

# Module 1: Exploratory Data Analysis in One Dimension

# Overview

- This module will introduce you to vectorized data structures and the Pandas library.
- You will learn how to explore single dimensional data sets.
- Pandas 2.0

# **Vectorized Data Structures**

# **what are they?**

**Vectorized Data Structures let you  
perform operations on your data all at once**

# Advantages of Vectorized Data Structures

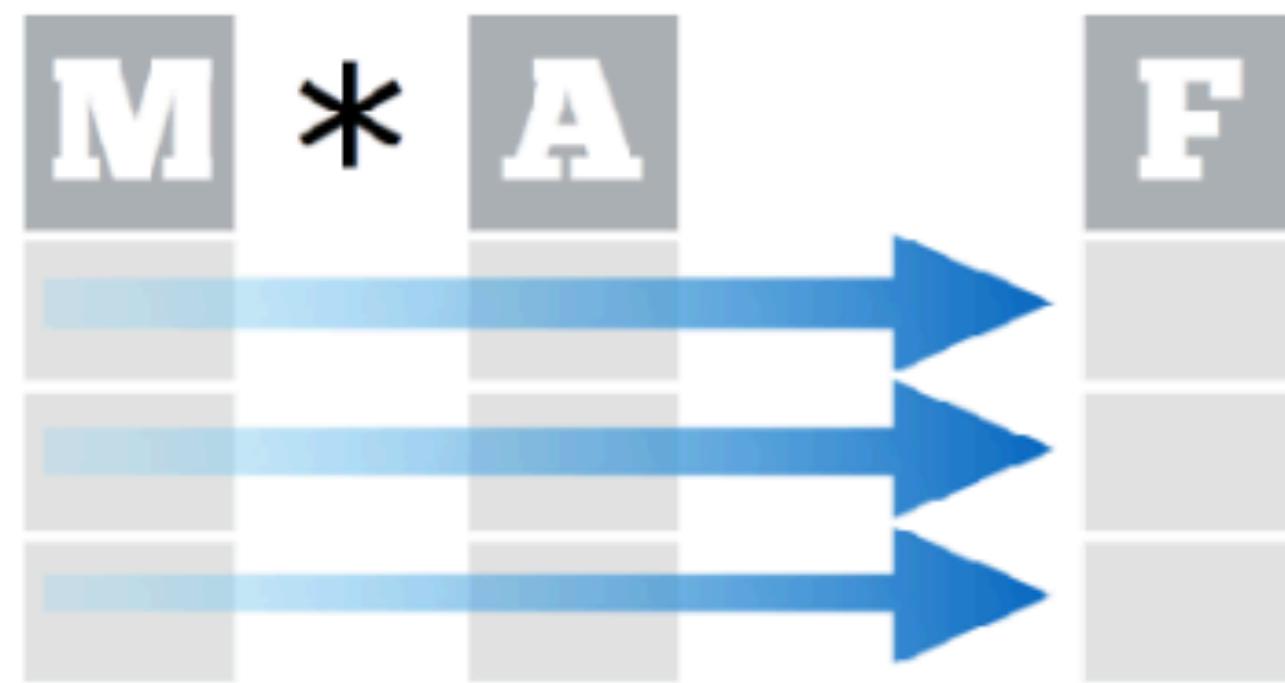
- More readable and simpler code
- Allows the module to optimize for CPU and Memory usage
- Pass serialized objects from one system to another. (More on this later)

```
for x in range(0, len( data )):  
    data[ x ] = data[ x ] + 1
```

```
for x in range(0, len( data )):  
    data[ x ] = data[ x ] + 1
```

odds = evens + 1

$$F = M * A$$



Each **variable** is saved  
in its own **column**



&



Each **observation** is  
saved in its own **row**

**No loops**





# What is Pandas?

- Pandas is the standard OSS data manipulation library for Python
- At its core, it is a collection of vectorized data structures.
- Pandas is the foundation of the Python data science ecosystem, so understanding it is key to being effective at data science using Python.
- In March 2023, Pandas 2.0 was released which had some major new features.

Dimensions	Name	Description
1	Series	Indexed 1 dimensional data structure
1	Timeseries	Series using timestamps as an index
2	DataFrame	A two dimensional table
3	Panel	<del>A three dimensional mutable data structure</del>

**Columns**

The diagram illustrates the structure of a table. A vertical double-headed arrow labeled "ROWS" points to the five rows of the table. A horizontal double-headed arrow labeled "Columns" points to the three columns: "Regd. No", "Name", and "Marks%".

Regd. No	Name	Marks%
1000	Steve	86.29
1001	Mathew	91.63
1002	Jose	72.90
1003	Patty	69.23
1004	Vin	88.30

# The Series Object

**A Series is like a list**

**A Series is like a list or a  
dictionary**

**A Series is like a list or a  
dictionary but BETTER!!**

**The Series is the primary building block for all the other data structures we will discuss**

```
import pandas as pd  
import numpy as np  
import matplotlib.pyplot as plt
```

# Creating a Series

```
myData = pd.Series( <data>, index=<index> )
```

# Creating a Series

```
series1 = pd.Series( [ 'a' , 'b' , 'c' , 'd' , 'e' ] )  
  
series2 = pd.Series( { 'firstName' : 'Charles' ,  
'lastName' : 'Givre' } )
```

# Accessing a Series

```
series1 = pd.Series( [ 'a' , 'b' , 'c' , 'd' , 'e' ] )
```

```
print( series1 )
```

```
0    a  
1    b  
2    c  
3    d  
4    e  
dtype: object
```

# Accessing a Series

You can access items in a Pandas Series by index, similar to a python list. Just as in a regular list, indexing starts at zero.

```
series1 = pd.Series( [ 'a' , 'b' , 'c' , 'd' , 'e' ] )  
print( series1[3] )
```

d

# Accessing a Series: Slicing

```
series1 = pd.Series( [ 'a' , 'b' , 'c' , 'd' , 'e' ] )
```

```
print( series1[1:3] )
```

```
1      b  
2      c  
dtype: object
```

# Accessing a Series

```
series1 = pd.Series( [ 'a' , 'b' , 'c' , 'd' , 'e' ] )
```

```
print( series1[1:3] )
```

1	b
2	c

dtype: object

```
series2 = series1[1:3]  
series2.reset_index( drop=True )
```

# Accessing a Series

```
record = pd.Series(  
    {'firstname': 'Charles',  
     'lastname': 'Givre',  
     'middle': 'classified' } )
```

```
record[ 'firstname' ]
```

Charles

# Accessing a Series

```
record = pd.Series(  
    {'firstname': 'Charles',  
     'lastname': 'Givre',  
     'middle': 'classified' } )  
  
record[ 'firstname', 'lastname' ]
```

```
firstname      Charles  
lastname       Givre  
dtype: object
```

# Accessing a Series

```
record = pd.Series(  
    {'firstname': 'Charles',  
     'lastname': 'Givre',  
     'middle': 'classified' } )
```

```
record[0]
```

Charles

# Accessing a Series

```
randomNumbers = pd.Series(  
    np.random.randint(1, 100, 50) )
```

```
randomNumbers.head()
```

```
0      48  
1      34  
2      84  
3      85  
4      58
```

```
dtype: int64
```

# Accessing a Series

```
randomNumbers = pd.Series(  
    np.random.randint(1, 100, 50) )  
  
randomNumbers.tail( 7 )  
43      66  
44      66  
45      43  
46      55  
47      99  
48      82  
49      19  
  
dtype: int64
```

# Filtering Data in a Series

```
randomNumbers [ <boolean condition> ]  
randomNumbers [ randomNumbers < 10 ]  
  
12      5  
21      2  
24      1  
27      1  
29      1  
  
dtype: int64
```

# Filtering Data in a Series

```
record.str.contains('Cha')
```

```
firstname      True
lastname     False
middle        False
dtype: bool
```

```
record[ record.str.contains('Cha') ]
```

```
firstname    Charles
dtype: object
```

# String Functions

Function	Explanation
Series.str.contains(<pattern>)	Returns true/false if text matches a pattern
Series.str.count(<pattern>)	Returns number of occurrences of a pattern in a string
Series.str.extract(<pattern>)	Returns matching groups from a string
Series.str.find(<string>)	Returns index of first occurrences of a substring (Note: not regex)
Series.str.findall(<pattern>)	Returns all occurrences of a regex
Series.str.len()	Returns the length of text
Series.str.replace(<pat>, <replace>)	Replaces matches with a replacement string

# Date/Time Operations

```
pd.to_datetime(<times>, format='<format string>')
```

# Selected Date/Time Operations

Function	Explanation
<code>series.dt.year</code>	Returns the year of the date time
<code>series.dt.month</code>	Returns the month of the date time
<code>series.dt.day</code>	Returns the days of the date time
<code>series.dt.weekday</code>	Returns the day of the week
<code>series.dt.is_month_start</code>	Returns true if it is the first day of the month
<code>series.dt.strftime()</code>	Returns an array of formatted strings specified by a <code>date_format</code>

```
combinedSeries = series1.add( series2 )
```

```
def addTwo( n ):  
    return n + 2
```

```
odds.apply( addTwo )
```

```
odds.apply( lambda x: x + 1 )
```

# Questions?

# **In Class Exercise**

Please take 30 minutes and complete  
**Worksheet 1.1: Working with One Dimensional Data**

# Explore Your Data



- **Mean:** The mean is the average value of a set of numbers
- **Median:** The median is the middle value of an ordered set of numbers
- **Mode:** The mode is the value from a set which is repeated the most frequently.
- **Range:** Difference between minimum and maximum
- **Standard Deviation:** Measures dispersion in a data set. Close to zero indicates little dispersion.

# Intro Stats: IQR

The **interquartile range** is a measure of where the “middle fifty” is in a data set. Where a range is a measure of where the beginning and end are in a set, **an interquartile range is a measure of where the bulk of the values lie.**

```
IQR = data.quantile(0.75) - data.quantile(0.25)
```

# Intro Stats: Variance

The **variance** of a set of values,  $\sigma^2$ , is the average of the square of the difference of the values in the dataset from the dataset's mean.

$$\sigma^2 = \frac{\sum_{i=1}^n (x_i - \mu)^2}{n}$$

`data.var(axis=0)`

# Intro Stats: Std. Deviation

The standard deviation,  $\sigma$ , is the square root of the variance:

We use the **standard deviation** much more regularly than the **variance** because it is on the same scale as the original data:

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \mu)^2}{n}}$$

`data.std(axis=0)`

# Intro Stats: Covariance

**Covariance**, like the variance, is a measure of spread, however it also measures how closely two datasets track each other.

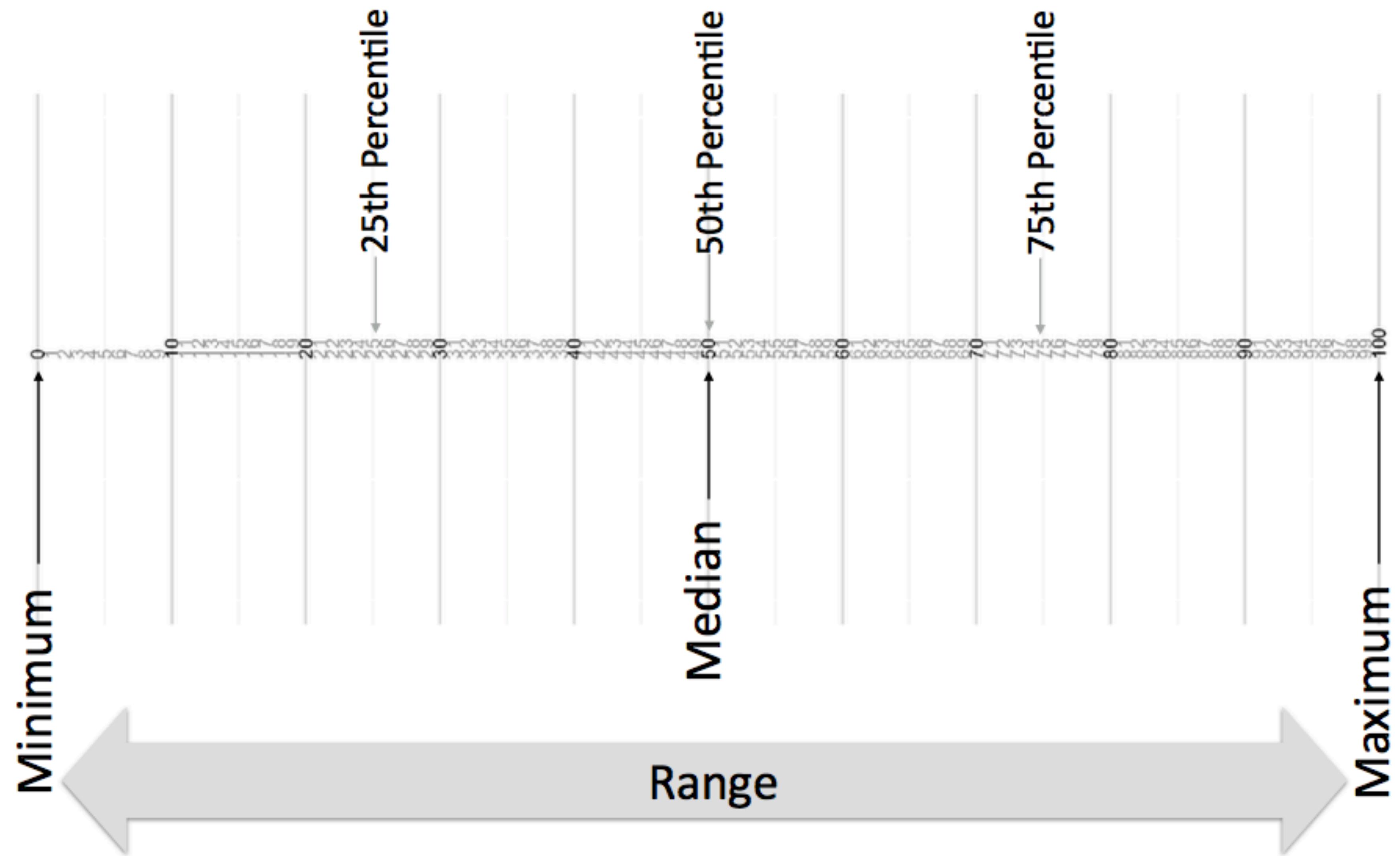
- **Covariance** is a squared quantity, so it is not on the same scale as the mean
- **Covariance** of different pairs of variables can have completely different scales

$$Cov(x, y) = \frac{\sum_{i=1}^n (x_i - \mu_x)(y_i - \mu_y)}{n}$$

# Tukey 5 Number Summary

- **Minimum:** The smallest value in the dataset
- **Lower Quartile:** Smallest 25% of the dataset
- **The Median:** The middle value of the dataset
- **Upper Quartile:** The largest 25% of the dataset
- **Maximum:** The largest value in the dataset





<b>Series.abs()</b>	Absolute Value of the Series
<b>Series.count()</b>	Returns number of non-empty values in the series
<b>Series.max()</b>	Returns maximum value in the Series
<b>Series.mean()</b>	Returns the mean of a Series
<b>Series.median()</b>	Returns the median of a Series
<b>Series.min()</b>	Returns the minimum value in a Series
<b>Series.mode()</b>	Take a guess..
<b>Series.quantile([q])</b>	Returns the quantiles of a Series
<b>Series.sum</b>	Returns the sum of a series
<b>Series.std</b>	Returns the standard deviation of a Series

# Series.describe( )

## Series.describe( )

```
>>> random_numbers.describe()
count      50.000000
mean       50.620000
std        30.102471
min        1.000000
25%       25.500000
50%       54.000000
75%       73.000000
max       99.000000
dtype: float64
```

```
names = pd.Series(  
[ 'Jim', 'Bob',  
'Bob', 'Steve', 'Jim', 'Jane', 'Steph', 'Emma', 'Rachel' ])  
  
names.describe()
```

```
names = pd.Series(  
['Jim', 'Bob',  
'Bob', 'Steve', 'Jim', 'Jane', 'Steph', 'Emma', 'Rachel'])
```

```
names.describe()
```

```
count         9  
unique        7  
top          Jim  
freq          2  
dtype: object
```

# Finding Unique Values

```
unique_nums = []
for key, value in random_numbers.iteritems():
    if value not in unique_nums:
        unique_nums.append(value)
```

**NO!!!**

```
series.drop_duplicates()  
series.unique()
```

# Counting Unique Occurrences

`series.value_counts()`

```
series.value_counts(bins=5)
```

```
series.value_counts(bins=5,  
normalize=True)
```

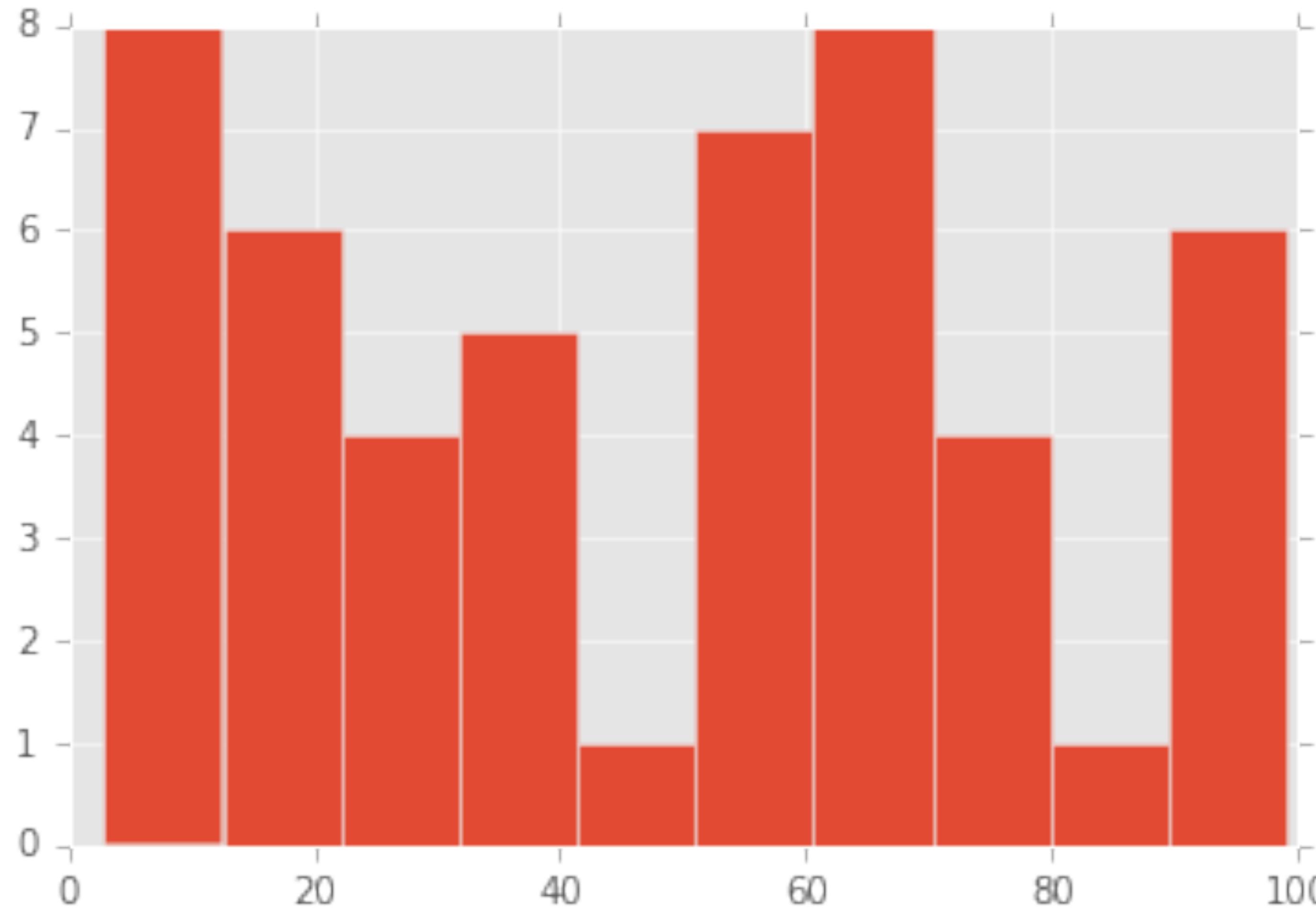
```
series.value_counts(bins=5,  
normalize=True,  
dropna=False)
```

```
In [7]: area_codes2.value_counts()
```

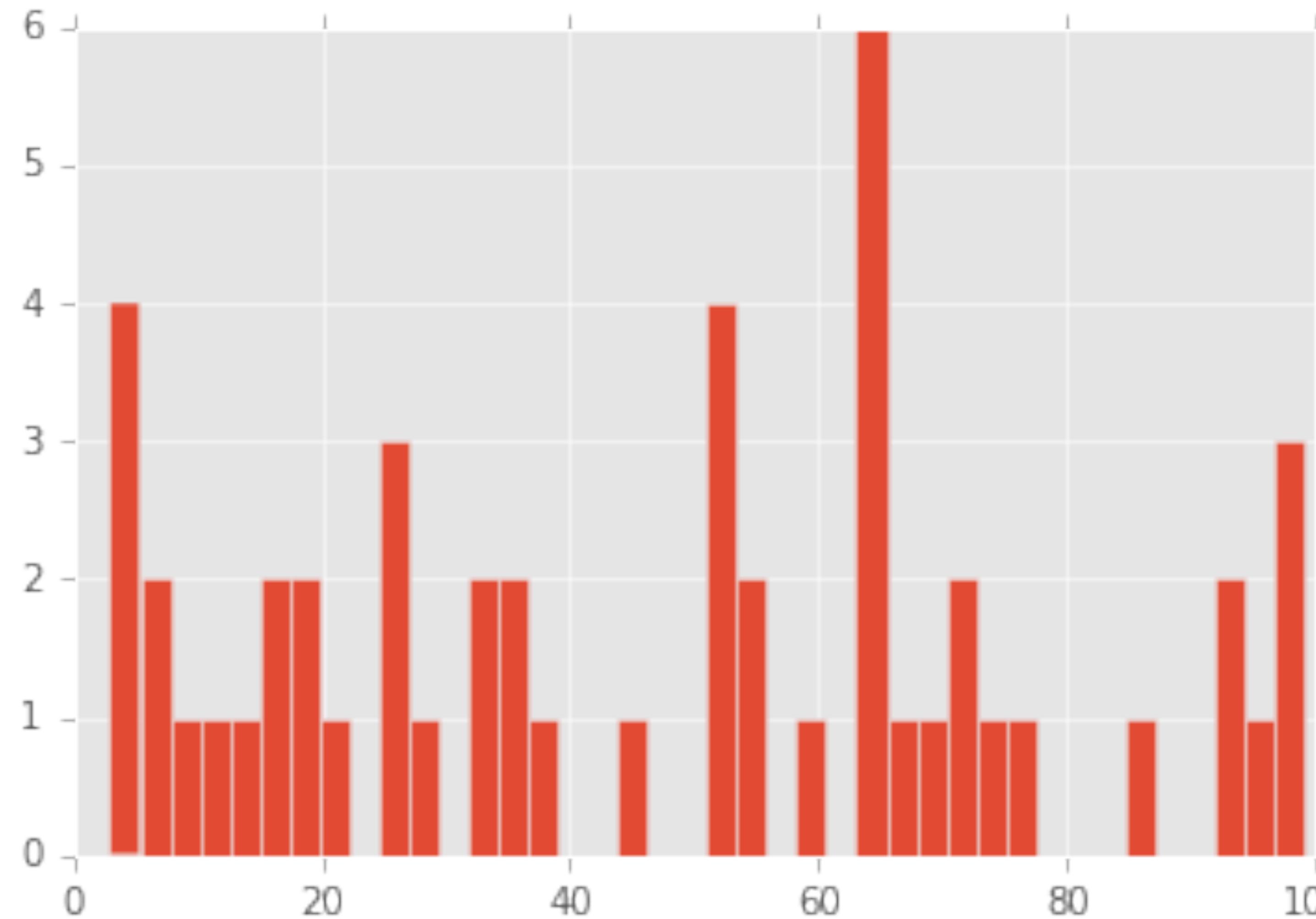
```
Out[7]: 833      7  
        811      5  
        822      5  
        899      3  
        844      3  
        855      2  
dtype: int64
```

# series.hist()

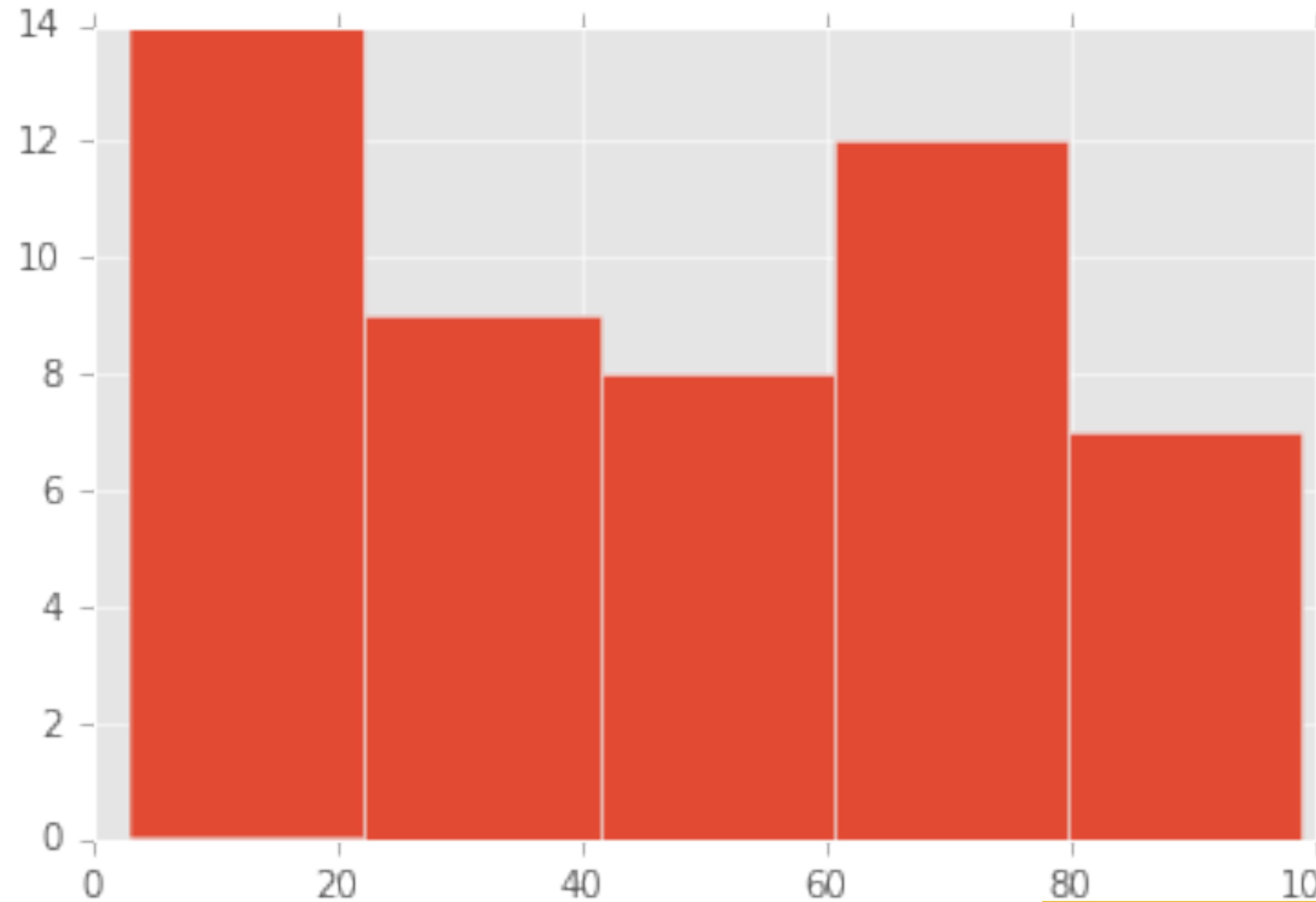
# series.hist()



# series.hist(bins=40)

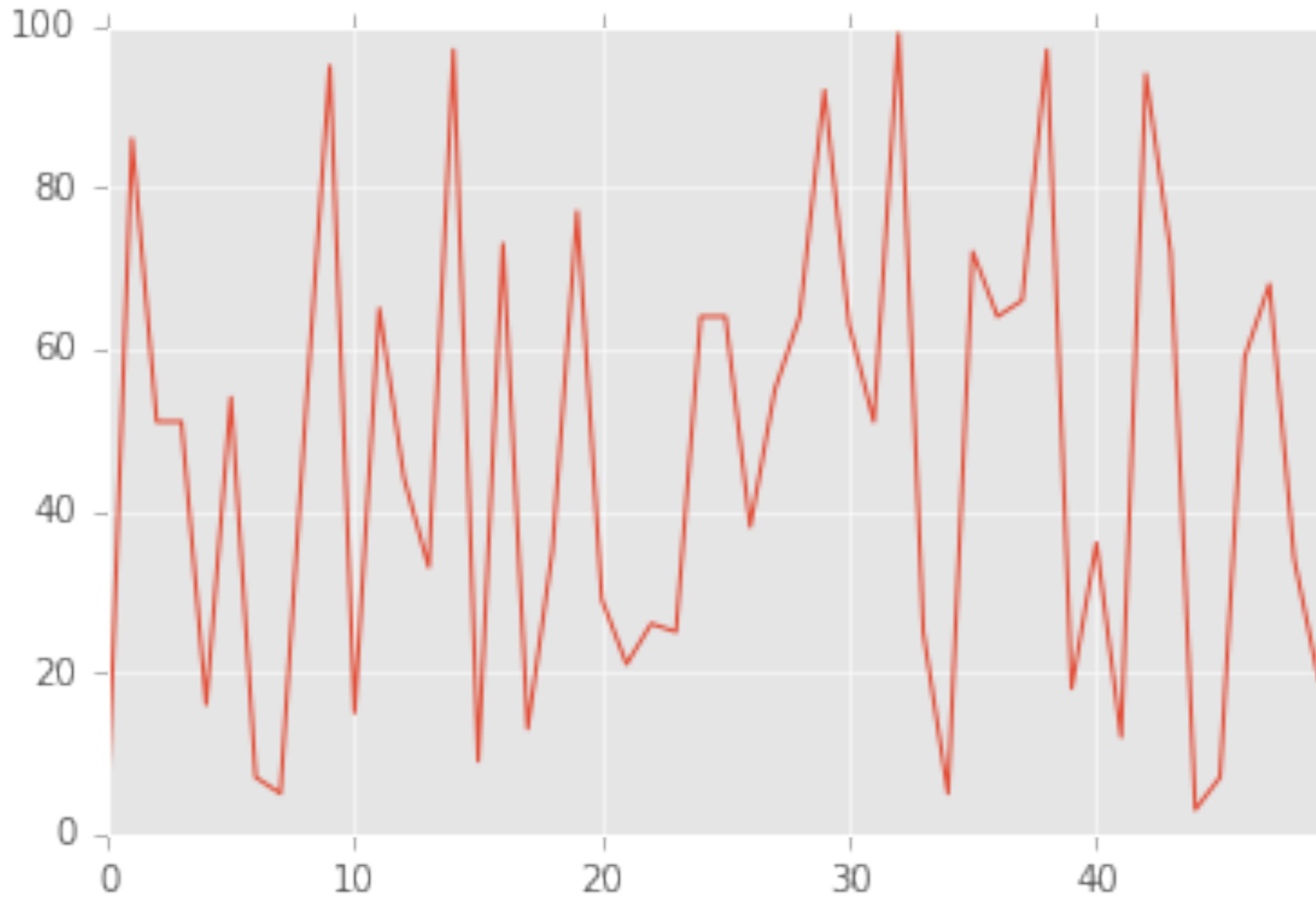


# series.hist(bins=5)

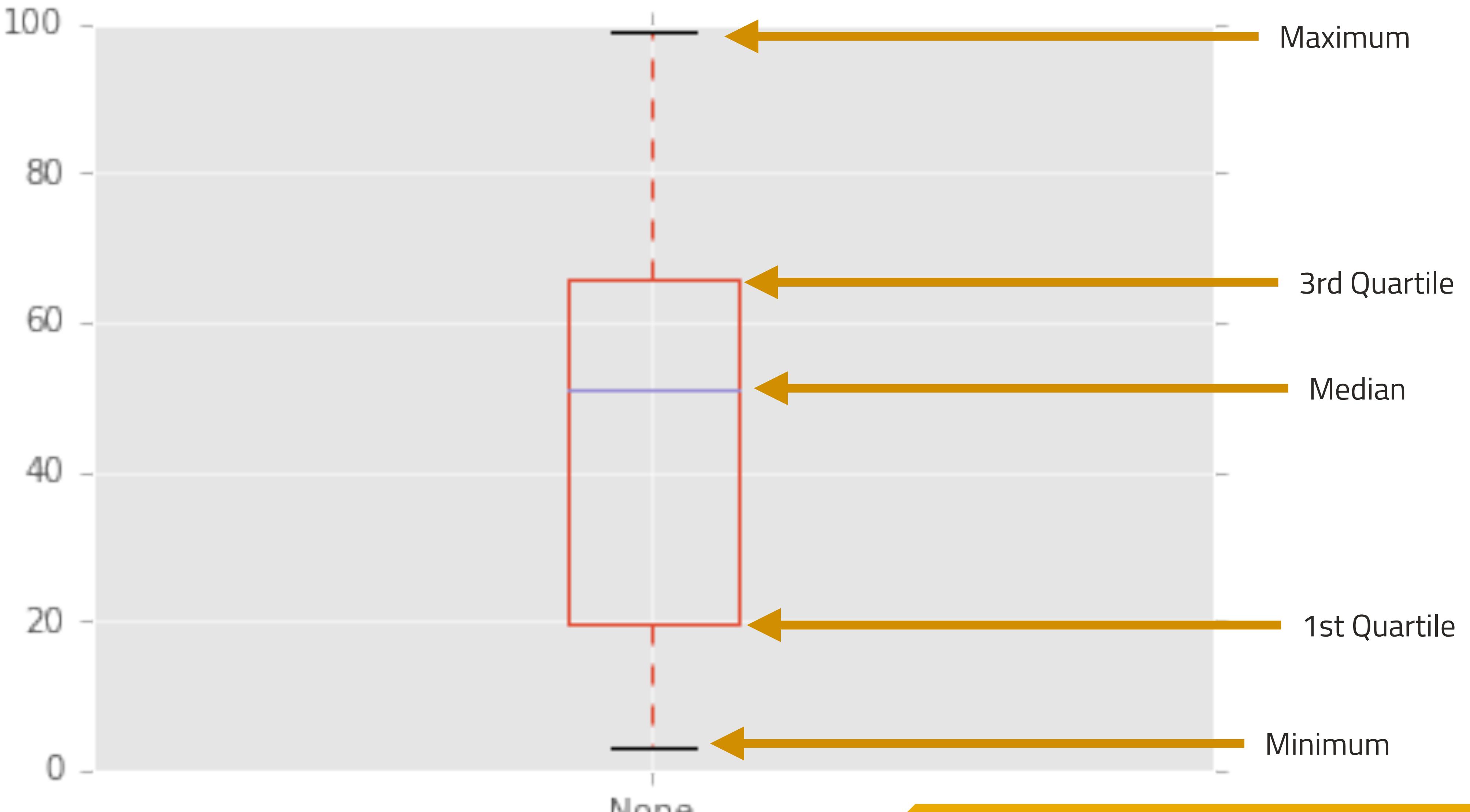


`series.plot()`

# series.plot()

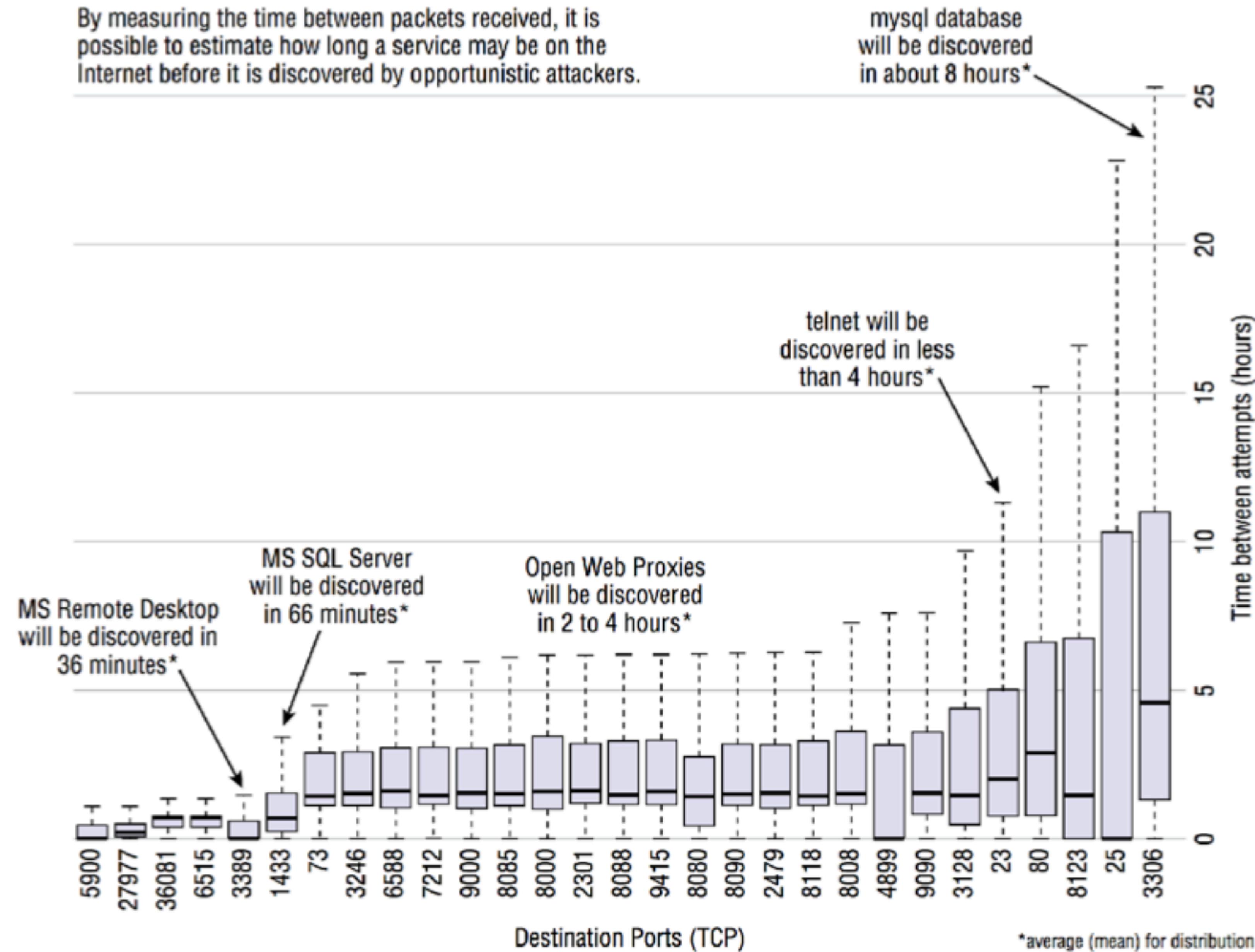


`series.plot(kind='box')`



## How long will a service go undiscovered by opportunistic attackers?

By measuring the time between packets received, it is possible to estimate how long a service may be on the Internet before it is discovered by opportunistic attackers.

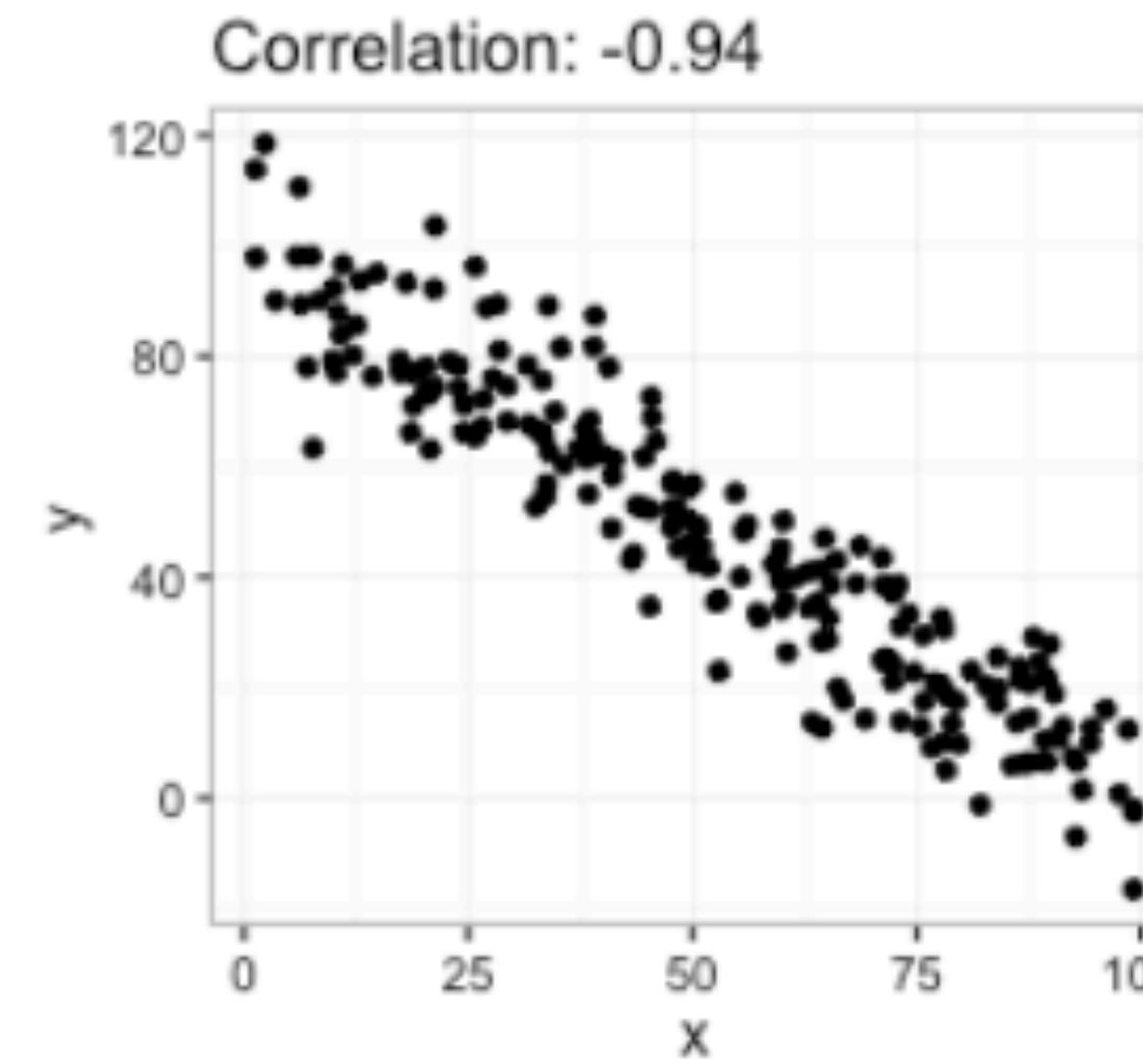
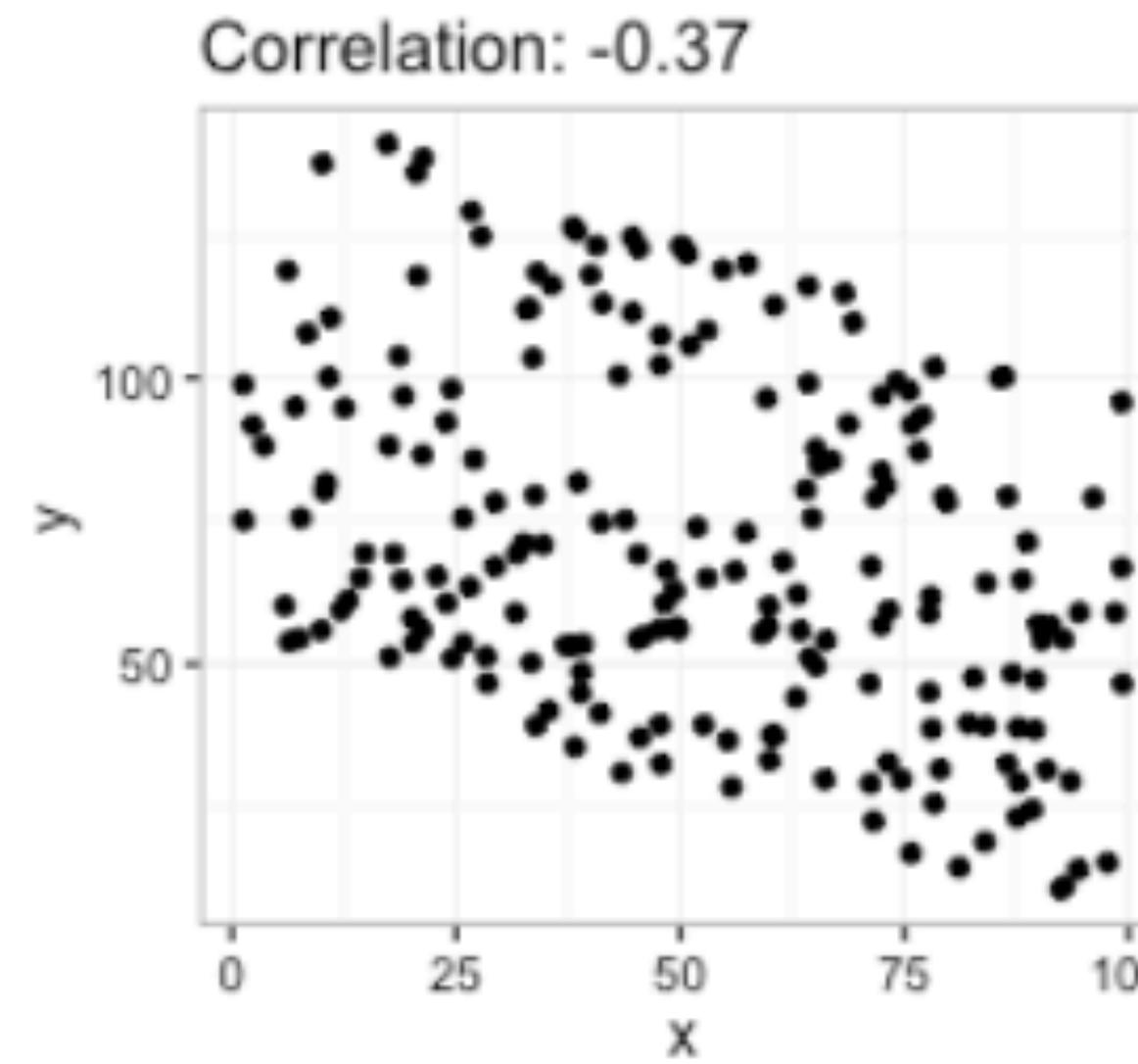
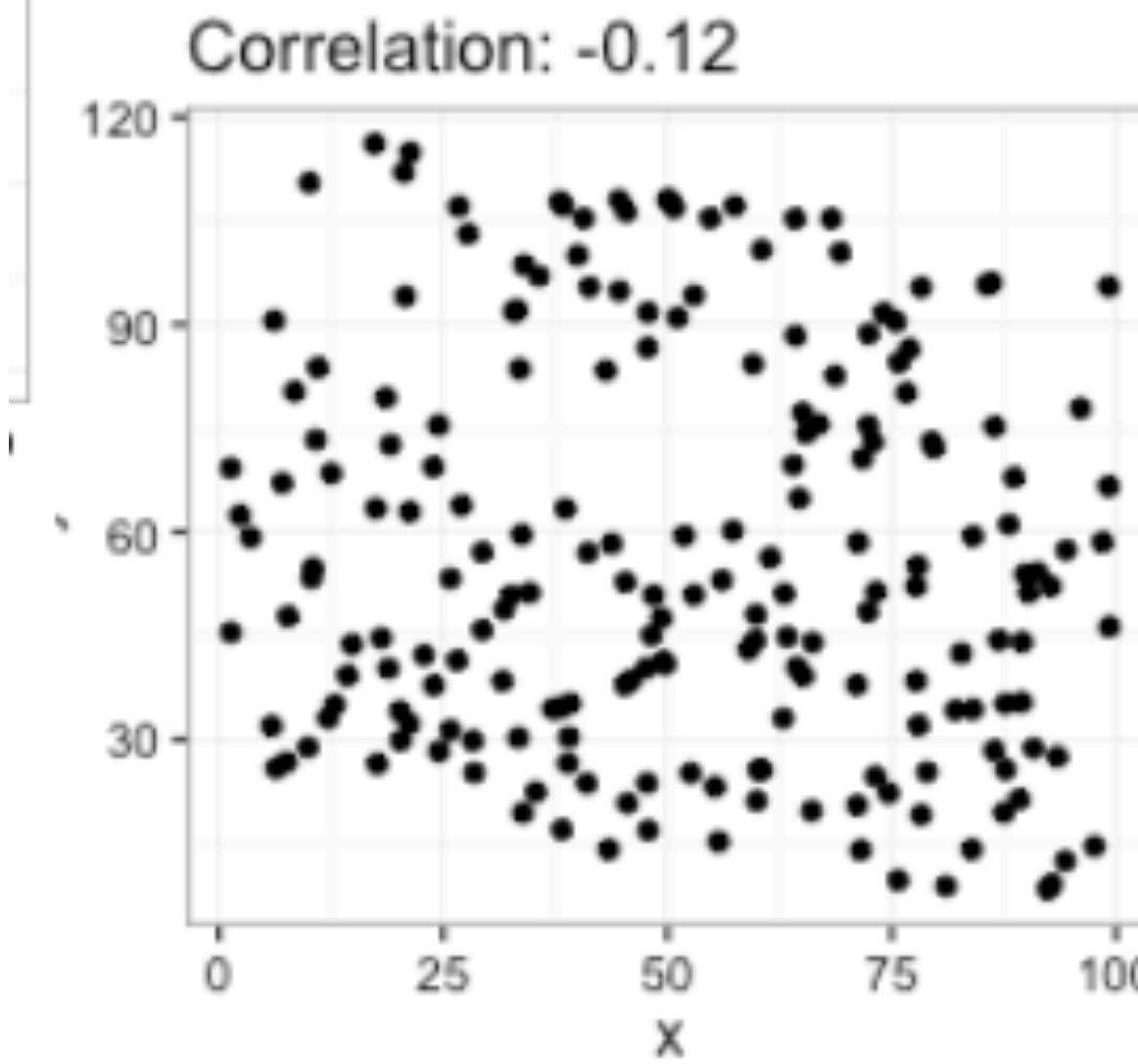
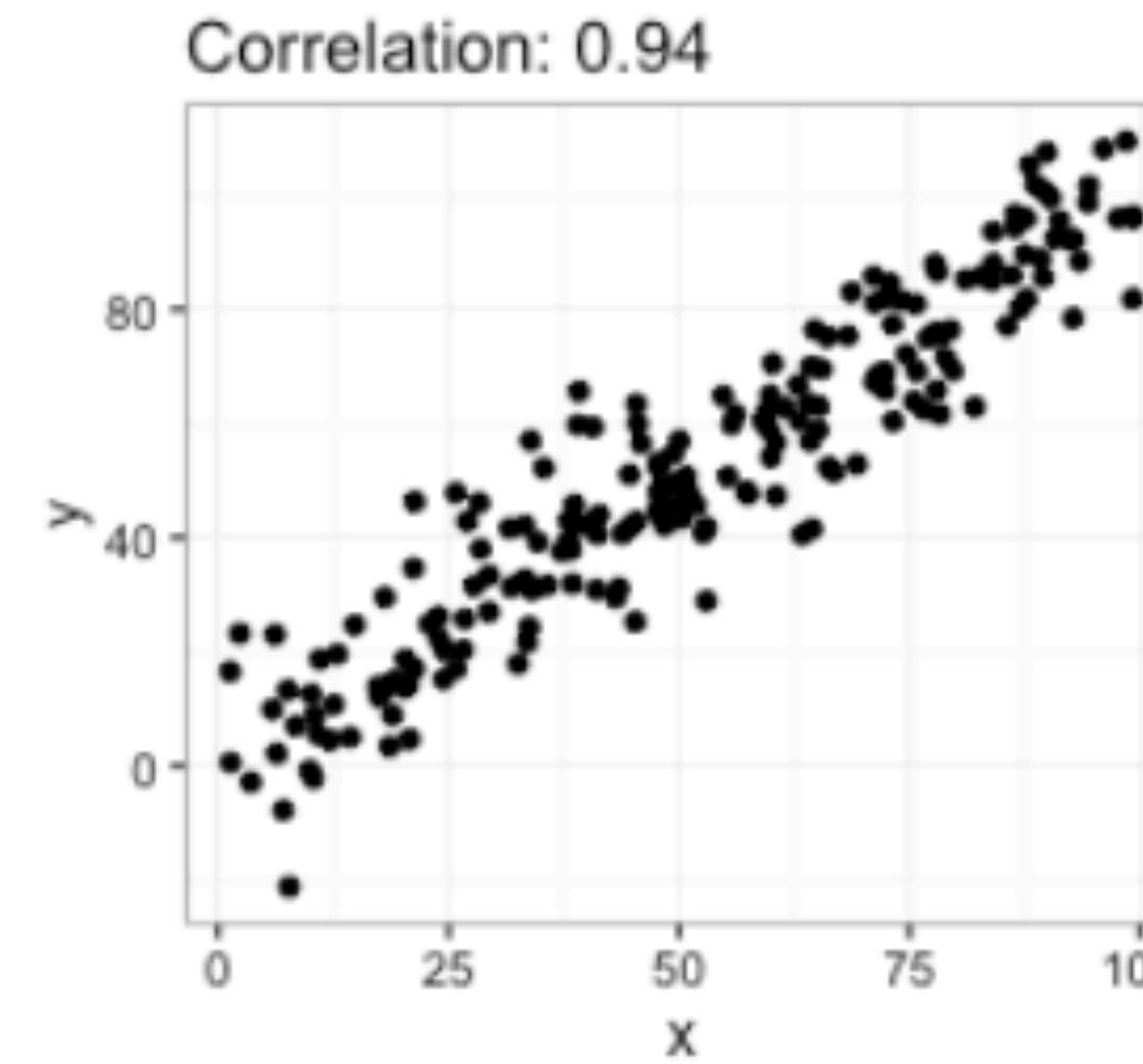
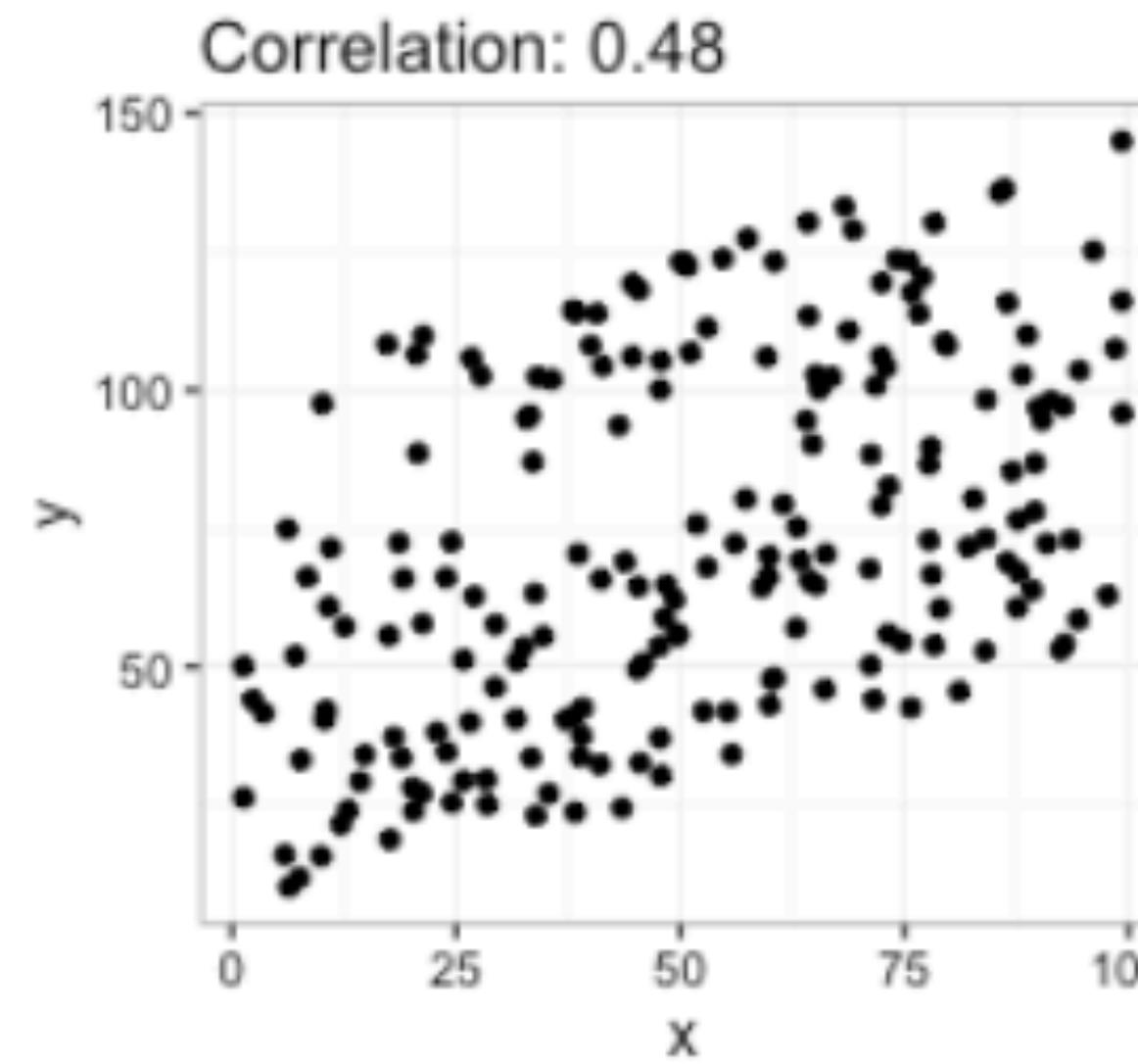
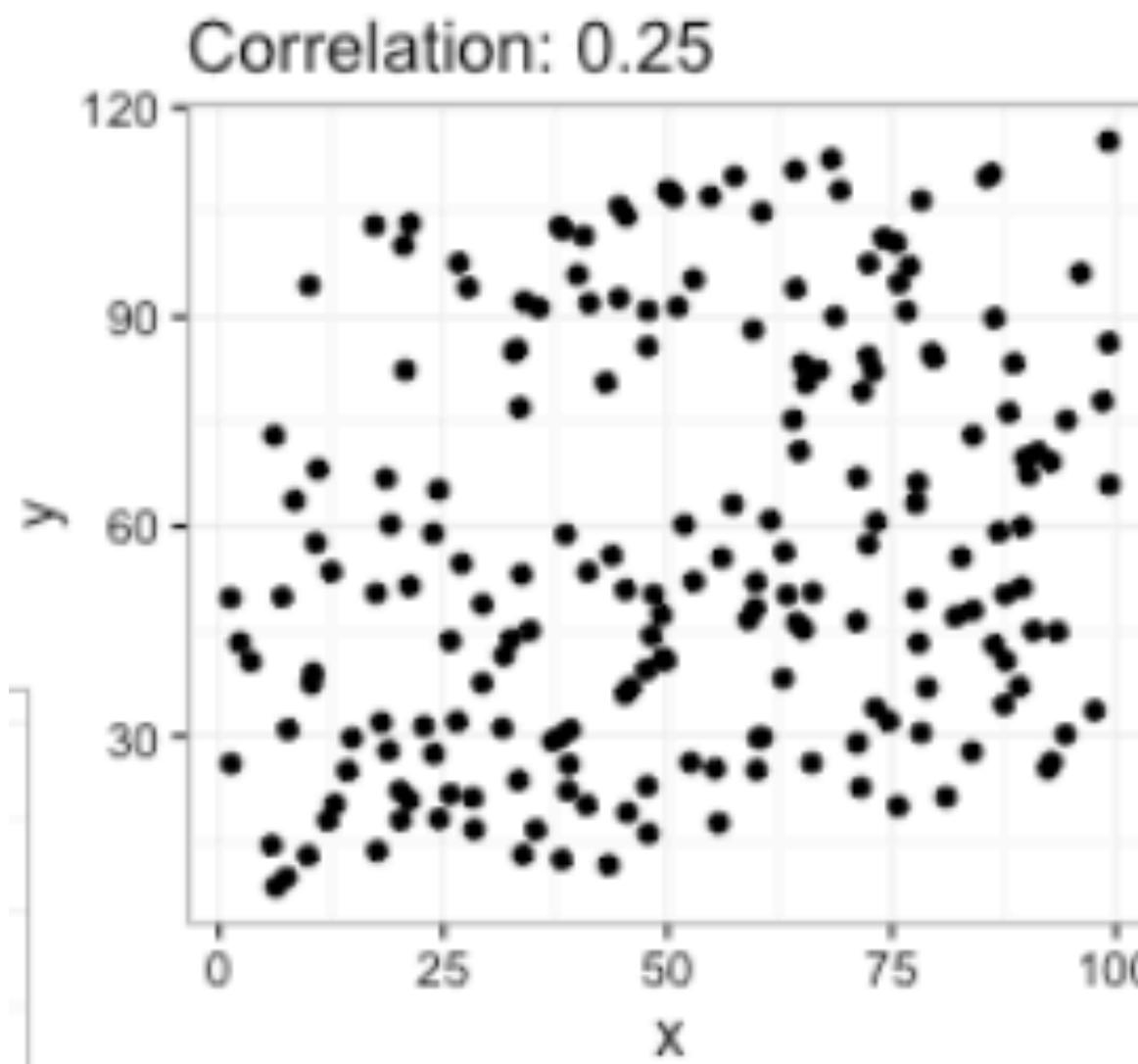


# **Correlations between Datasets**

# Correlations

- Measurement of the relationship between **two continuous variables**
- Output is between -1 and 1, with 1 being perfect correlation, -1 is perfect negative correlation, 0 is no correlation.
- Correlation measurement is referred to as  $r$ .

# Correlations



# Correlations

```
series1.corr( series2 )
```

# Questions?

# In Class Exercise

Please take 30 minutes and complete  
Worksheet 1: Exploring One Dimensional Data