**Book conventions**

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**A group of animals with text

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**Order of operations**

**PEMDAS**: parentheses, exponents, multiplication, division, addition, and subtraction

**Expressing dependent and independent variables in a function**

You can use *y = 2x + 1* or *f(x) = 2x + 1* to express the dependent variable *y* as a function of *x*.

If you have *two independent variables* you write the function like *f(x, y) = 2x + 3y*. In this function two independent variables *x* and *y* and one dependent variable the output of *f(x, y)*. The graph of this function will be plotted on three dimensions to produce a plane of values rather than a line.

**Cartesian plane, x-y plane, coordinate plane**

When we plot on a two-dimensional plane with two number lines (one for each variable) it is known as a *Cartesian plane*, *x-y plane*, or *coordinate plane*. По-русски: *прямоугольная система координат* или *Декартова система*. We trace a given x-value and then look up the corresponding y-value, and plot the intersections

as a line.

Example of a Cartesian plane:

A graph of a line in a graph

Description automatically generated

Notice that due to the nature of real numbers (or decimals, if you prefer), there are an infinite number of x values. This is why when we plot the function f(x) we get a continuous line with no breaks in it. There are an infinite number of points on that line, or any part of that line.

**Straight-line function / straight-line graph**

This is a straight-line *f(x) = 2x + 1*:

A graph of a function

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**Parabola function / parabola graph**

This is a parabola *f(x) = x2 + 1*:

A graph of a function

Description automatically generated

It is continuous but not linear. It does not produce values in a straight line. When a function is continuous but curvy, rather than linear and straight, we call it a *curvilinear function*.

**Summation symbol sigma Σ**

If I want to iterate the numbers 1 through 5, multiply each by 2, and sum them, here is how I would express that using a summation

A number with numbers and a plus two

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**Exponents**

23 2 is the base and 3 is the exponent (number of times 2 should be multiplied by 2: 2 \* 2 \* 2)

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When we multiply exponents together with the same base, we simply add the exponents, which is known as the *product rule*:



Division:

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A math equations with numbers and symbols

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A black and white image of a mathematical equation

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**Roots**

A  asks “What number multiplied by itself will give me 4?” which of course is 2. Note here that 41/2 is the same as 4:

41/2 =  = 2

Cubed roots are similar to square roots, but they seek a number multiplied by itself three times to give a result. A cubed root of 8 is expressed as  and asks “What number multiplied by itself three times gives me 8?” This number would be 2 because 2 \* 2 \* 2 = 8.

A math equation with numbers and equations

Description automatically generated with medium confidencepower rule

A number and equal sign

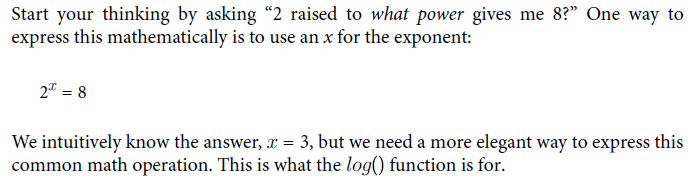
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A black and white image of a mathematical equation

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**Logarithms *log()***

A logarithm is a math function that finds a power for a specific number and base.





A math equations on a white background

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Algebraically speaking, this is a way of isolating the *x*, which is important to solve for *x*.

**Properties for exponents and logarithms**

A math equations on a white background

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**Natural logarithms *log() ln()***

When we use *e* as our base for a logarithm, we call it a *natural logarithm*.



However, in Python, a natural logarithm is specified by the log() function. As discussed earlier, the default base for the log() function is *e*. Just leave the second argument for the base empty and it will default to using *e* as the base

**Function that approaches 0 but never reaches 0 *lim***

A graph of a function

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**Derivatives**



A math equations with numbers

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**Partial derivatives**

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**The chain rule**

Finding the derivative of *z* with respect to *x*:

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Description automatically generated with medium confidence A mathematical equation with numbers

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This is the chain rule, which says that for a given function *y* (with input variable *x*) composed into another function *z* (with input variable *y*), we can find the derivative of *z* with respect to *x* by multiplying the two respective derivatives together:

A mathematical equation with black text

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The chain rule is a key part of training a neural network with the proper weights and biases. Rather than untangle the derivative of each node in a nested onion fashion, we can multiply the derivatives across each node instead, which is mathematically a lot easier.

**Integrals**

The opposite of a derivative is an integral, which finds the area under the curve for a given range.

Packing rectangles under a curve to approximate area:

A graph on a grid

Description automatically generated

**Riemann sums**

Khan Academy has a great [article](https://www.khanacademy.org/math/ap-calculus-ab/ab-integration-new/ab-6-3/a/definite-integral-as-the-limit-of-a-riemann-sum) explaining how to use limits for Reimann Sums.

**Probability**

Probability is how strongly we believe an event will happen, often expressed as a percentage.

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**Probability** is about quantifying predictions of events yet to happen, whereas **likelihood** is measuring the frequency of events that already occurred. In statistics and machine learning, we often use **likelihood** (the past) in the form of data to predict **probability** (the future).

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Convert probability into odds:

A math equations with numbers

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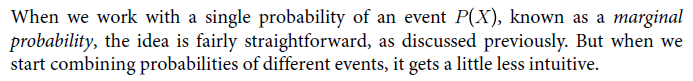
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Probability is purely theoretical of how likely an event is to happen and does not require data. Statistics, on the other hand, cannot exist without data and uses it to discover probability and provides tools to describe data.

Think of predicting the outcome of rolling a 4 on a die (that’s the singular of dice). Approaching the problem with a pure probability mindset, one simply says there are six sides on a die. We assume each side is equally likely, so the probability of getting a 4 is 1/6, or 16.666%. However, a zealous statistician might say, “No! We need to roll the die to get data. If we can get 30 rolls or more, and the more rolls we do the better, only then will we have data to determine the probability of getting a 4.” This approach may seem silly if we assume the die is fair, but what if it’s not? If that’s the case, collecting data is the only way to discover the probability of rolling a 4.

**Marginal probability**



**Joint probability**

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A math problem with numbers and equations

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A close-up of text

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**Union probability**

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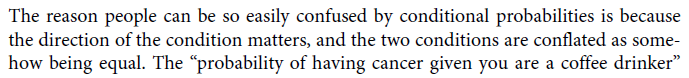
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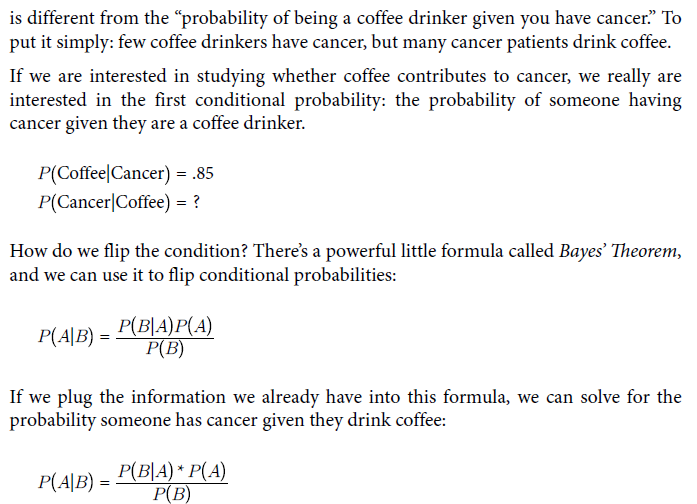
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**Conditional Probability and Bayes’ Theorem**

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**Joint and union conditional probabilities**

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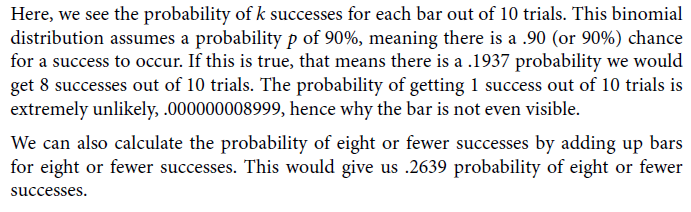
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**Binomial Distribution**

Binomial distribution measures how likely *k* successes can happen out of *n* trials given *p* probability. Visually it looks like:

A graph of a number of individuals

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**Beta T-Distribution**

A close up of text

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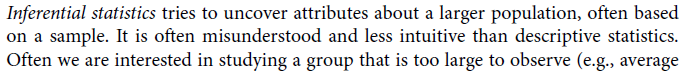
**Descriptive and Inferential Statistics**

**Descriptive statistics:**

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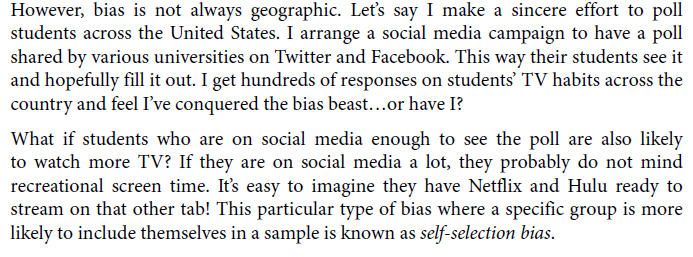
**Inferential statistics:**



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**Self-selection bias:**



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**Confirmation bias:**

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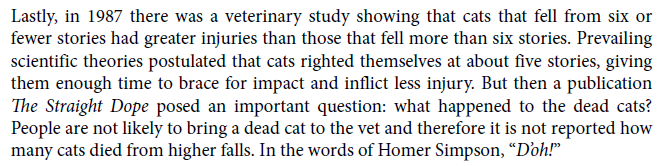
**Survival bias:**

A text on a page

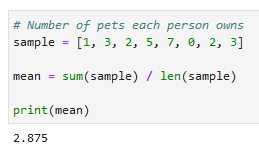
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A cartoon of a stick figure standing on a table with money bags

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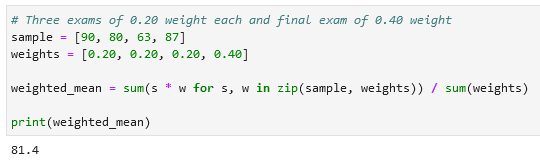
**Mean**

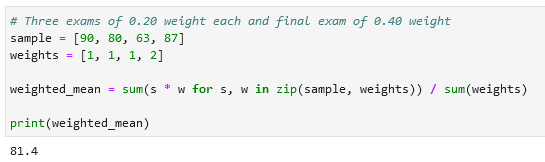


A math equations and numbers

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**Weighted mean**

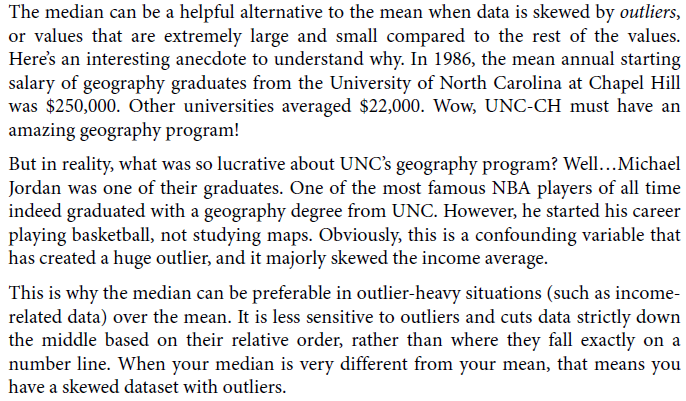




**Median**

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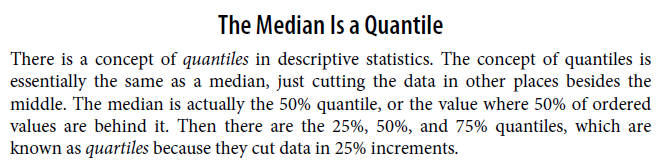
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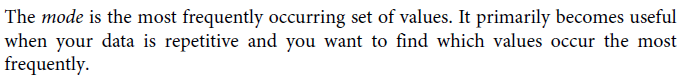
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**Quantiles**



**Mode**





Calculate mode (use functions like from collections import defaultdict(lambda: 0):

A screenshot of a computer code

Description automatically generated

A defaultdict is a dictionary-like object that allows you to set a default value for keys that don't exist in the dictionary. This can be especially useful when you're counting occurrences of elements, like in your mode function.

A screenshot of a computer code

Description automatically generated

**Population variance and standard deviation**

**Population variance**

Variance is a measure of how spread out our data is.

A screenshot of a number of pets

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A graph of a graph with green dots and black text

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**Calculate variance:**

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**Population standard deviation**

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**Calculate population standard deviation:**

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**Sample variance and standard deviation**

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Description automatically generated

**Calculate sample variance and sample standard deviation:**

A screenshot of a computer code

Description automatically generated

Both variance and standard deviation have increased when we treated them as a population and not a sample. This is correct as a sample could be biased and imperfect representing the population. Therefore, we increase the variance (and thus the standard deviation) to increase our estimate of how spread out the values are. A larger variance/standard deviation shows less confidence with a larger range.

**The Normal Distribution**

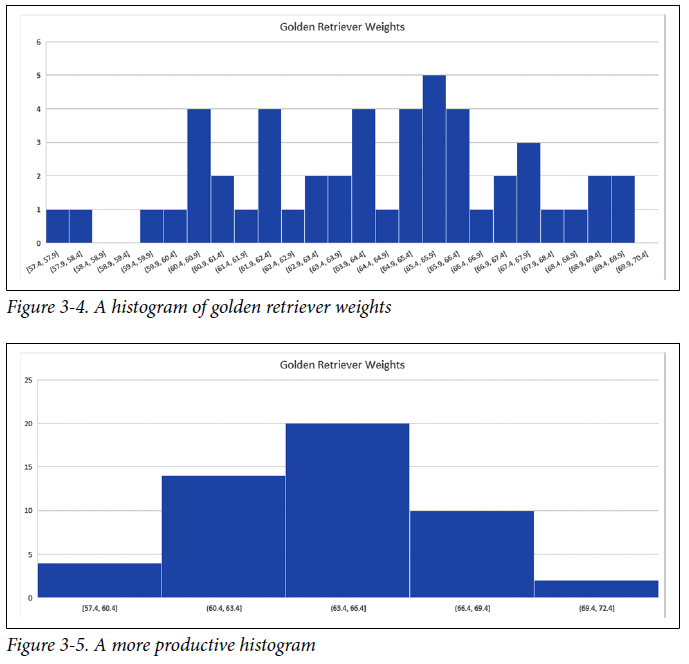
We touched on probability distributions in the last chapter, particularly the binomial distribution and beta distribution. However the most famous distribution of all is the normal distribution. The normal distribution, also known as the Gaussian distribution, is a symmetrical bell-shaped distribution that has most mass around the mean, and its spread is defined as a standard deviation. The “tails” on either side become thinner as you move away from the mean.

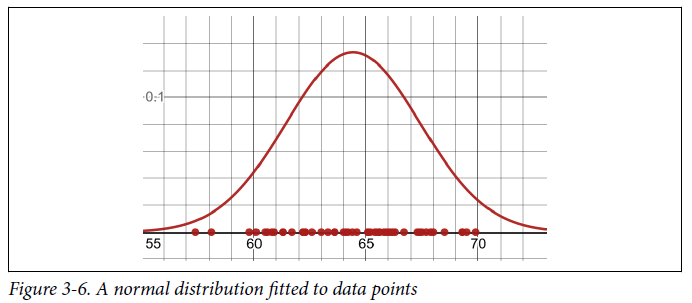
A graph with a red line

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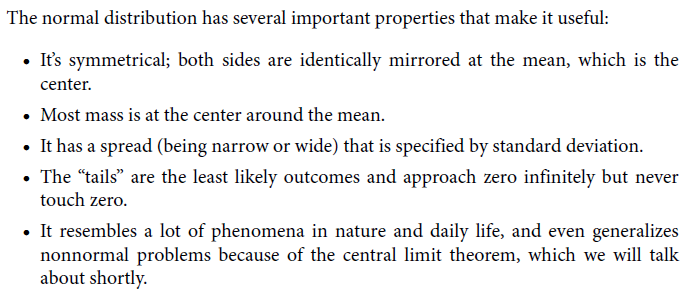
A screenshot of a computer

Description automatically generated

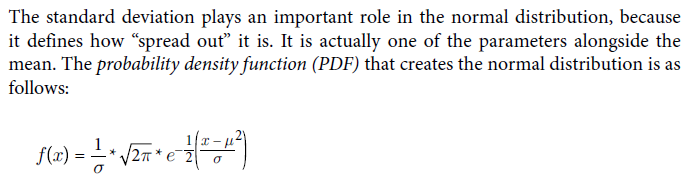


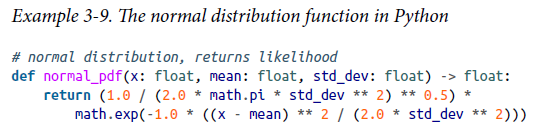


**Properties of a normal distribution**



**The Probability Density Function (PDF)**

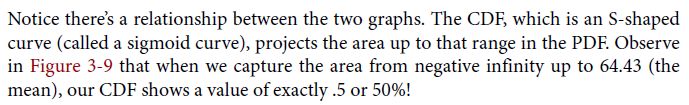


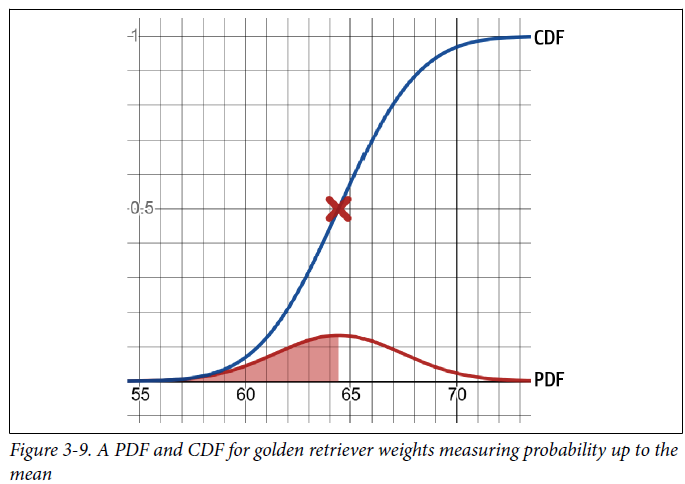


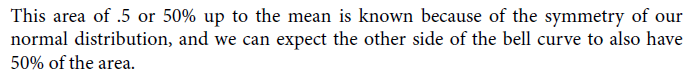
**The Cumulative Distribution Function (CDF)**

A graph with a red line

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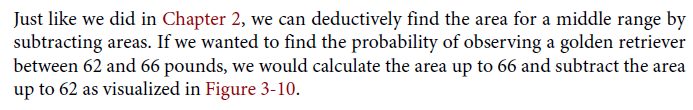




**Calculate the normal distribution CDF in Python using scipy.stats and norm.cdf:**

A screenshot of a computer program

Description automatically generated



A diagram of a function

Description automatically generated

A computer screen shot of a program

Description automatically generated

