



# Chaos Theory?

## *Done by:*

- Razan Mohammed Sameer
- Istabraq Abdulaziz Atea

## *Supervised by:*

- The math teacher: Abeer Abdulla

## *School:*

- Roqaya Preparatory

# Contents

- Why Chaos theory?
- Our steps.
- What exactly is chaos?
- When was chaos discovered?
- What went wrong?
- The butterfly effect.
- Why is it called butterfly effect?
- Applications.
- How Chaos Theory Shown In mathematics?
- Conclusion.
- Feedback.
- References.

# Why Chaos Theory?

I am **Istabraq** I was watching a movie on T.V called "chaos" the movie was about a series of crimes that appeared random but when analyzed and turned into equations and variables it showed a clear pattern, it was called chaos theory .I was wandering if it was a real math theory and what applications will it have, so I asked my teacher on the next day about it, and I was disappointed that she didn't know any thing about it but she promised me to search about it. At the end of day my teacher called me and showed me a website that contains information, photos and videos all about Chaos Theory. Gogling about it gave a group of videos but the best was an experiment with a pendulum.

My friend **Razan** and I tried to make an experiment by using a grid paper and 4 colors in which we pulled one randomly and colored one square with this color. We thought that we were making a similar experiment to that of the pendulum. We colored and colored and colored .but it didn't work, so what went wrong??..... we did more searching on the internet and found out that we did a big mistake, yes pulled randomly, but we didn't have a system that could be described chaotic that had an initial condition that changed with time, and that we need a specialized computer program that we hope to have one day. The relation that the theory shared with math was amazing, and shows that no need for complicated functions and a great number of variables, iterating functions with a single variable can behave as a chaotic system.

We were interested and enjoyed our results about this theory.

# *Our Steps*

1. **G**ot the idea.
2. **S**earched and collected information about the steps of making a research?
3. **R**esearched it on the internet on different websites.
4. **P**rinted out the info.
5. **D**ownloaded related videos.
6. **S**howed, read, summarized and found relations.
7. **T**ried an experiment but it failed and led us to search for more information.
8. **S**ummarized conclusions.
9. **C**ollect the info. And present it as a PowerPoint.

# *What exactly is Chaos ?*

The name "chaos theory" comes from the fact that the systems that the theory describes are apparently disordered, but chaos theory is really about finding the underlying order in apparently random system.

## *When was Chaos first Discovered?*

### *And by whom.*

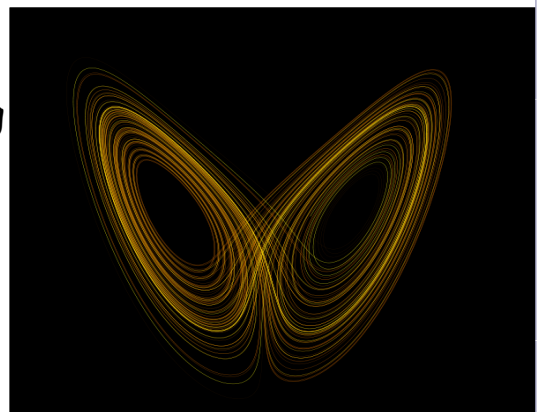
- The first true experimenter in chaos was a meteorologist, named **Edward Lorenz**.
- In **1960**, he was working on the problem of weather prediction. He had a computer set up, with a set of twelve equations to model the weather.
- It didn't predict the weather itself. However this computer program did theoretically predict what the weather might be.
- One day in **1961**, he wanted to see a particular sequence again. To save time, he started in the middle of the sequence, instead of the beginning. He entered the number off his printout and left to let it run.
- When he came back an hour later, the sequence had evolved differently instead of the same pattern as before; it diverged from the pattern, ending up widely different from the original.

# *What Went Wrong??!*

To his surprise the weather that the machine began to predict was completely different from the weather calculated before. Lorenz tracked this down to the computer print out .the computer worked with 6 digits precision ,but the print out rounded variables off to 3 digits numbers ,so a value like 0.506127 was printed as 0.506 .this difference is tiny and the consensus no effect. However Lorenz had discovered that small changes in initial condition produce large changes in the long term outcome. This effect came to be known as the "Butterfly Effect"

## *The Butterfly Effect*

The amount of difference in the starting points of the two curves is so small that it is comparable to a butterfly flapping its wings .



# Why is it called "butterfly effect"?

"Butterfly effect" probably known as the so called sensitivity initial conditions is because of the title of a paper given by Edward Lorenz in 1972 to the American association for the advancement of science in Washington

Dose the flap of a butterfly's wings in Brazil set off a tornado in Texas?

The flapping wing represent a small change in the initial conditions of the system, witch causes a chain of events leading to large scale phenomena. Had the butterfly not flapped its wings, the trajectory for the system might have been vastly different.

This phenomenon, common to chaos theory, is also known as sensitive dependence on initial conditions. With a starting number of 2, the final result can be entirely different from the same system with a starting value of 2.000001. It is simply impossible to achieve this level of accuracy - just try and measure something to the nearest millionth of an inch!

# *Applications*

Chaos theory is applied in many scientific disciplines:

Mathematics , ecology , computer science , economics , finance , philosophy , physics , politics , population dynamics , psychology and robotics.

## *Video*



This video shows an experiment of a system that can be described as chaotic.

The initial condition that changed and affected on the behavior of the system is the place where The Loop of the pendulum was going to start its motion.

# How Chaos Theory Shown In mathematics?

- In mathematics, chaos theory describes the behavior of a certain dynamic system -systems.
- Dynamical system; any thing that moves or changes in time.
- As a result for this sensitivity the behavior of chaotic system appears random.

## What are examples of dynamic systems?

Such dynamic systems occur in different types of science:-

- 1- Motion of plants
- 2- Weather
- 3- Stock motion
- 4- Chemical reactions

## How can I classify the system as chaotic?

The most important question to be classified is.....

"can I predict what will happen???"

and....

"can I predict how this motion will evolve by time???"

Some of these are predictable for example:

- 1- You can predict that tomorrow the sun is going to rise.
- 2- In the morning when you add your coffee to the water you can predict that it will not cause an explosion .

While the weather and the stock market are totally unpredictable that's because they depend on so many variables that no body can predict variables to predict the behavior of their equations.

On the other side in mathematic there are two many mathematical system that depend on single variables can behave just unpredictable like those complicated systems.

## What are examples of those mathematical systems?

Iterating functions.....

\*\* This process of iteration is a dynamical system since the numbers are changing in time

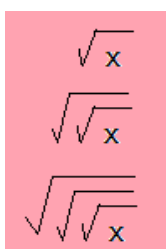
Examples (1):

Square root x

Start with  $x$

Then compute

Then compute



And so on .....

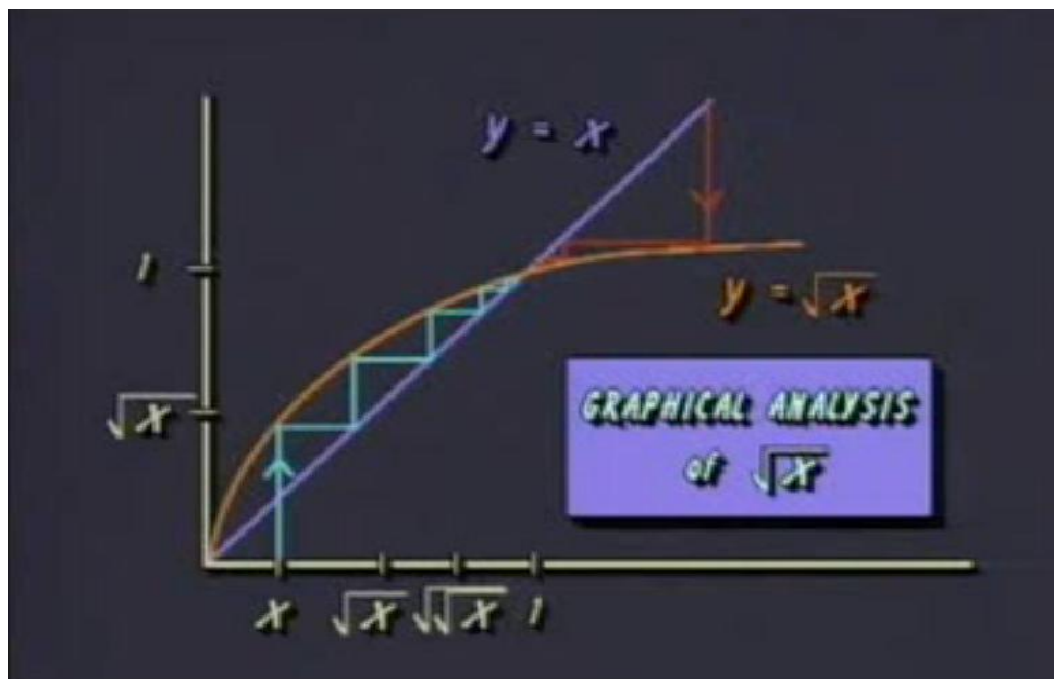
Can you predict what will happen if you iterate this function over and over again .....

# Video



What an amazing result starting with any number it will end up at **one**, this is an example of mathematical chaotic system that you can predict its behavior.

This graph shows how iterating square root function is going to have a bath that moves between the graph of square root  $x$  and the graph of  $y=x$  till it stops at one which is the intersection point.



Examples (2):

Sin x .....

Can you predict how this system is going to behave???

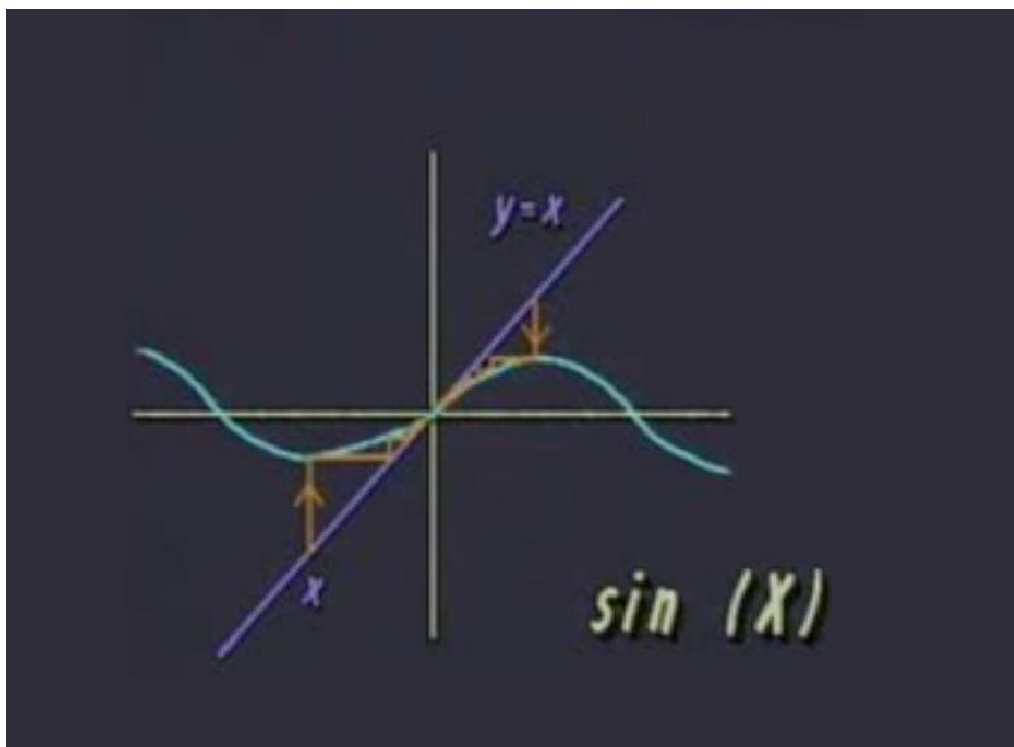
If you iterate it your calculation is going to stop at ....

# Video



This is another example of mathematical chaotic system that you can predict its behavior.

This graph shows how iterating  $\sin x$  function is going to have a path that moves between the graph of  $\sin x$  and the graph of  $y=x$  till it stops at zero which is the intersection point.



Examples (3):

$\cos x \dots$

Can you predict how this system is going to behave???

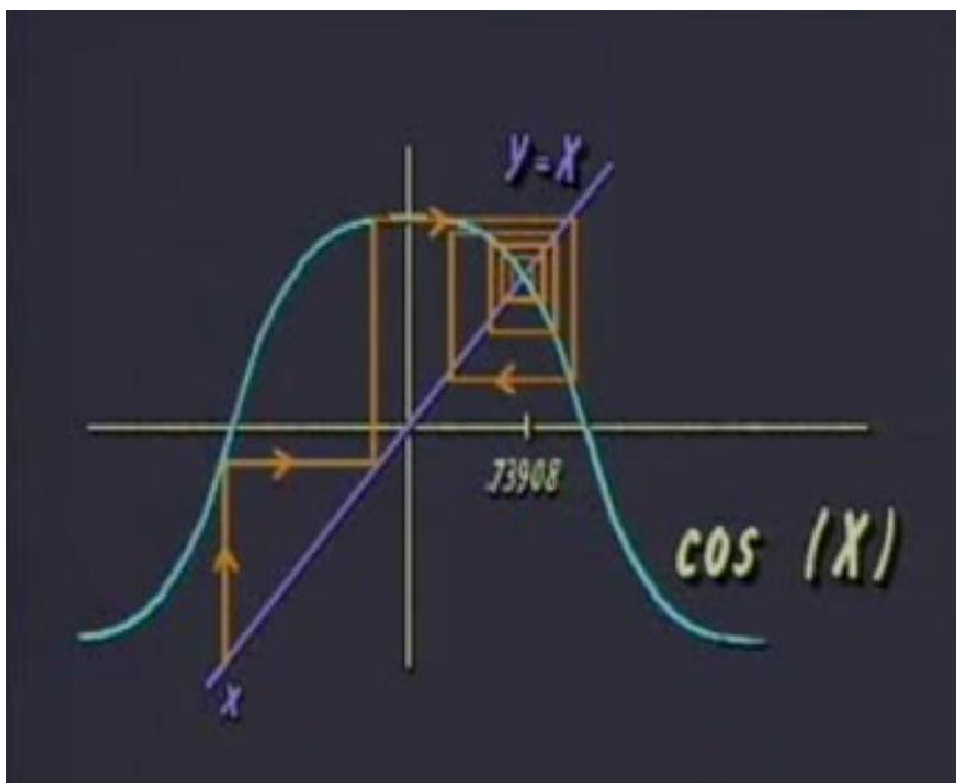
If you iterate it your calculation is going to stop at ...

# Video



This is also an example of mathematical chaotic system that you can predict its behavior.

This graph shows how iterating  $\cos x$  function is going to have a path that moves between the graph of  $\cos x$  and the graph of  $y=x$  till it stops at a strange number which is  $0.73908$  which is the intersection point.



Examples (4):  
 $4x(1-x)$ .....

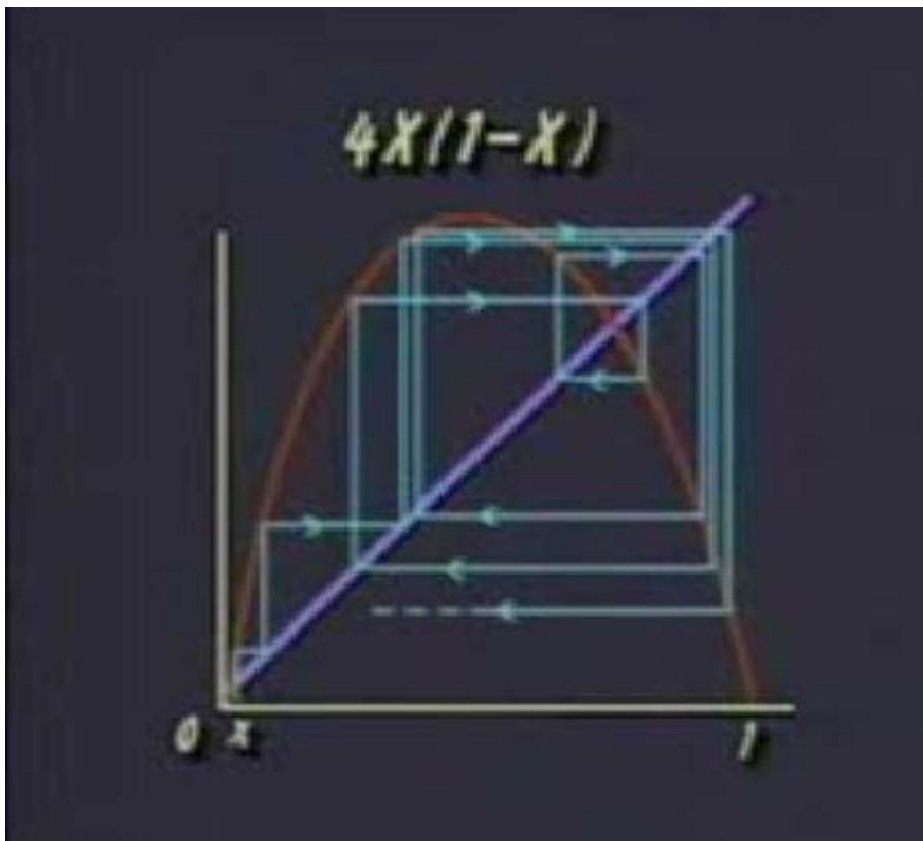
Can you predict how this system is going to behave?????

# Video



You can notice that there is no pattern that's because its chaotic and totally un predictable. Computer graph images. Computer experts (are essential for this kind of studies).

This graph shows how iterating  $4x(1-x)$  function is going to have a bath that moves between the graph of  $4x(1-x)$  and the graph of  $y=x$  that shows no pattern and its not easy to predict its behavior on the long run.



# *Video Pictures*

those images produced by iteration for some functions -those were produced 4 years ago for the first time no one can know what will happen exactly or facts .

## *Video*



# Conclusion

- ☒ Chaos theory is really about finding the underlying order in apparently random system.
- ☒ The first true experimenter in chaos was a meteorologist, named **Edward Lorenz** in 1960.
- ☒ This phenomenon, common to chaos theory, is also known as sensitive dependence on initial conditions or "butterfly effect"
- ☒ In mathematics, chaos theory describes the behavior of a certain dynamic system -systems.
- ☒ The most important question to be classified is...  
"can I predict what will happen???" and...  
"can I predict how this motion will evolve by time???"
- ☒ Some of these are predictable while others are totally unpredictable.
- ☒ In mathematic there are two many mathematical system that depend on single variables can behave just unpredictable like those complicated systems.
- ☒ Chaos theory needs a specialized computer program to be shown.

# Feedback

- Chaos theory was an amazing subject with wonderful results
- We were interested searching about it.
- We are looking for having another idea for anew research.
- We learned many new ideas.
- We wish to have those computer programs that can show the behavior of the graphs of chaotic systems.

# References

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Department of mathematics - Boston University.