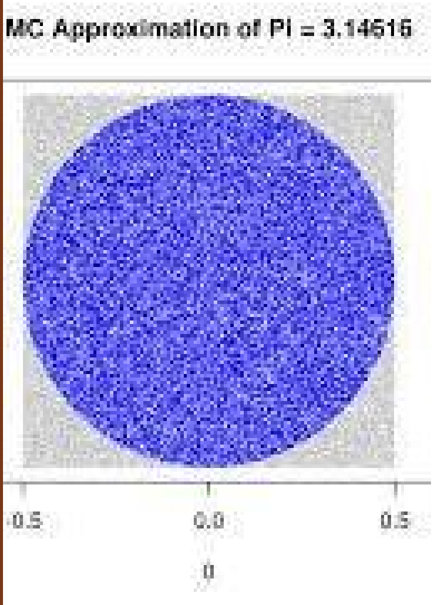
The result is rather significant since 3.36 is pretty close to the π value that is 3.14. This experiment was interesting for us because we didn't know this method to determine an approximate value of π. Our value was not that far from the true value.

Baptiste Jobard & Léo Quesnot, aged 16.

calculating probabilities

What is the problem ?

The Monte-Carlo method uses probabilities to calculate π.



"Here you can see a picture of our material"

here is the material necessary to realize a probability i have either easily:We used a pizza box covered with transparent plastic. Inside there were 500 grains of ricze and a circle drawed. example:← ← ← ← ← ← ← we have 250 grains in total and only 200 are inside the circle so we do 200/250=0.8 0.8/(π/4)=1.01

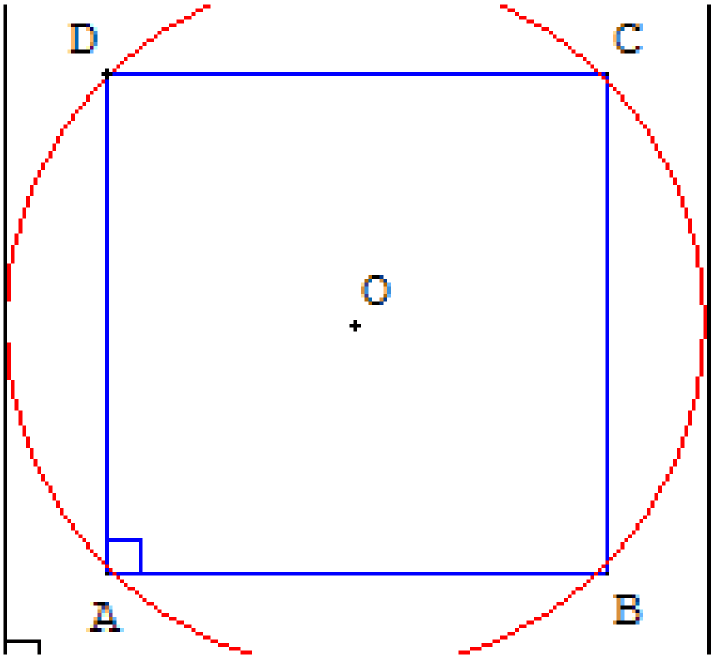
Using the Monte-Carlo method is quite simple, Necessary a box and then we counted the number of grains outside the circle. We subract this number to 500, to know the number of grains inside the circle. We used the next formula:

n° of grains inside the circle/n° of total grains. The result since you divide the area of circle by the area of a square gives π/4.

```
from math import*
from random import*
from matplotlib.pyplot import*

# Calcul d'une approximation de Pi par la méthode de Monte-Carl

n=int(input("Combien d'essais dans l'échantillon?"))
r=0

for i in range(n):
    x=random() #Tirage uniforme d'un point du carré unité
    y=random()
    if x**2+y**2<1: #Vérification de sa position par rapport au
        plot(x,y,'ro') # à l'intérieur
        r=r+1 # on le comptabilise
    else:
        plot(x,y,'bo') #à l'extérieur


p=(r/n) # Calcul de l'approximation de l'aire obtenue

axis([0,1,0,1]) # affichage des résultats de l'expérience
text(0.2,0.2, 'Aire='+str(float(p)),size=30)
show()
```

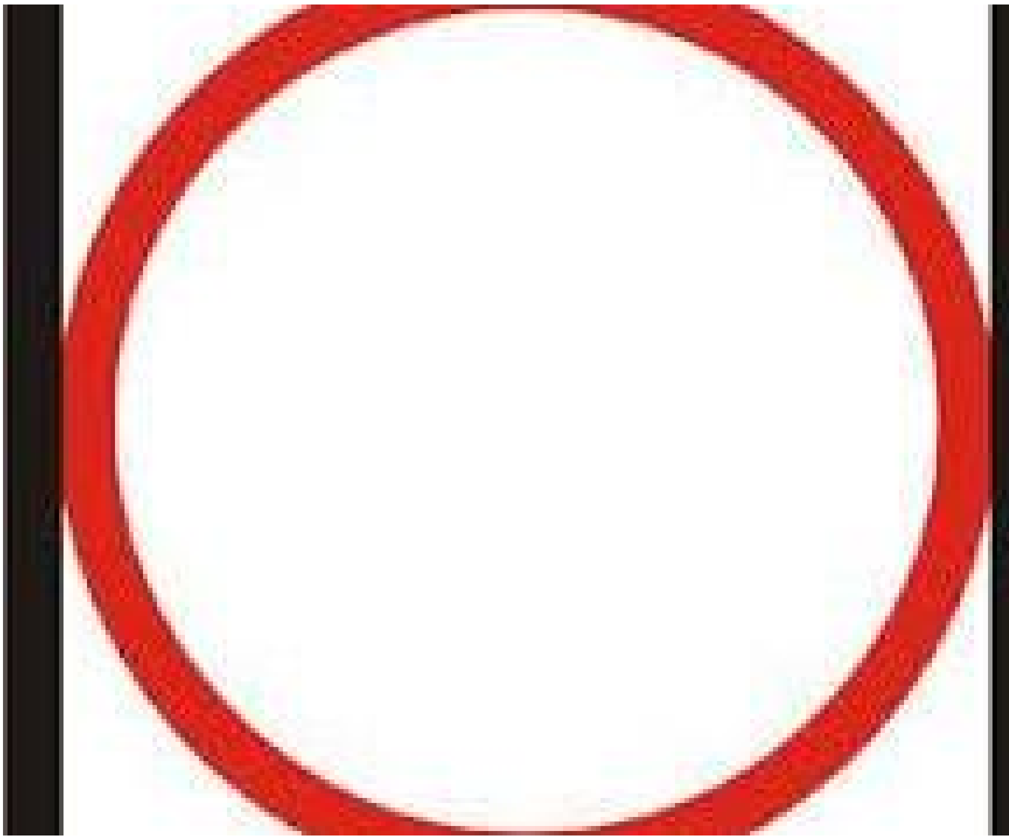
Opinion: I find it very interesting to calculate a probability because we can have the probability of something like casino games

Baron Romain & Aubril Melvin



THE MONTE CARLO METHOD

the monte Carlo method consist in creating a square where we draw a circle,we then put a dandom number of grains of rice in this square and thanks to this we can calculate the area of the circle. for that we have to find the formule. Wedid this classroom experience we buuilt a square to 28cm and we drew a cricle the area of the square does 784cm,teh radius of the circle to 14cm we calculate the area of the circle to divide with the areasquare so the calculation is616/784 witch is about equal am 0.785 and the fourtimes this quotient is 4 multiply by 0.785 wich is about equal at 3.14 we have with my team utilised this method but we did not find the right result The equation to find area od the circle is pi rcarrré and the equation ton find the circunfuerence of the circle is 2 pi r ANd in class we worked witch python and this program aplly the x and y coordinates to the registrants thuefore, cach grain of rice M can he identified by an x coordinates and a y coordinates pythagonas'theorem gives the distance OM
OMcarré=x+y



Here is the list of approximations of π found with the Spain Method and the experiment in class.

3,141592654
3,141592654
3,141592654
3,141592654
π

Approximations of π found with the Spain Method.

how find π?

〖Area〗 _(Square)=L^2

〖Area〗 _Circle=π ×r^2= π ×L^2/4

Ratio= 〖Area〗 _Circle / 〖Area_Square)]=(π ×L^2/4)/L^2= π/4

So,
π=Ratio ×4

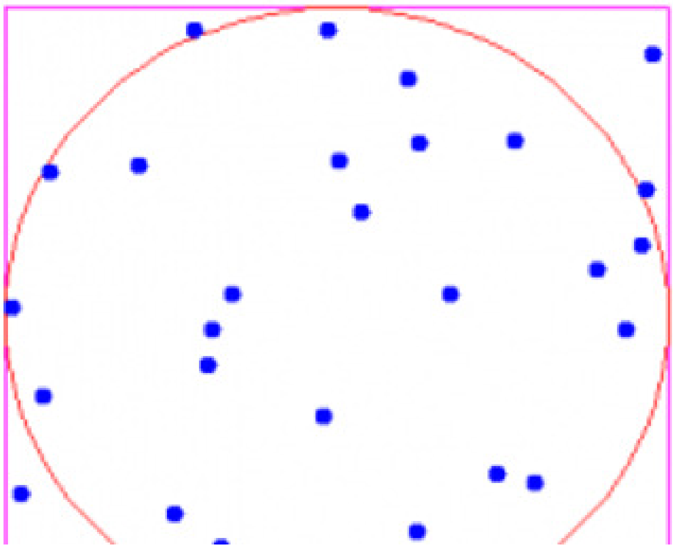
3,72
3,84
3,56
3,32
3,6

approximations of π found with the experiment in class.

What is the Monte Carlo Method?

The Monte-Carlo method is used to find an approximation of π. We find this method when we put points random in a square, then we count the number of points present in the circle which is inside the square, then we calculate the ratio between number of points inside the circle compare to total number of points. Moreover, the probability of a point landing, in the circle or in the square is proportional to these form areas.

The Spain method:
For the method, with the paper of Spain, we have chosen a length of a side for the square, we have calculated his area. After we have taken a circle, is radius is a half of the side of the square. We have also calculated his area. Then we have divided the area of the circle by the area of the square and multiply by four this quotient. So, we found an approximation of π.



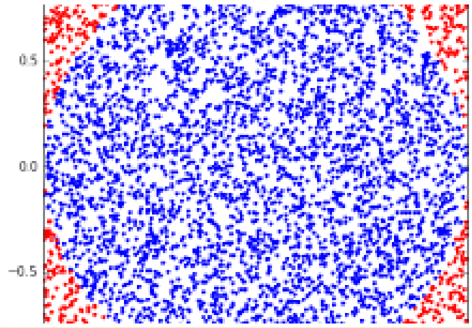
An Image of the Monte Carlo Method who comes from Spain

TITRE LOREM IPSUM MET

The experiment in class with rice consists to take some grains of rice and to throw them on the square with the circle inside. After we have counted the number of grains inside the circle, then we have divided the number of grains in the circle by the total number of grains. And we had multiply by four this quotient to obtain an approximation of π. There are some examples in the table to the left:

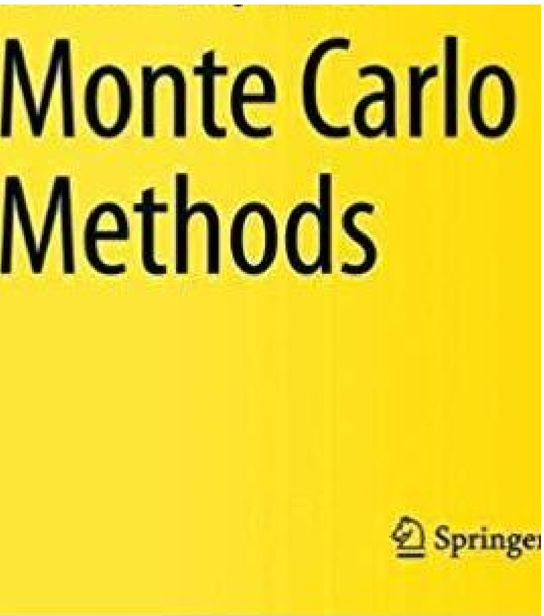
My personal comment: The result is approximately equal to pi, at all the time, because for the three tests we have divide the area of the circle by the area of the square, or we have also divided the number of grains of rice by the total number of grains of rice. And every time we have multiply by four this quotient. But the program was not really clear for me.

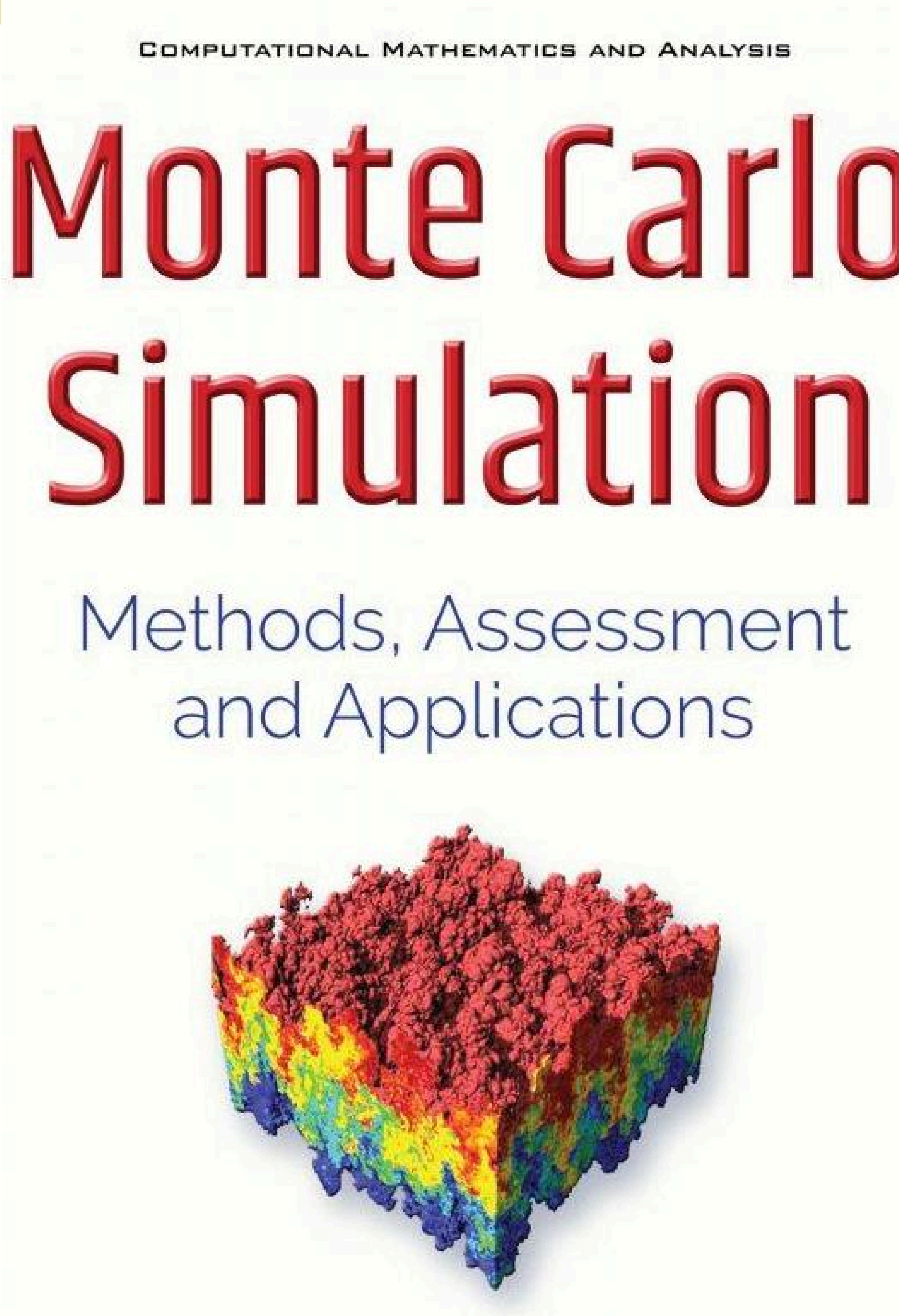
The method Monte Carlo… finally explained



The Monte Carlo method : what is it ?

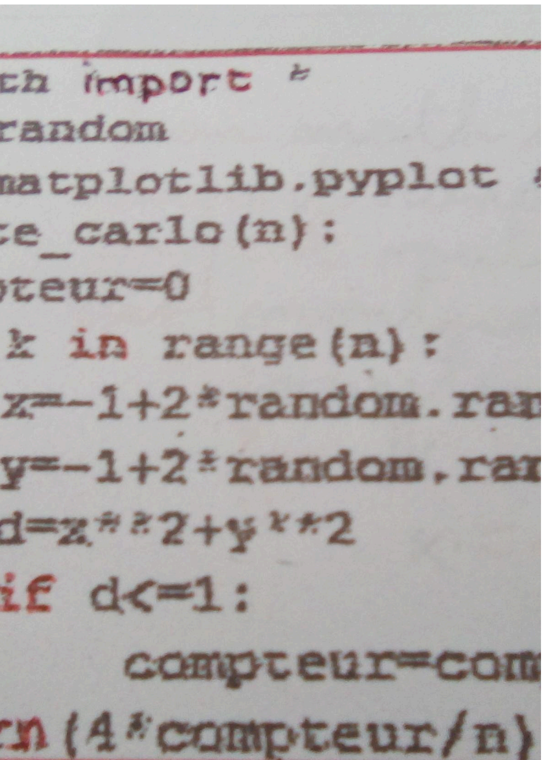
N°01 - 10 février 2020





MONTE

CARLO



PYTHON

```
"""module monte Carlo"""
import os
from math import *
import random
#import matplotlib.pyplot as plp

def monte_carlo(n):
    """ Monte_Carlo function"""
    compteur=0
    for k in range(n):
        x=-1+2*random.random()  # Random number in range(-1,
        y=-1+2*random.random()  # Random number in range(-1,
        d=x**2+y**2             # r² = x² + y²  : Circle defin
        if d<=1:                # if the x and y random value
                                #r<=1, if not the x²+y²>1 so
            compteur = compteur+1 # incrementation of the val
    return (4*compteur/n)       # ratio between Circle area a
                                #this ratio by 4 to return a


# test of the fonction table
if __name__ == "__main__":
    print (monte_carlo(100))
    os.system("pause")
```

.

The explanation of the program

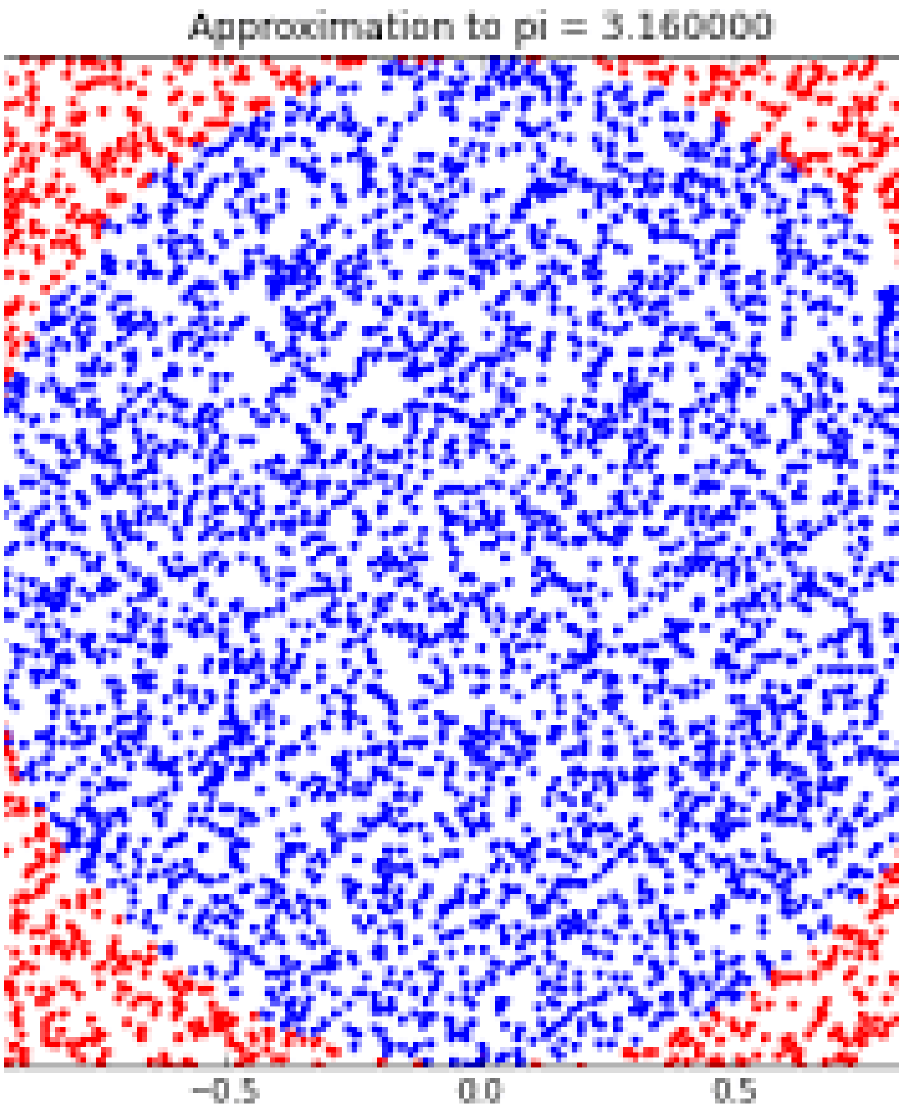
The program choose a random number in range (-1, 1) for abscissa X and another one with the same range for ordered Y. It compute after the formula “x^2+y^2” and check the result to determine if the point (x,y) is inside the trigonometric circle or not. If the result is superior than 1, it means that the point is outside the circle but still is in the square, if not, it means that it’s well in the circle. This is due to the following Circle fomula: $r^2 = x^2+y^2$. Then, it repeats it many times (“n” times) as specified by the function parameter “n”. The number of times that the point is inside the circle is recorded into a local variable. The ratio between number of times that the point is inside compare to the total number of points is the image of circle area divided by square area. The bigger “n” value is, the more accurate area ratio calculation is. The function return 4 times the ratio area calculation for readability, in order to be able to recognize the Pi value. The theorical value of this ratio is equal to $\pi R^2/L^2$ (with R as the circle radius, and L as the square side. In our case, L = 2R) So the ratio becomes equal to $\pi R^2/(2R)^2 = \pi/4$
And then $(\pi/4)*4= \pi$

The montecarlo method is used to calculate an approximate value of π We follow the Monte Carlo method in 4 steps :

- Take 100 rice grains
- Throw rice grains into a circle inscribed in the square
- Count the number of rice grains in the circle over 100
- Insert in an excell sheet

To calculate an approximate
value of π, calculate the length of the side of the square
and the radius of the inscribed circle: the side of the square measures 28 cm and the radius of the circle measures 14 cm.
Then, we measure the area of the two figures:

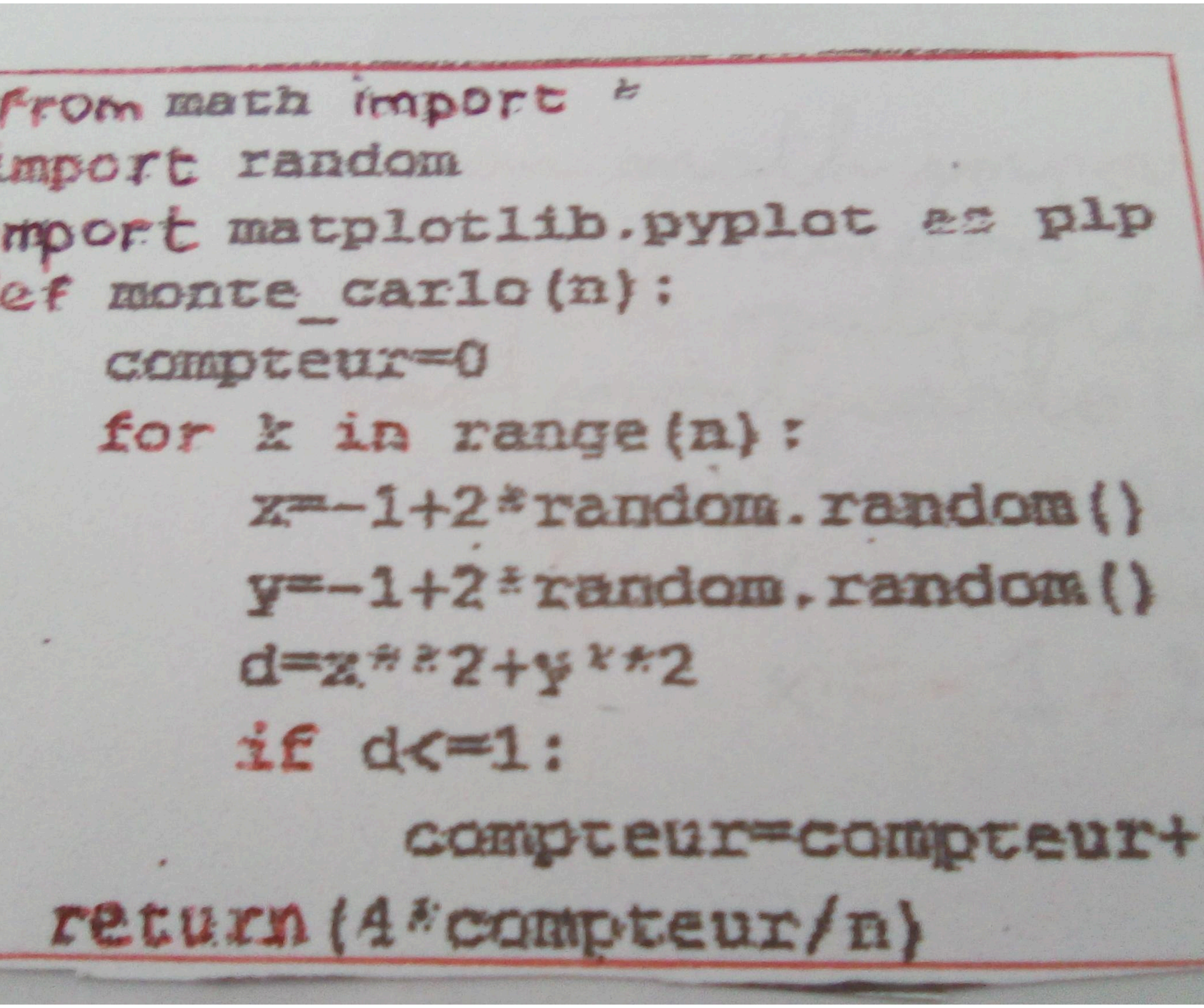
- Square area = (side)^2 = 28^2 = 784
- Area of the circle = π × (radius)^2 = π × (14)^2 ≈ 615.75



The area of the square is 784 cm^2.
The area of the circle is 615.75 cm^2. Then, we perform the following calculation:
square area ÷ circle area ≈ 615.75 ÷ 784 ≈ 0.785 Finally, we multiply by 4 the result for the four sides of the square so: 0.785 × 4 ≈ 3.14. The result is 3.14. It is indeed an approximate value of π so this method is good.

Dates

Erwann, aged 16



```
from math import *
mport random
mport matplotlib.pyplot as plp
ef monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+
return(4*compteur/n)
```

Next, we write a programming in Python, to simulate the Monte Carlo method explain.

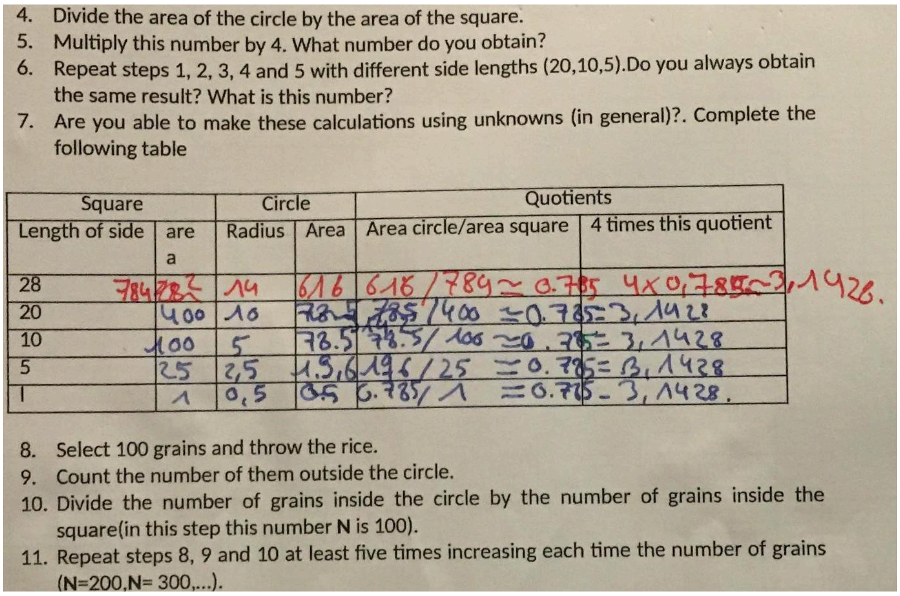
Comment : The result is good because this programm is very good for founding calculations very hard.

Monte Carlo Method

• We will see how we calculated π in different ways with the Monte Carlo method in class.

• <u>Monte Carlo method to approximate π.</u>
We first complete a data table which allows to find an approximation of the π number. In this table we divide the side area of the circle by the area of a square whose length is the diameter of the circle. We multiply this result by 4 and this gives an approximation of the number π.

• <u>Experience with rice in a circle inscribed into a square.</u>
Take a square in cardboard and draw a circle inscribed in it, then take a number of grains of rice and throw them into the square. Count the number of grains of rice inside the circle and then divide this number of grains of rice by the total number of grains of rice the square. The result was each time close to π number / 4.
<u>Result:</u> 85/100=0.85
0.85 x 4= 3.4 it's ~ π.
850/1000=0.85
0.85 x 4= 3.4 it's ~ π.


4. Divide the area of the circle by the area of the square.
5. Multiply this number by 4. What number do you obtain?
6. Repeat steps 1, 2, 3, 4 and 5 with different side lengths (20,10,5).Do you always obtain the same result? What is this number?
7. Are you able to make these calculations using unknowns (in general)?. Complete the following table

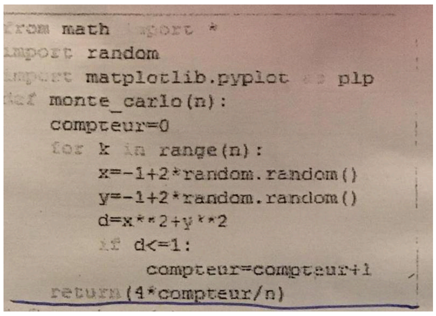
Square		Circle		Quotients	
Length of side	are a	Radius	Area	Area circle/area square	4 times this quotient
28	784 28²	14	616	616/784 ≃ 0.785	4x0,785 ≃ 3,1428.
20	400	10	78.5	785/400 ≃ 0.785	= 3,1428
10	100	5	78.5	78.5/100 ≃ 0.785	= 3,1428
5	25	2,5	19,6	19,6/25 ≃ 0.785	= 3,1428
1	1	0,5	0.5	0.785/1 ≃ 0.785	- 3,1428.

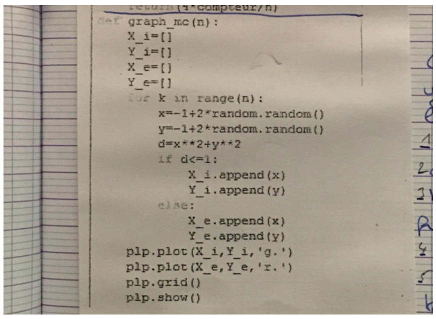
8. Select 100 grains and throw the rice.
9. Count the number of them outside the circle.
10. Divide the number of grains inside the circle by the number of grains inside the square(in this step this number **N** is 100).
11. Repeat steps 8, 9 and 10 at least five times increasing each time the number of grains (**N**=200,**N**= 300,...).

↑***Picture of the data table that we filled with the results.***

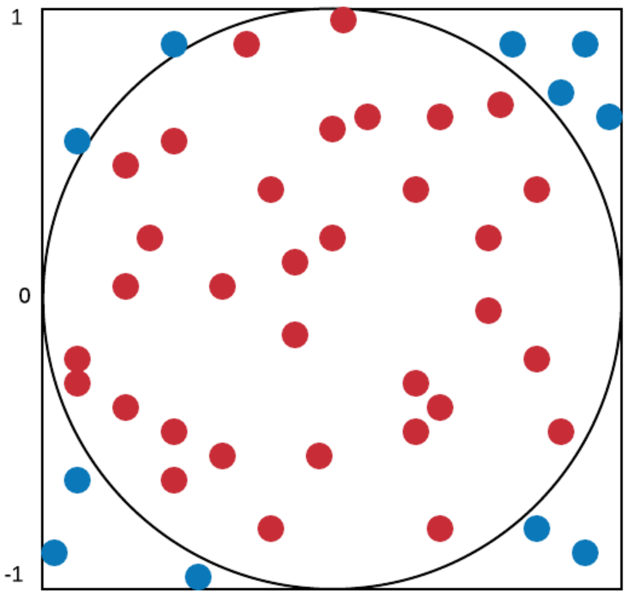
Two images of the algorithm made in python language. →

•<u>An algorithm that calculates π.</u>
We copy an algorithm in Python on our calculator which allows to simulate the experience made in class digitally. This algorithm simulates our experience and he gives us results fairly close to the results we had in the 2 classroom experiments.


```
from math import *
import random
import matplotlib.pyplot as plp
def monte_carlo(n):
    compteur=0
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+1
    return(4*compteur/n)
```


```
def graph_mc(n):
    X_i=[]
    Y_i=[]
    X_e=[]
    Y_e=[]
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            X_i.append(x)
            Y_i.append(y)
        else:
            X_e.append(x)
            Y_e.append(y)
    plp.plot(X_i,Y_i,'g.')
    plp.plot(X_e,Y_e,'r.')
    plp.grid()
    plp.show()
```

• Image of the classroom experience. Taken on google. →



<u>General conclusion:</u>

• With all these experiences, we can accurately estimate the π number. The results are all close to the π number.I can conclude that the experiments worked and gave good results

Lilian Marie, aged 16.

How calculate pi In 3 Method :

In the school we have learning 3 method to calculate pi :

We applicate the second Method : Dropping bean in a box...

How we have found pi :
With my groups of 4 people we have do this three precedent :
1st method :
We have take the random lenght of square's side. We have calculate each area of each lenght of square's side with the following formule : ***side x side = square's area***
For the next step we need to calculate the circle's area.
In a another time, we have calculate the radius, we have divide by two the lenght of square's side. Now with the radius, we have calculate the circle's area.
Now with the circle's area and the square's area, we have all for use the formule : Area circle / area square So we have use the formule and we have multiply by four this result. We have got pi : 3,14

2nd method :
We have a box, on the box we have a paper where is draw a circle in a square.
The teacher give us a lot of bean to throw in the box. We have too another paper with a board :
The rules, in five attempt, we must begin to one hundred bean and add one hundred bean to each attempt.
We have count the bean inside the square.
We have divide the number in the square by the number in the circle. After we have multiply by four the each result and we get approximatly **pi = 3.14**
3th method : With the last method, we have use python to simulate the second method. We have write the coding text on our calculator to understand this.

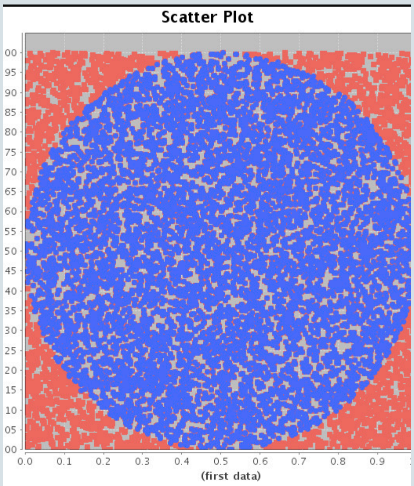
Rules of the first Method:

The first method it's to design a circle in a square and divide the circle's area and the square's area. The last step, it's to multiply by 4 this quotient. Now you have the number of pi.

BRÈVES

Rules of the 2nd Method

The second method it's to design a circle in a square and drop rice in the middle of the circle.
The next step it's to count of them outside and inside and divide the number of grains inside the circle by the number of grains inside the square.
Multiply by 4 the quotient and we have



The result we can get with the 3th Method

Rules of the 3th Method

In the school we have a Calculator where we can code in Python. It is really hard to write the code but it is fun.
We have write the code and we have get pi...

```
    compteur=0
    for k range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1:
            compteur=compteur+1
    return((4*compteur/n)
def graph_mc(n):
    X_i=[]
    Y_i=[]
    X_e=[]
    Y_e=[]
    for k in range(n):
        x=-1+2*random.random()
        y=-1+2*random.random()
        d=x**2+y**2
        if d<=1
            X_i.append(x)
            Y_i.append(y)
        else:
            X_e.append(x)
            Y_e.append(y)
    plp.plot(X_i,Y_i,'g.')
    plp.plot(X_e,Y_e,'r.')
    plp.grid()
    plp.show()
```

Extract of a Python's code for simulate the 2nd Method with a computer

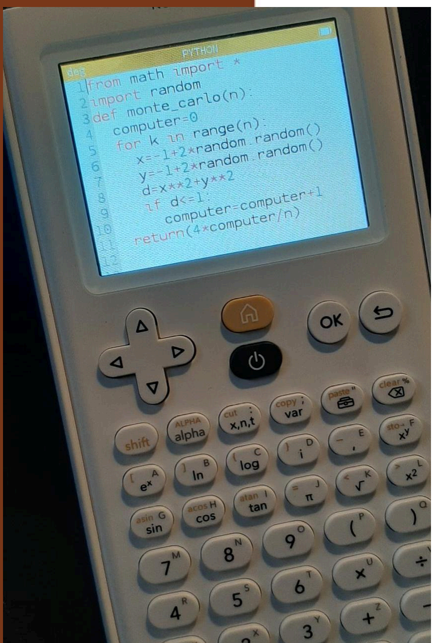
Writer by Keryan HOUSSIN, 16 aged

Calculating the approximation of π with monte carlo method.

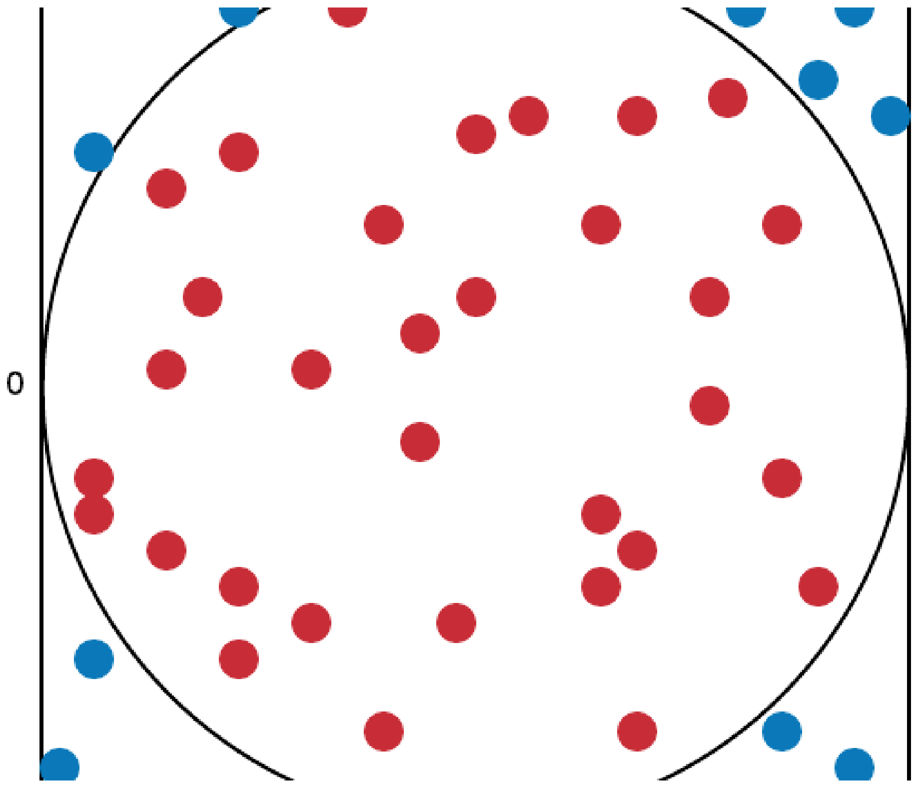
We learned to calculate π using differnet methods, the first was using a diagram drawn on cardboard and graines.The second method was with a calculating numworks and Python.

This method consists in calculating an approximation of pi thanks to a cardboard and seeds. First we draw a square in which we write a circle. Then we take a handful of seeds and we throw them in the box, seeds will be distributed in the circle and in the square, see image. The calculation is to divide the number of seeds inside the circle by the number of seeds inside the square.

Thanks to our calculators we were able to create a program in the programming language python. This allowed us by making lines of code to program an algorithm allowing to simulate the same thing as with the box (see if against)

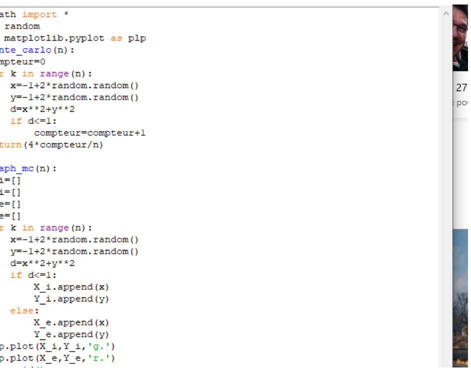


Calculating with Python on numwoks

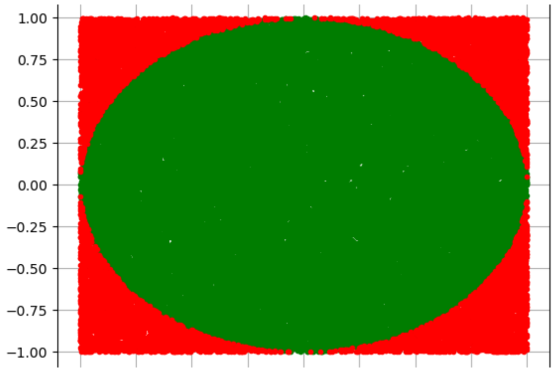


The calcul of π with grains and boxpaper

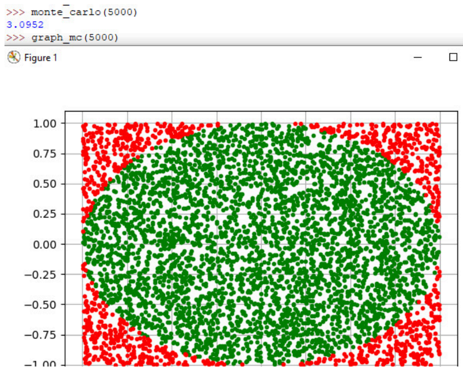
Monte Carlo Method:



For me the result it is good because the program reproduces well the circle and the square with

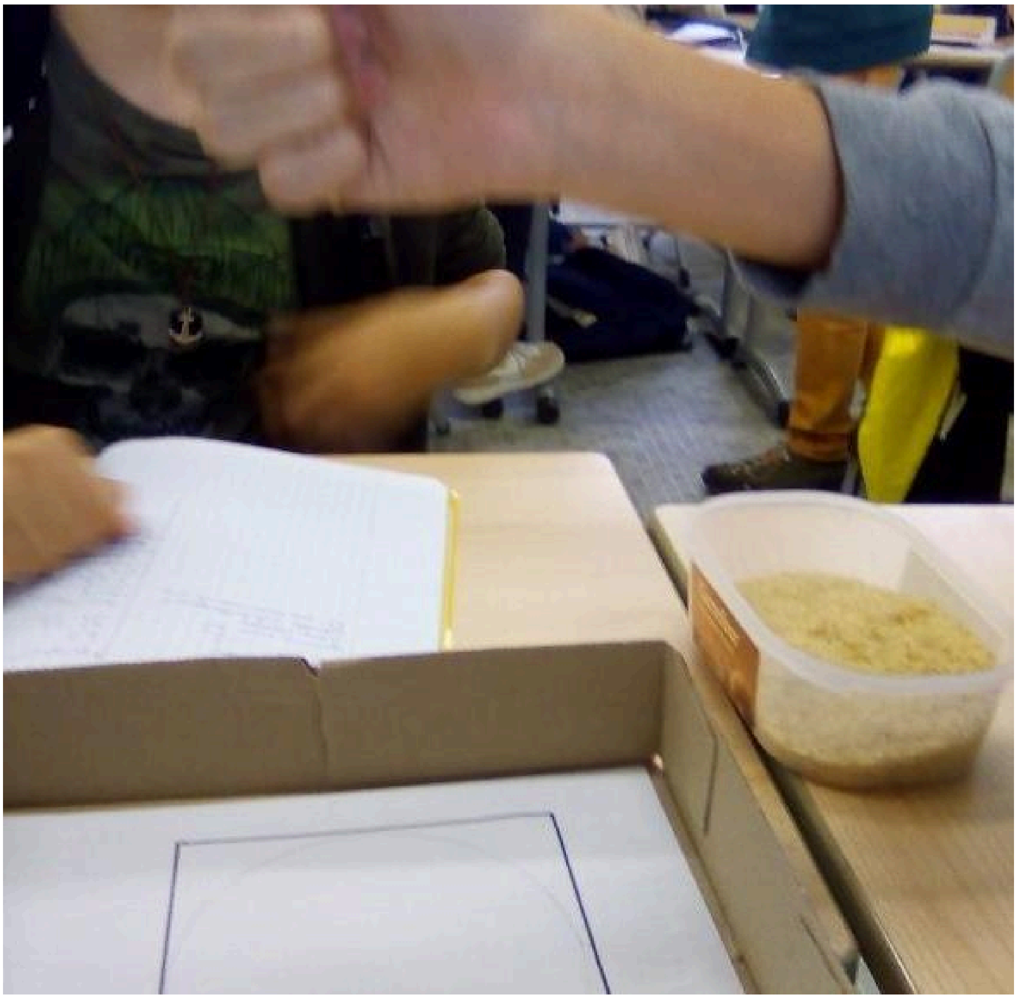


But the larger the number, the more complete the area of the circle and square will be and that the result will approach π.



And if the number is smaller the area of the circle and the square will not be complete so the result will be less than π.

What is the problem?

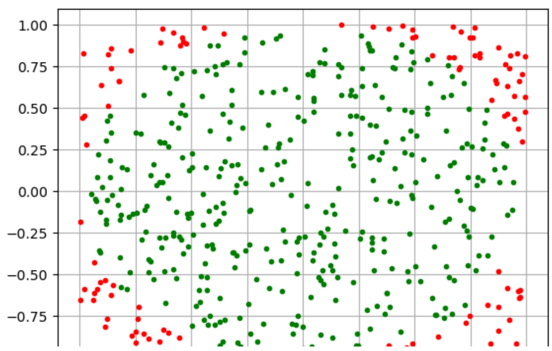


The method explained as on the “paper” from Spain.

The experiment in class: We throw rice grain in a box then; we counted the number of rice grain in the circle then those in the square. We noted on the board the results (and calculations) found with my team. Then, we compared our results with the whole classroom

The last step was to create a program on our calculator in order to calculate the number of rice grains in the circle and in the square.

The last step was to create a program on our calculator in order to calculate the number of rice grains in the circle and in the square.



My personal comment on this result: it is good? why?

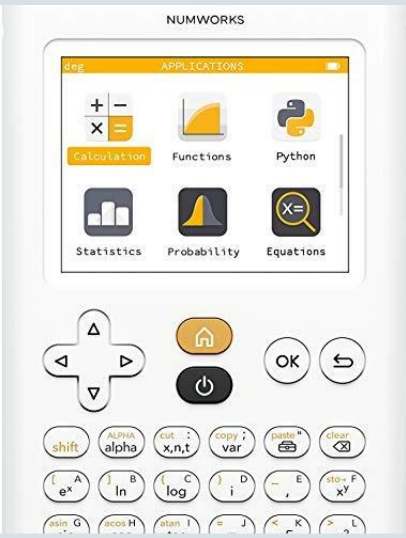
-I think this result is incredible that this experience was with grain of rice.

program

the program

The program is to know if there is a grain of rice in the circle. The compteur is equal to 0 well we have to have at the end a result minus 0 to have a grains of rice. We write x is equal to minus one plus two scared and y equal to -1+2^². We use pythagore x^² +y^² it means the result and it's finish.

the calculator NUMWORKS to help us to calculate..



Monte Carlo method

how to find an approximation of π with the Monte Carlo

Method : you have to inscribed a square inside, a circle. Divide the area circle by the area of the square and you multiply the result by 4 . It should be approximate by equal to π .

In class we did it with grains of rice, at the beginning we had 100 rices, we throw them inside the square. There were 65 grains in the square and 55 in the circle, We have following the method, we find 3,38 as an approximating π.

class's experience...

class's expérience

In team, we have make a square and inside a circle, divided area's circle by area's square and multiply by 4. We have found 3,1428, it was a good approximating.