

# STATISTICS FUNDAMENTALS

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## STATISTICS FUNDAMENTALS

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# LEARNING OBJECTIVES

- ▶ Use NumPy and Pandas libraries to analyze datasets using basic summary statistics: mean, median, mode, max, min, quartile, inter-quartile range, variance, standard deviation, and correlation
- ▶ Create data visualizations - including: line graphs, box plots, and histograms- to discern characteristics and trends in a dataset
- ▶ Identify a normal distribution within a dataset using summary statistics and visualization
- ▶ ID variable types and complete dummy coding by hand

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**COURSE**

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# PRE-WORK

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## **PRE-WORK REVIEW**

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- ▶ Create and open an iPython Notebook
- ▶ Complete the Python pre-work

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**OPENING**

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# STATISTICS FUNDAMENTALS

# LET'S REVIEW THE DATA SCIENCE WORKFLOW

The steps:

1. Identify the problem
2. Acquire the data
3. Parse the data
4. Mine the data
5. Refine the data
6. Build a data model
7. Present the results



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# TODAY

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- ▶ We're going to begin to talk about step 3: Parsing the Data
- ▶ We'll begin to talk about the fundamentals of Statistics

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## INTRODUCTION

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# LAYING THE GROUND WORK



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## **WE'RE GOING TO COVER SEVERAL TOPICS**

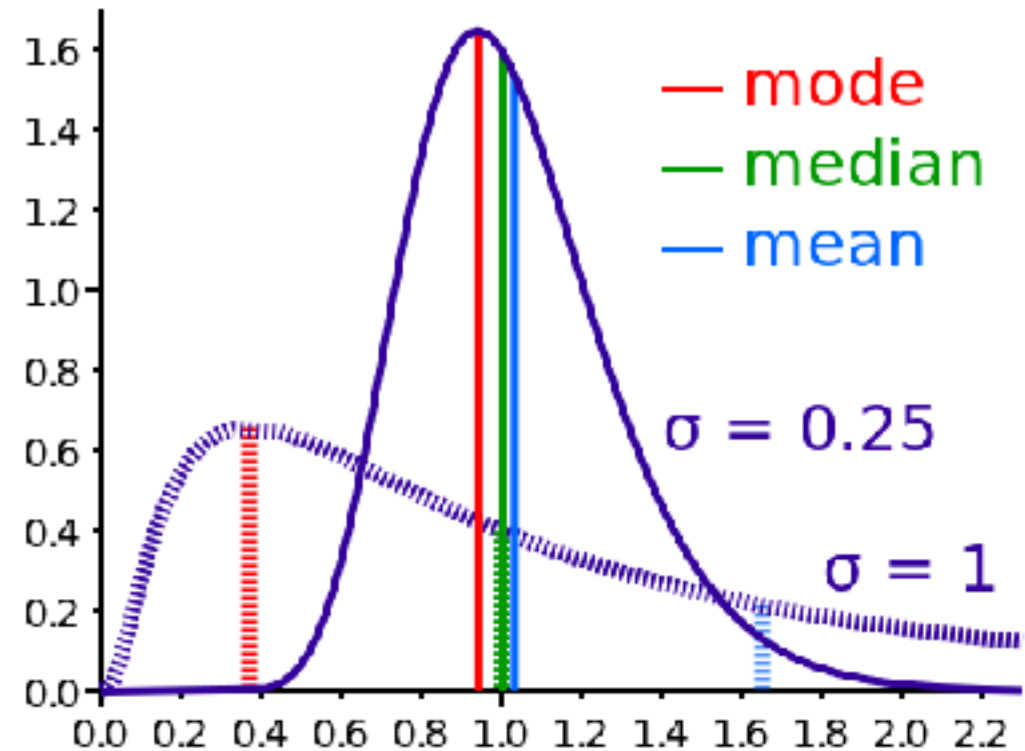
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- ▶ Measures of Central Tendency
  - ▶ Mean
  - ▶ Median
  - ▶ Mode
- ▶ Measures of Dispersion
  - ▶ Interquartile Range
  - ▶ Variance
  - ▶ Standard Deviation
- ▶ Max
- ▶ Min
- ▶ Quartile
- ▶ Correlation

# MEAN

- ▶ The mean of a set of values is the sum of the values divided by the number of values. It is also called the average.

$$\overline{X} = \frac{\sum X}{N}$$



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## MEAN EXAMPLE

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- Find the mean of 19, 13, 15, 25, and 18.

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## MEAN EXAMPLE

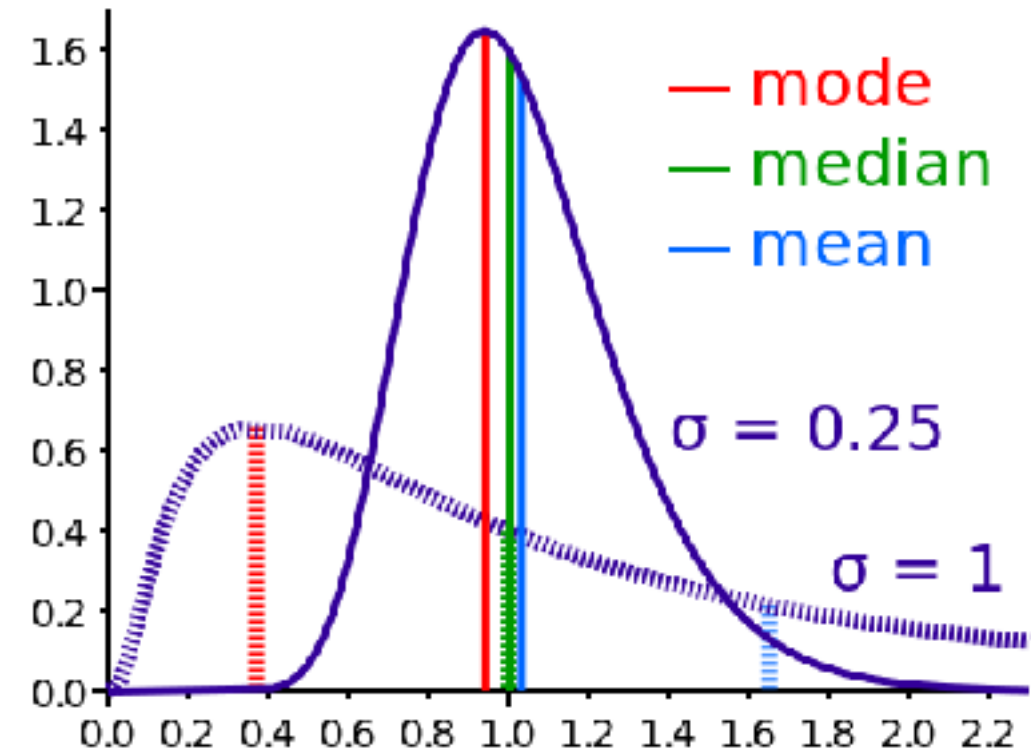
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- Find the mean of 19, 13, 15, 25, and 18.

$$\frac{19 + 13 + 15 + 25 + 18}{5} = \frac{90}{5} = 18$$

# MEDIAN

- ▶ The median refers to the midpoint in a series of numbers.
- ▶ To find the median
  - ▶ Arrange the numbers in order smallest to largest.
  - ▶ If there is an odd number of values, the middle value is the median.
  - ▶ If there is an even number of values, the average of the middle two values is the median.



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## **MEDIAN EXAMPLE**

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- ▶ Find the median of 19, 29, 36, 15, and 20.

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## MEDIAN EXAMPLE

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- Find the median of 19, 29, 36, 15, and 20.

Ordered Values:

15, 19, 20, 29, 36

20 is the median

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## **MEDIAN EXAMPLE**

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- ▶ Find the median of 67, 28, 92, 37, 81, 75.



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## MEDIAN EXAMPLE

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- Find the median of 67, 28, 92, 37, 81, 75.

Ordered Values:

28, 37, 67, 75, 81, 92

67 and 75 are the middle values.

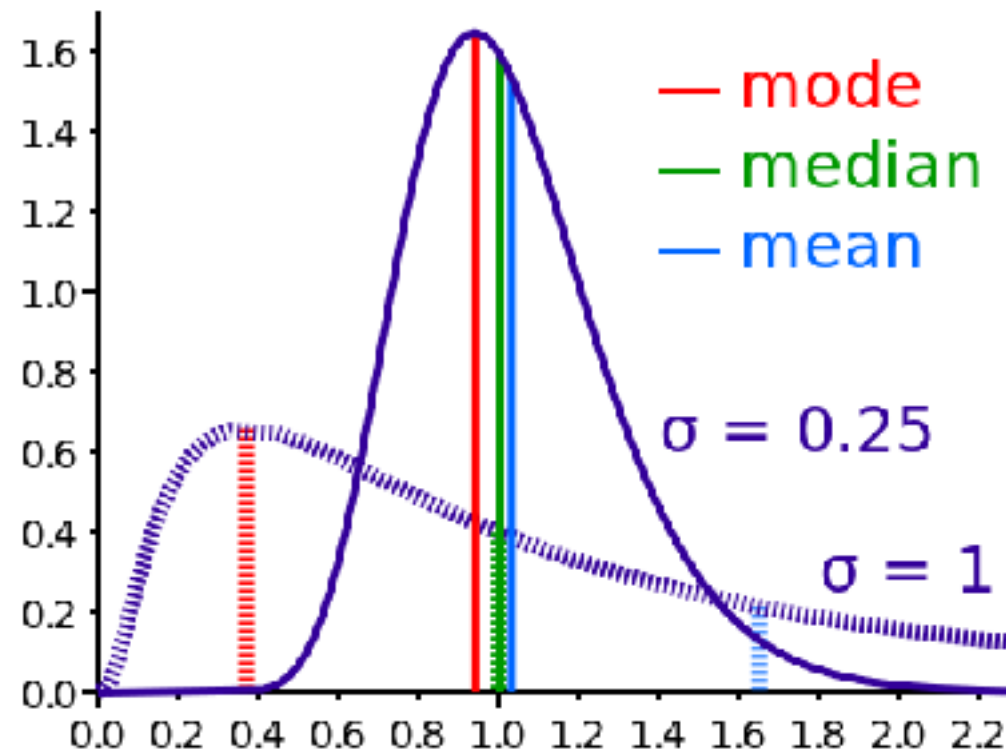
$$\frac{67 + 75}{2} = \frac{142}{2} = 71$$

71 is the median.

# MODE

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- ▶ The mode of a set of values is the value that occurs most often.
- ▶ A set of values may have more than one mode or no mode.



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## MODE EXAMPLE

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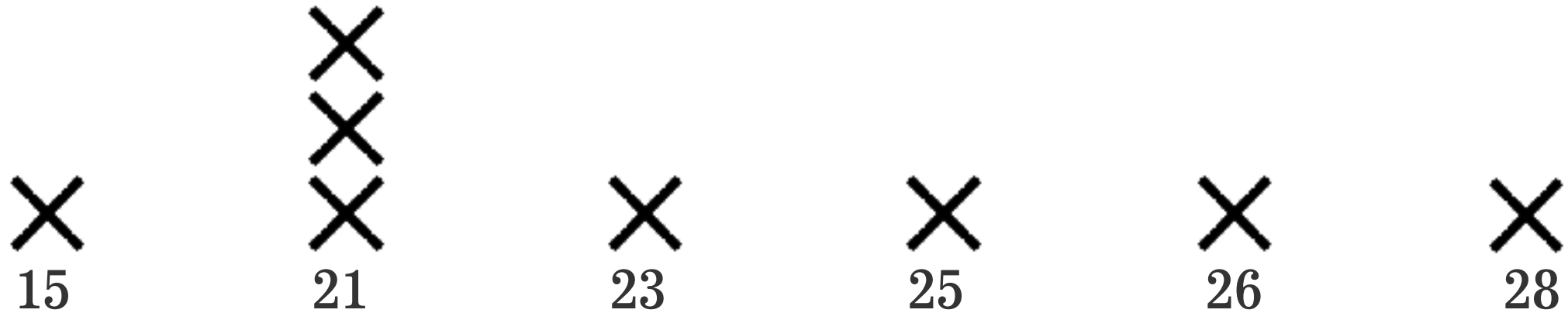
- Find the mode of 15, 21, 26, 25, 21, 23, 28, and 21.

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## MODE EXAMPLE

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► Find the mode of 15, 21, 26, 25, 21, 23, 28, and 21.



21 is the mode because it occurs most frequently

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## **MODE EXAMPLE**

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- ▶ Find the mode of 12, 15, 18, 26, 15, 9, 12, and 27.

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## MODE EXAMPLE

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► Find the mode of 12, 15, 18, 26, 15, 9, 12, and 27.



12 and 15 are the modes since the both occur twice.

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## MODE EXAMPLE

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- Find the mode of 4, 8, 15, 21, and 23.

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## MODE EXAMPLE

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► Find the mode of 4, 8, 15, 21, and 23.

×

4

×

8

×

15

×

21

×

23

There is no mode since all values occur the same number of times.



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# ACTIVITY: KNOWLEDGE CHECK

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## EXERCISE

### ANSWER THE FOLLOWING QUESTIONS (5 minutes)

1. For the following groups of numbers, calculate the mean, median and mode by hand. Also determine the min and max.
  - a. 18, 24, 17, 21, 24, 16, 29, 18
  - b. 75, 87, 49, 68, 75, 84, 98, 92
  - c. 55, 47, 38, 66, 56, 64, 44, 39

### DELIVERABLE

Answers to the above questions

**CODEALONG**

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# SUMMARY STATISTICS IN PANDAS

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## **CODEALONG: SUMMARY STATISTICS IN PANDAS**

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- ▶ Open the starter-code notebook located in `lessons/lesson-03/code/` starter-code of the class repo.

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## CODEALONG PART 1: BASIC STATS

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► We can use Pandas to calculate the mean, median, mode, min, and max.

Methods available include:

`.min()` - Compute minimum value

`.max()` - Compute maximum value

`.mean()` - Compute mean value

`.median()` - Compute median value

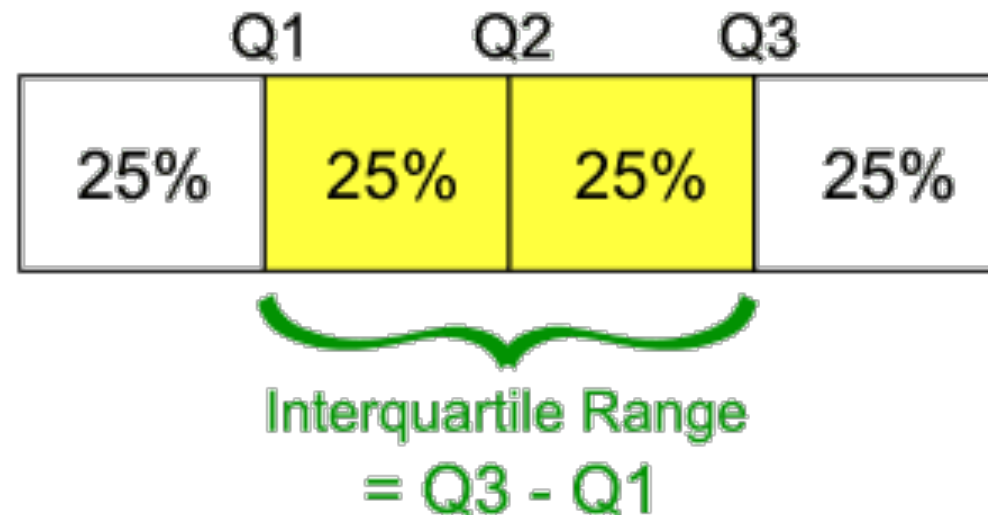
`.mode()` - Compute mode value

`.count()` - Count the number of observations

## QUARTILES AND INTERQUARTILE RANGE

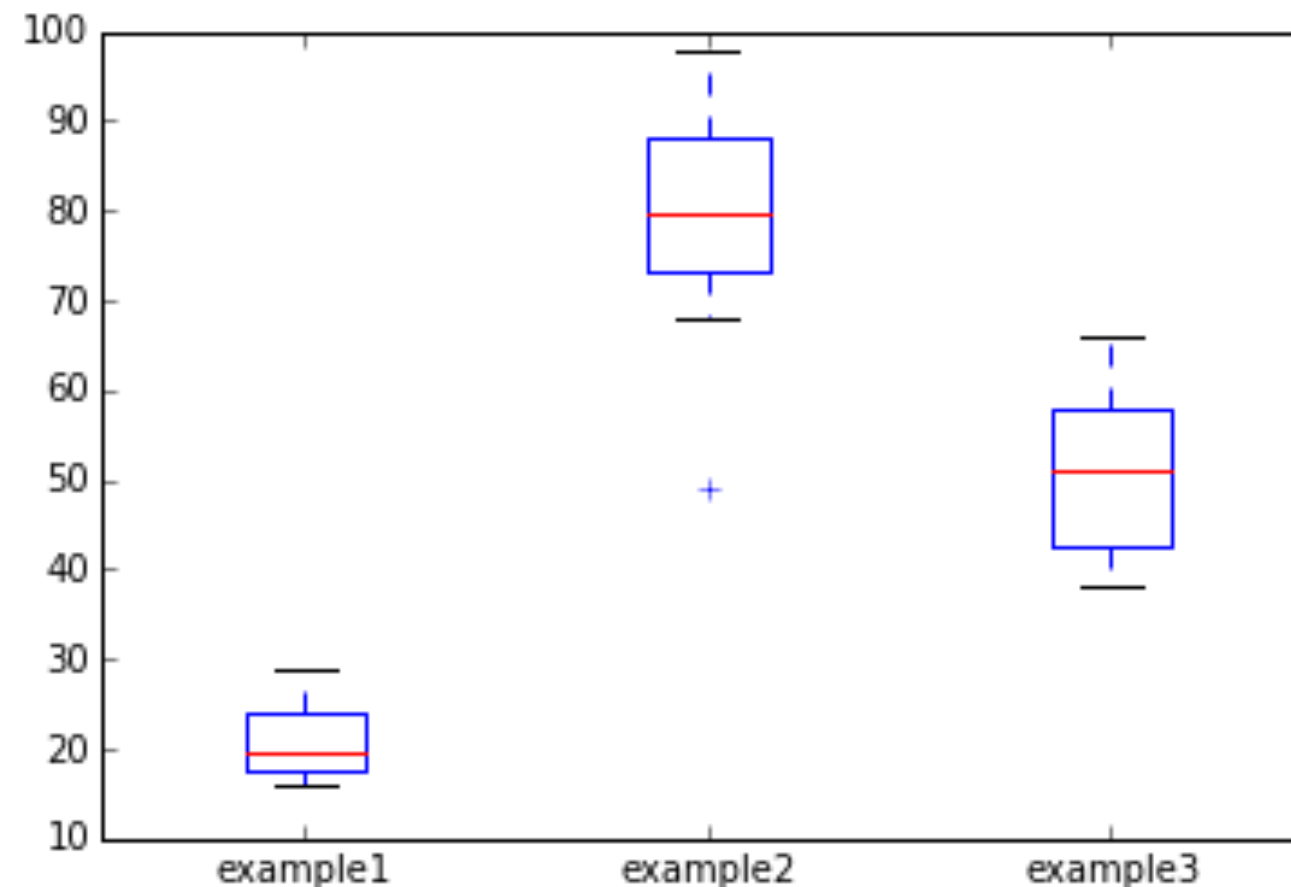
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- ▶ Quartiles divide a rank-ordered data set into four equal parts.
- ▶ The values that divide each part are called first, second, and third quartiles, denoted  $Q1$ ,  $Q2$ , and  $Q3$ , respectively.
- ▶ The interquartile range (IQR) is  $Q3 - Q1$ , a measure of variability.



## CODEALONG PART 2: BOX PLOT

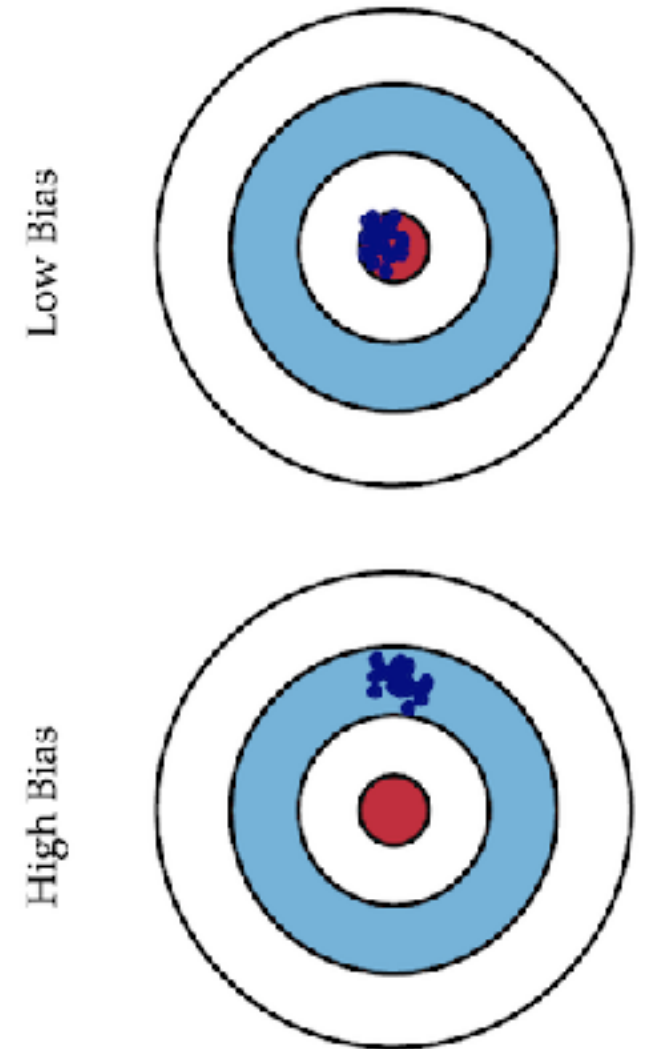
- Box plots give a nice visual of min, max, mean, median, and the quartile and interquartile range.



## BIAS VS. VARIANCE

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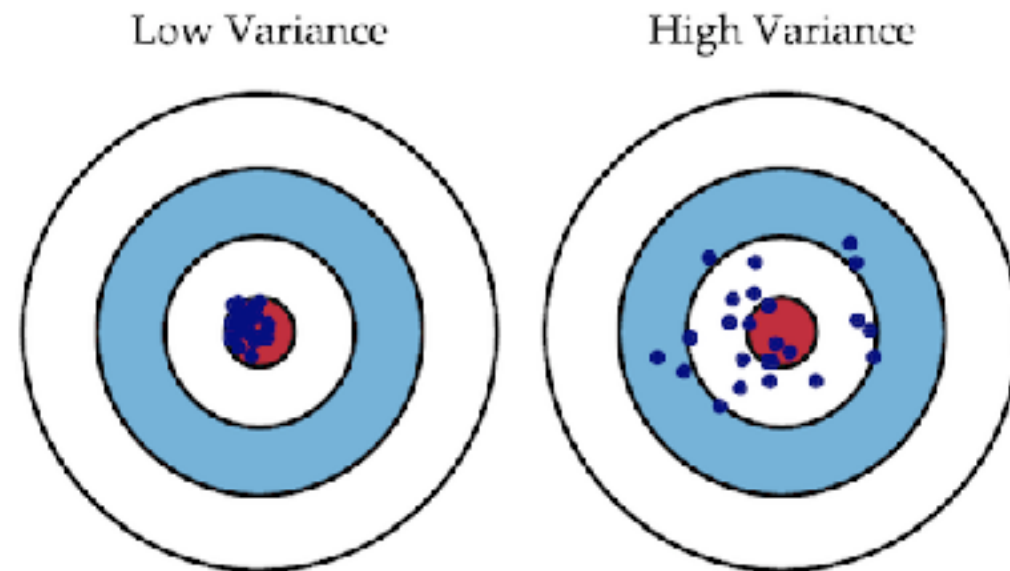
- ▶ Error due to **bias** is calculated at the difference between the *expected prediction* of our model and the *correct value* we are trying to predict.
- ▶ Imagine creating multiple models on various datasets. **Bias** measures *how far off in general* models' predictions are from the correct value.



## BIAS VS. VARIANCE

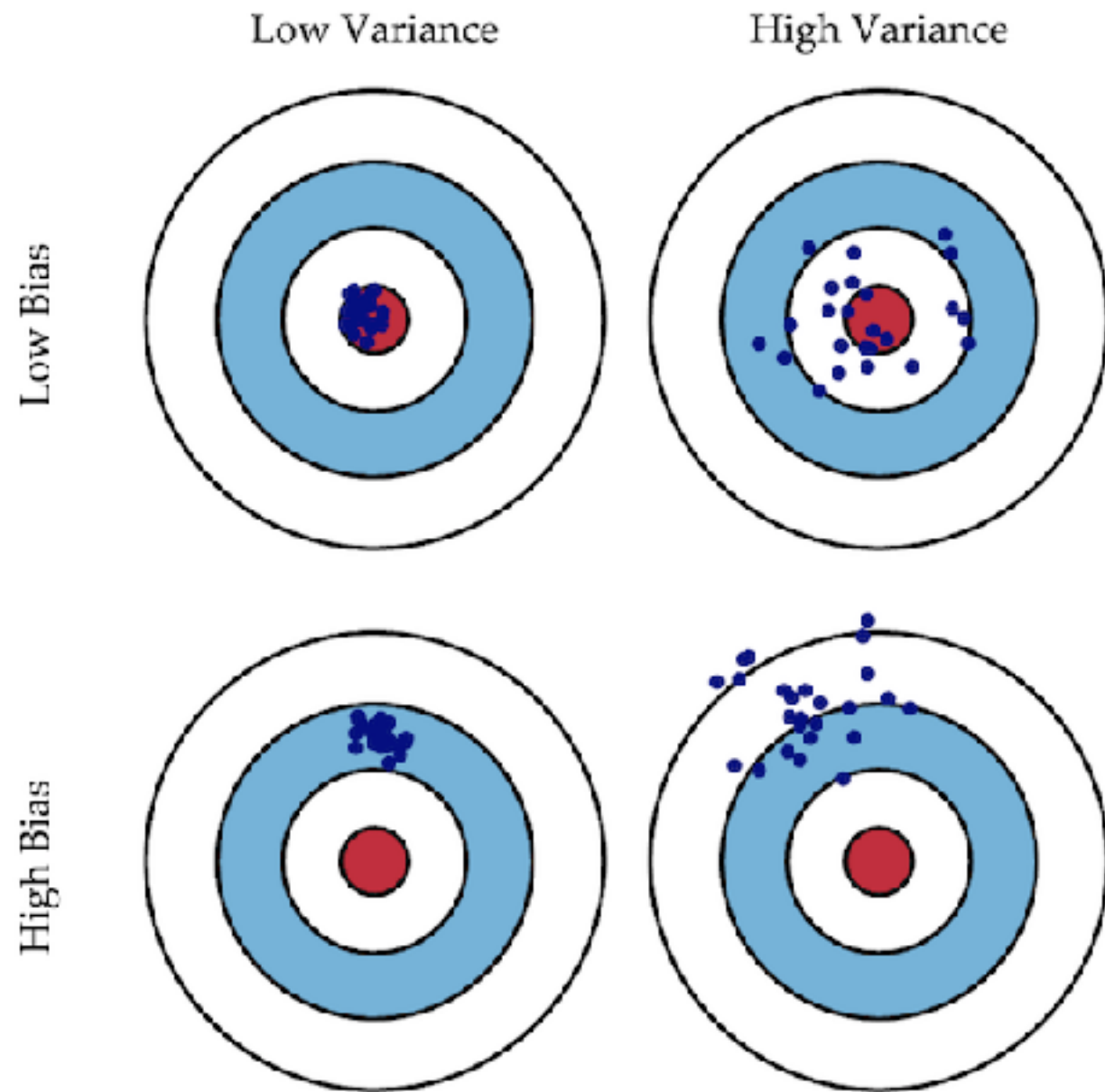
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- ▶ Error due to **variance** is taken as the variability of a model prediction for a given point.
- ▶ Imagine creating multiple models on various datasets. The **variance** is *how much the predictions for a given point vary* between different realizations of the model.





# BIAS VS. VARIANCE



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## STANDARD DEVIATION

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- ▶ Standard deviation (SD,  $\sigma$  for population,  $s$  for sample) is a measure that is used to quantify the amount of variation or dispersion of a set of data values.
- ▶ Standard deviation is the square root of variance.

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

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## STANDARD ERROR

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- ▶ The standard error of the mean (SEM) quantifies the precision of the mean.
- ▶ It is a measure of how far your sample mean is likely to be from the true population mean.
- ▶ It generally increases with the size of an estimate, meaning a large standard error may not indicate the estimate of the mean is unreliable.
- ▶ It's often better to compare the error in relation to the size of the estimate.

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## STANDARD ERROR

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$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

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## CODEALONG PART 3: STANDARD DEVIATION & VARIANCE

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► You can calculate variance and standard deviation easily in Pandas.

Methods include:

`.std()` - Compute Standard Deviation

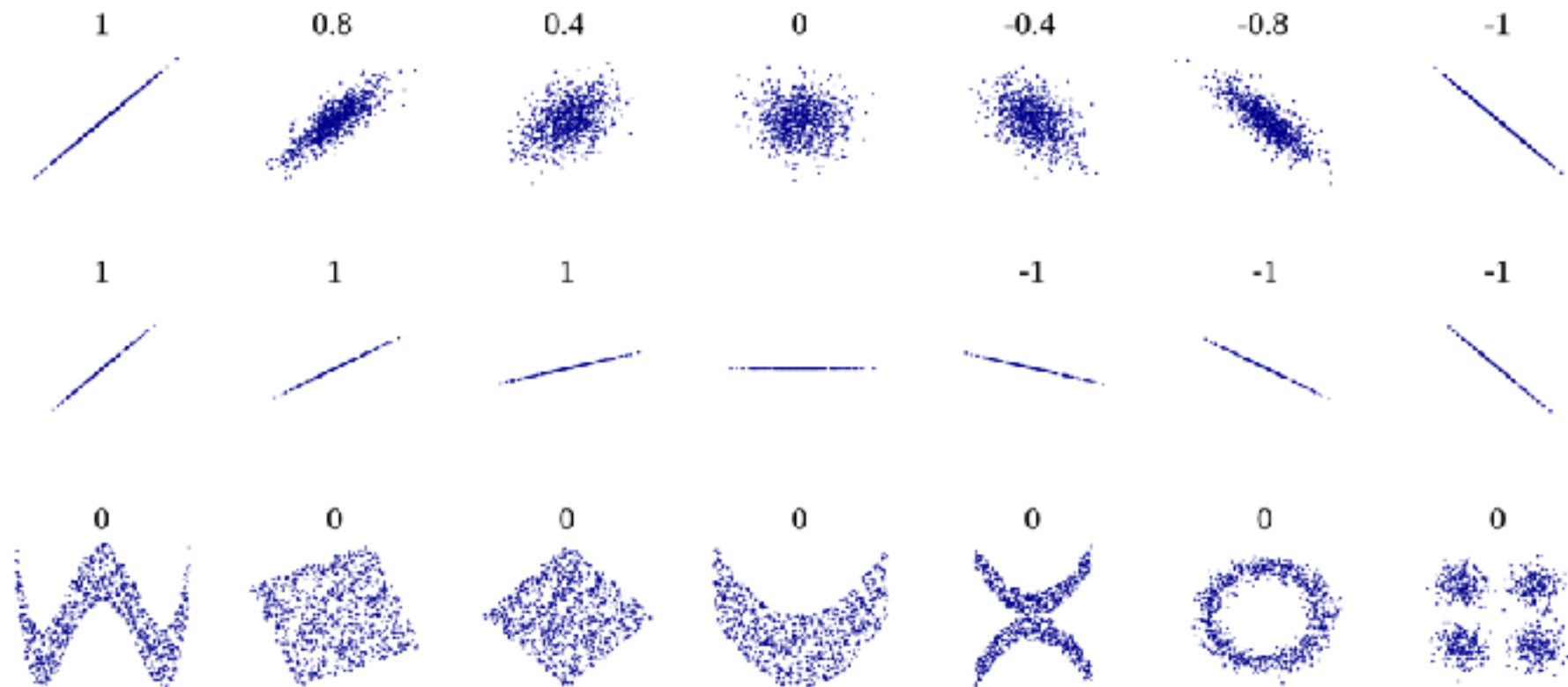
`.var()` - Compute variance

`.describe()` - short cut that prints out count, mean, std, min, quartiles, max

# CORRELATION

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- ▶ The correlation measures the extent of interdependence of variable quantities.
- ▶ Example correlation values



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## CONTEXT

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- ▶ For most projects, descriptive stats will come first. These help you get to know your dataset better.
- ▶ Sometimes, descriptive stats may be all you need to answer your question.

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## INTRODUCTION

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# IS THIS NORMAL?



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## THE NORMAL DISTRIBUTION

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- ▶ A normal distribution is often a key assumption to many models.
- ▶ The normal distribution depends upon the *mean* and the *standard deviation*.
- ▶ The *mean* determines the center of the distribution. The *standard deviation* determines the height and width of the distribution.

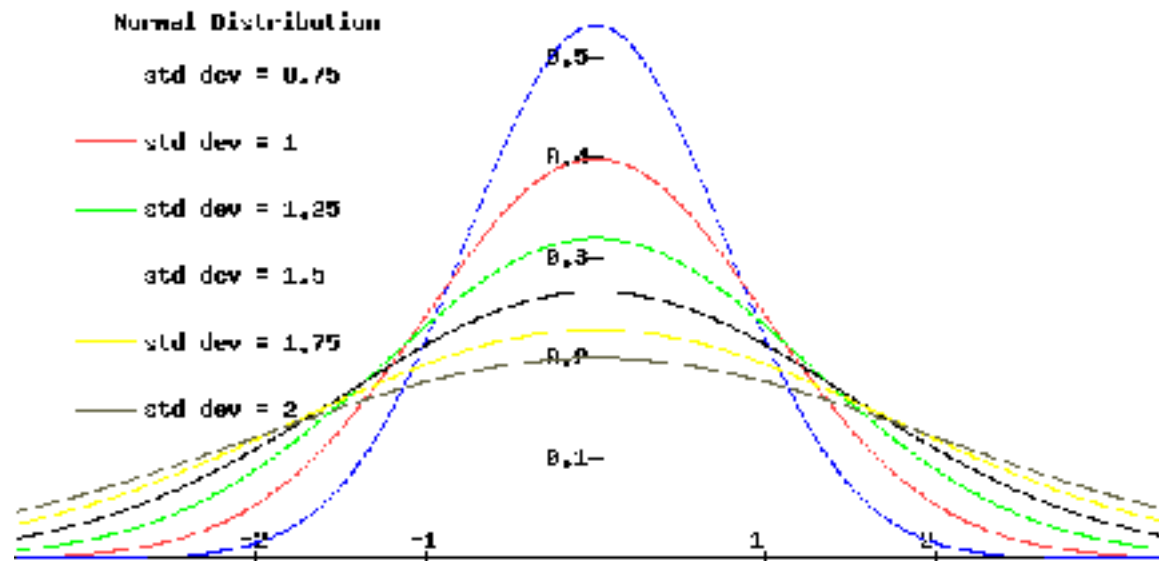


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# THE NORMAL DISTRIBUTION

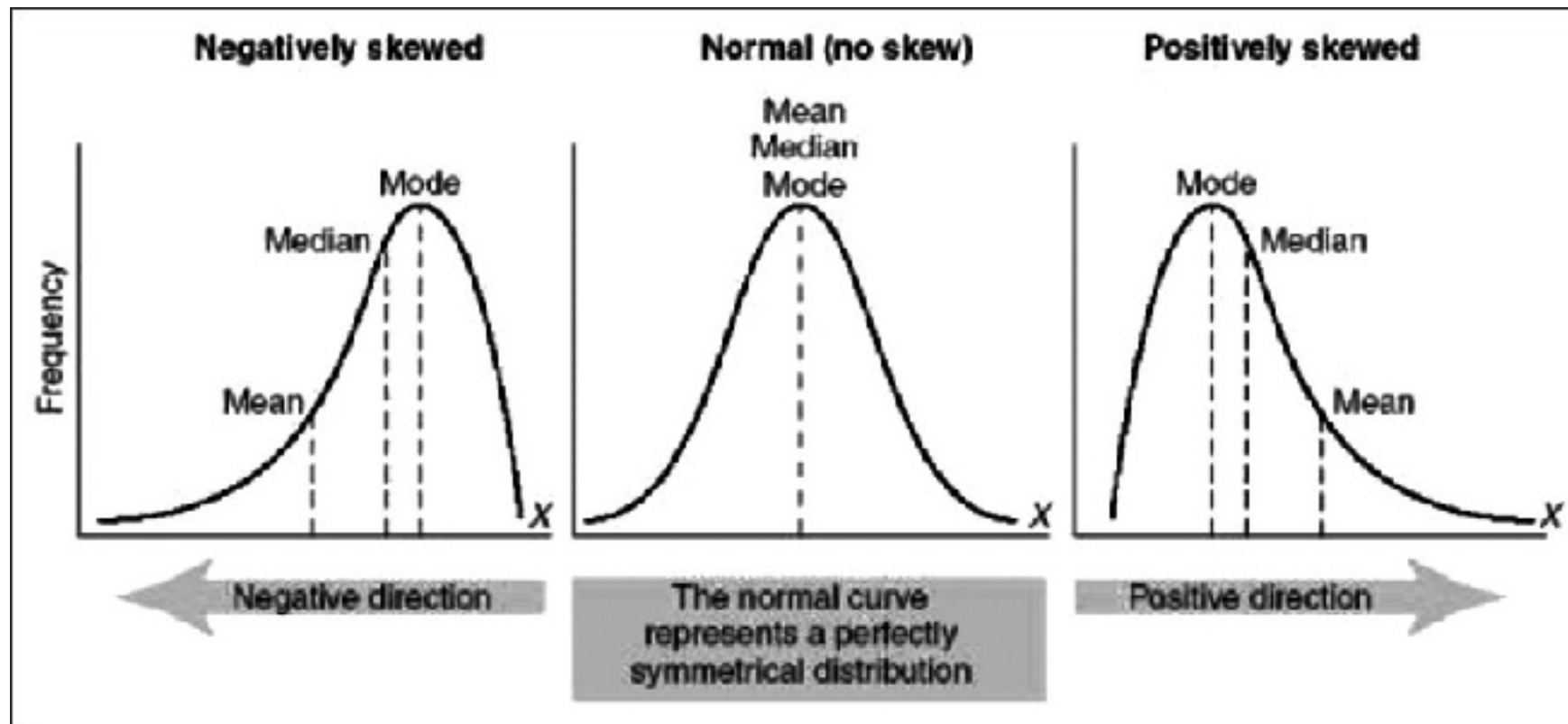
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- ▶ Normal distributions are symmetric, bell-shaped curves.
- ▶ When the standard deviation is large, the curve is short and wide.
- ▶ When the standard deviation is small, the curve is tall and narrow.



# SKEWNESS

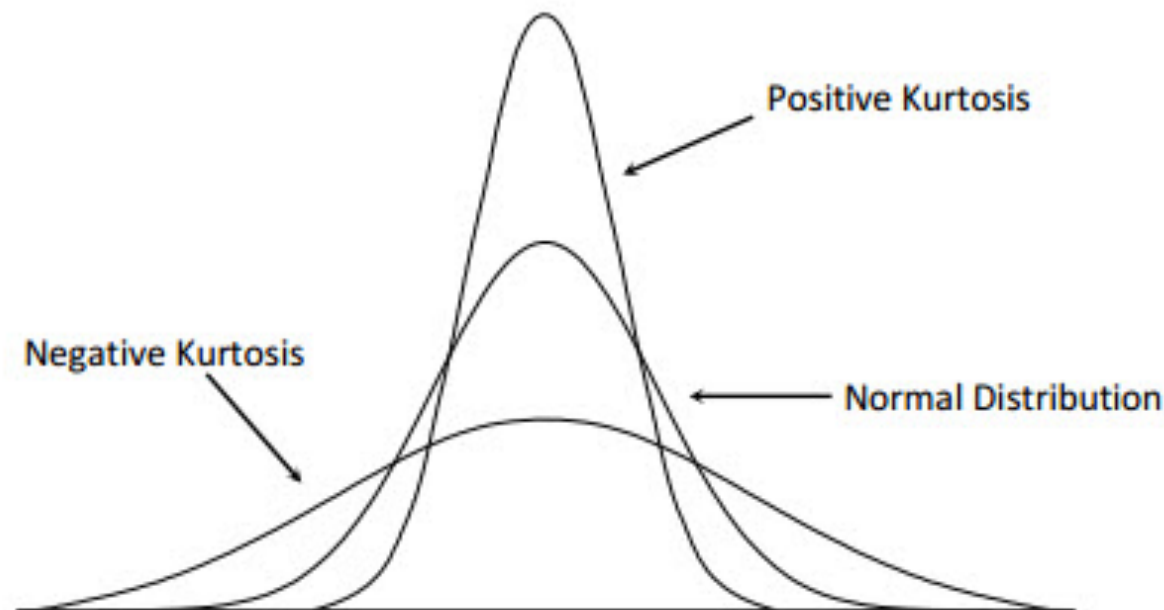
- ▶ Skewness is a measure of the asymmetry of the distribution of a random variable about its mean.
- ▶ Skewness can be positive or negative, or even undefined.



# KURTOSIS

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- ▶ Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution.
- ▶ Datasets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have **heavy tails**.



**DEMO**

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# **DETERMINING THE DISTRIBUTION OF YOUR DATA**

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## **DETERMINING THE DISTRIBUTION OF YOUR DATA**

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- ▶ Follow along as we walk through this in an iPython Notebook.

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## GUIDED PRACTICE

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# IS THIS SKEWED?

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# ACTIVITY: IS THIS SKEWED?

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## EXERCISE

### DIRECTIONS (10 minutes)

1. We're going to walk through several images of datasets.
2. For each image, vote on whether the image is:
  - a. Normal
  - b. Positively, negatively, or not skewed
  - c. Has positive, negative, or zero kurtosis
3. Determine how you would correct the issue with each dataset to return it to the normal distribution.



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## INTRODUCTION

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# VARIABLE TYPES

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## VARIABLE TYPES

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- ▶ Numeric variables can take on a large range of non-predetermined, quantitative values. These are things such as height, income, etc.
- ▶ Categorical variables can take on a specific set of variables. These are things such as race, gender, paint colors, movie titles, etc.

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**DEMO**

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# CLASSES

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## CLASS/DUMMY VARIABLES

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- ▶ Let's say we have the categorical variable area, which takes on one of the following values: rural, suburban, and urban.
- ▶ We need to represent these numerically for a model. So how do we code them?

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## CLASS/DUMMY VARIABLES

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► How about  $0=\text{rural}$ ,  $1=\text{suburban}$ , and  $2=\text{urban}$ ?

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## CLASS/DUMMY VARIABLES

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- ▶ But this implies an ordered relationship - is urban **twice** suburban?  
That doesn't make sense.
- ▶ However, we can represent this information by converting the one area variable into two new variables:  
  
area\_urban and area\_suburban.

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## CLASS/DUMMY VARIABLES

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- ▶ We'll draw out how categorical variables can be represented without implying order.
- ▶ First, let's choose a reference category. This will be our “base” category.
- ▶ It's often good to choose the category with the largest sample size and a criteria that will help model interpretation. If we are testing for a disease, the reference category would be people without the disease.

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## CLASS/DUMMY VARIABLES

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- ▶ Step 1: Select a reference category. We'll choose `rural` as our reference category.
- ▶ Step 2: Convert the values `urban`, `suburban`, and `urban` into a numeric representation that does not imply order.
- ▶ Step 3: Create two new variables: `area_urban` and `area_suburban`.



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## CLASS/DUMMY VARIABLES

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- ▶ Why do we need only two dummy variables?

rural	urban	suburban
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- ▶ We can derive all of the possible values from these two. If an area isn't urban or suburban, we know it must be rural.
- ▶ In general, if you have a categorical feature with  $k$  categories, you need to create  $k-1$  dummy variable to represent all of the information.

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## CLASS/DUMMY VARIABLES

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- ▶ Let's see our dummy variables.

	area_urban	area_suburban
rural	0	0
suburban	0	1
urban	1	0

- ▶ As mentioned before, if we know  $\text{area\_urban}=0$  and  $\text{area\_suburban}=0$ , then the area must be rural.

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## CLASS/DUMMY VARIABLES

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- ▶ We can do this for a gender variable with two categories: male and female.
- ▶ How many dummy variables need to be created?

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## CLASS/DUMMY VARIABLES

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► # of categories - 1 = 2 - 1 = 1

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## CLASS/DUMMY VARIABLES

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- ▶ We will make `female` our reference category. Thus, `female=0` and `male=1`.

	<code>gender_male</code>
<code>female</code>	<code>0</code>
<code>male</code>	<code>1</code>

- ▶ This can be done in Pandas with the `get_dummies` method.

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**INDEPENDENT PRACTICE**

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# DUMMY COLORS

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# ACTIVITY: DUMMY COLORS

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## EXERCISE

### DIRECTIONS (15 minutes)

It's important to understand the concept before we use the Pandas function `get_dummies` to create dummy variables. So today, we'll create our dummy variables by hand.

1. Draw a table like the one on the white board.
2. Create dummy variables for the variable “colors” that has 6 categories: blue, red, green, purple, grey, and brown. Use grey as the reference.

### DELIVERABLE

Dummy variables table for colors

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**CONCLUSION**

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# TOPIC REVIEW



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## REVIEW

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- ▶ Let's go through the process for creating dummy variables for “colors”.
- ▶ We talked about several different types of summary statistics, what are they?
- ▶ We covered several different types of visualizations; which ones?
- ▶ We talked about the normal distribution; how do we determine your data's distribution?
- ▶ Any other questions?

**COURSE**

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**BEFORE NEXT CLASS**

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## **BEFORE NEXT CLASS**

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# **DUE DATE**

► Project: Unit Project 1 due on **Wednesday, November 8th.**

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**LESSON**

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**Q & A**

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**LESSON**

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# EXIT TICKET

**DON'T FORGET TO FILL OUT YOUR EXIT TICKET**