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| * [SampleFiles](file:///C:\Users\Aaron\Desktop\MATLAB%20Guide%20to%20Fibonacci%20Numbers\SampleFiles) |

Part I Review of MATLAB

# Introduction

# Symbolic Computing

# Solving Equations

# MATLAB Functions

# Graphs in MATLAB

Part II Fibonacci Numbersand The Golden Ratio

# Fibonacci Numbers

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| * [SampleFiles\Ch06](file:///C:\Users\Aaron\Desktop\MATLAB%20Guide%20to%20Fibonacci%20Numbers\SampleFiles\Ch06) |

As expected, the slope of the line is almost as before. The angle of the line is calculated as tan-1(0.4812) = 25.7o, exactly as before. An alternative method to plot the logarithms of Fibonacci numbers is to use the MATLAB command semilogy in association with the MATLAB function fibonacci(n). The graph obtained in this way will also be an almost straight line but will be slightly different from the graphs obtained here.

Fibonacci numbers are closely related to exponential growth in nature. Botanists noticed that there are many plants that tend to have a Fibonacci number for the leaves and petals. Fibonacci numbers also appear prominently in the family tree of rabbits. Actually, Leonardo Fibonacci first noticed these numbers when he studied the problem of breeding of rabbits under ideal circumstances. Let us elaborate on this problem and how it is related to Fibonacci numbers. See the books in references [48-56] and the web links [57-67].

Consider a hypothetical situation of rabbits breeding as follows. Start with two rabbits who after a time produce two new rabbits. After a certain time, these four rabbits produce four new rabbits. Thus, we end up with eight rabbits. In the next cycle of breeding, another eight rabbits are produced to make the total 16 rabbits and so on. Thus, we get the exponential sequence 2, 4, 8, 16, 32, …. which is just a sequence of the powers of 2, i.e. 21, 22, 23, 24, 25, … . This sequence follows the law of exponential growth. See the books in references [48-56] and the web links [57-67].

However, the real situation is different. When we have four rabbits, the newborn rabbits are too young to produce new rabbits right away. They have to skip a cycle before they start producing more rabbits. In this way, the number of rabbits accumulating follows the Fibonacci sequence 1, 1, 2, 3, 5, 8, 13, 21, … and so on. This is how Leonardo Fibonacci first deduced this interesting series by considering how rabbits breed naturally. This is explained in detail below. See the books in references [48-56] and the web links [57-67].

Let us start with one rabbit. After one cycle, this rabbit produces a new rabbit – the total becomes two. After the second cycle, the old rabbit produces another new rabbit but the little rabbit skips this cycle and does not produce any new rabbits. The total now becomes three rabbits. After another cycle, the two old rabbits produce two new rabbits but the little one skips this cycle and does not produce. Thus the total now becomes five rabbits following the Fibonacci sequence precisely. Thus, we obtain the numbers 1, 2, 3, 5, 8, 13, 21, …. for the total number of rabbits. This is exactly what Leonardo Fibonacci originally observed and is what started the interesting topic of Fibonacci numbers. See the books in references [48-56] and the web links [57-67].

Fibonacci numbers appear in nature often enough to show that they reflect some naturally occurring patterns. These patterns can be spotted by studying how certain plants grow. For example, if you look at an array of seeds in the center of a sunflower, you will notice what looks like spiral patterns curving left and right. If you count these spirals, you will be surprised to obtain a Fibonacci number. If you divide the spirals into those pointed left and right, you will get two consecutive Fibonacci numbers. You can find such spiral patterns in pinecones, pineapples, and cauliflower.  See the books in references [48-56] and the web links [57-67].

Other examples where Fibonacci numbers occur naturally are in plant growth and branches of plants. For example, if you count the number of petals on a flower, you will be surprised to find the total to be a Fibonacci number. Lilies and irises have three petals while buttercups and wild roses have five. Delphiniums have eight petals and so on. Notice that 3, 5, and 8 are Fibonacci numbers. See the books in references [48-56] and the web links [57-67].

Fibonacci numbers also occur naturally in honeybee colonies. In these colonies, there is a queen, a few drones, and a lot of workers. The female bees all have two parents – a drone and a queen. However, drones have one parent each. Therefore, Fibonacci numbers appear in a drone’s family tree – each drone has one parent, two grandparents, three great-grandparents, and so on. See the books in references [48-56] and the web links [57-67].

A final example is that Fibonacci numbers appear in the human body. You have one nose, two eyes, three segments to each limb, and five fingers on each hand. These are all Fibonacci numbers. Furthermore, DNA molecules follow the Fibonacci sequence also measuring 34 angstroms long and 21 angstroms wide for each full cycle of the double helix. Of course, the numbers 34 and 21 are surprisingly Fibonacci numbers. See the books in references [48-56] and the web links [57-67].

# The Golden Ratio

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# Properties of the Golden Ratio

# Lucas Numbers

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In this chapter we will study Lucas numbers and the Lucas sequence of numbers. These numbers are closely associated with Fibonacci numbers. Lucas numbers are generated using the same rule as that of Fibonacci numbers, i.e. the next number is obtained by adding the previous two numbers. However, instead of starting with the numbers 1 and 1, we start with the numbers 2 and 1. Thus the third Lucas number is 3. The fourth Lucas number is 4. The fifth Lucas number is 7. Thus, the first few Lucas numbers are 2, 1, 3, 4, 7, 11, 18, 29, 47, 76, 123, …. This sequence of numbers is called the Lucas sequence. These numbers are generated using MATLAB interactively as follows:

# Generalizations of Fibonacci Numbers

# Random Fibonacci Numbers References

# MATLAB Books

# Books on Fibonacci Numbers

# Web Links for Fibonacci Numbers

# Installation of MATLAB

# Footnotes

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