# Python Packages

# Outline

- How to import packages
- Numpy
- Pandas
- Matplotlib

- Use import to load a library module into a program's memory.
- Then refer to things from the module as module_name.thing_name.
  - Python uses . to mean "part of".
- Use from ... import ... to load only specific items from a library module.
- Then refer to them directly without library name as prefix.
- Use import ... as ... to give a library a short *alias* while importing it.
- Then refer to items in the library using that shortened name.

```
import math
print('pi is', math.pi)
print('cos(pi) is',
math.cos(math.pi))

from math import cos, pi
print('cos(pi) is', cos(pi))


import math as m
print('cos(pi) is', m.cos(m.pi))
```

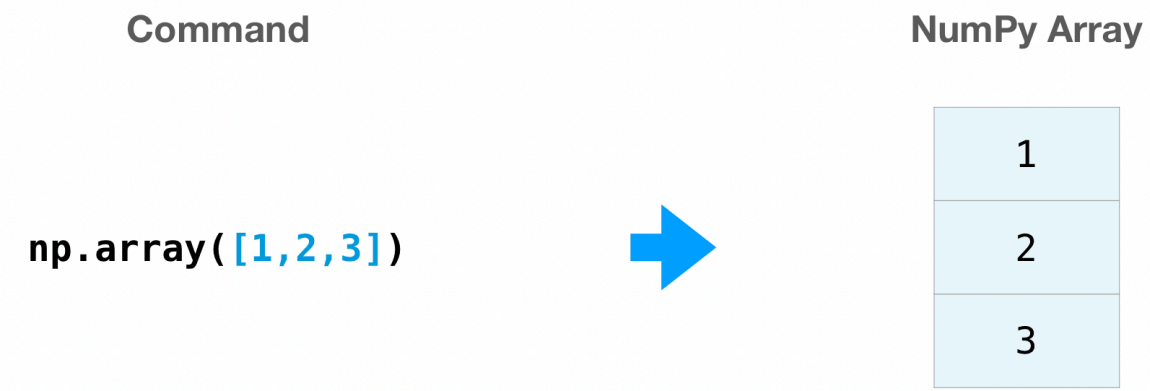
# Numpy

```
import numpy as np
```

https://numpy.org/doc/stable/reference/index.html

# Numpy

- np.array([Arrays Arrays Arrays])
- >>> a = np.array**([1, 2, 3, 4, 5, 6])**
- >>> a = np.array**([[1, 2, 3, 4], [5, 6, 7, 8], [9, 10, 11, 12]])**



# np.arange()

- start = 1
- stop  = 11
- step  = 1

- x = np.arange(start, stop, step)

- print(x)

- [ 1 2 3 4 5 6 7 8 9 10]

# np. linspace()

- start = 0
- stop  = 100
- n_elements = 201

- x = np.linspace(start, stop, n_elements)

- print(x)

# np.where()

- x_5 = np.where(x%5 == 0)
- print(x_5)
- print(x[x_5])

# np. savetxt() | np.loadtxt()

```
start  = 0
stop   = 100
n_elem = 501

x = np.linspace(start, stop, n_elem)

y = (.1*x)**2 - (5*x) + 3

np.savetxt('myfile.txt', np.transpose([x,y]))

data = np.loadtxt('myfile.txt')
print(data)
```

# Some numpy methods

| Method | Property |
| --- | --- |
| np.zeros(5,float) | yields a 5-element array of zeros of type float |
| a=np.empty(4) | yields a 4-element empty array |
| a.fill(5.5) | fills that array with 5.5 for all elements |
| np.arange(5) | yields an integer array of length 5 with increasing values |
| b=np.random.normal(10,3,5) | yields a 5 element array of normally distributed numbers with mean 10 and variance 3 |
| mask=b > 9 | creates a boolean array determing which numbers are greater than 9 |
| print(b[mask]) | prints the ones with values > 9 |
| b[mask]=0 | sets the ones > 9 to zero |

# Some numpy methods

```
c=np.random.normal(10,3,(2,4))
```

Creates a 2 x 4 array with normally distributed numbers with mean 10 and variance 3.

| | |
|---|---|
| c.dtype | data type |
| c.size | total number of elements |
| c.ndim | number of dimensions |
| c.shape | shape or dimensionality |
| c.nbytes | memory used (bytes) |
| c.min() | gives the minimum of c |
| c.max() | gives the maximum of c |
| c.sum() | sum of all elements |
| c.mean() | mean of all elements |
| c.std() | standard deviation of all elements |
| c.sum(axis=0) | will present sum along the 0th axis (column direction). The result will have reduced dimensionality |

# Indexing revisited

| Method | Property |
| --- | --- |
| d=c[0,:] | grabs the first (0th) row of c. |
| d=c[1,:] | grabs the second (1st) row of c. |
| d=c[:,0] | grabs the first column of c. |

# Pandas

**import pandas as** pd

https://pandas.pydata.org/docs/

# Pandas

- Great for reading data
- Data manipulation with integrated indexing.

diamonds | mtcars | iris

Show 10 entries Search:

| | carat | cut | color | clarity | depth | table | price | x | y | z |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.52 | Ideal | D | VS2 | 61.4 | 56 | 1664 | 5.16 | 5.19 | 3.18 |
| 2 | 0.5 | Very Good | F | SI1 | 62.3 | 60 | 1250 | 5.07 | 5.11 | 3.17 |
| 3 | 0.61 | Ideal | G | VVS2 | 61.6 | 54 | 2242 | 5.45 | 5.49 | 3.37 |
| 4 | 0.36 | Premium | G | VS2 | 62.5 | 58 | 756 | 4.55 | 4.51 | 2.83 |
| 5 | 0.7 | Very Good | E | VS2 | 63.5 | 54 | 2889 | 5.62 | 5.66 | 3.58 |
| 6 | 0.56 | Ideal | F | VS1 | 61.7 | 56 | 2016 | 5.32 | 5.28 | 3.27 |
| 7 | 1.19 | Premium | E | I1 | 60.2 | 61 | 3572 | 6.91 | 6.87 | 4.15 |
| 8 | 0.52 | Ideal | F | IF | 60.6 | 57 | 2575 | 5.21 | 5.22 | 3.16 |
| 9 | 0.38 | Ideal | E | IF | 62.7 | 55 | 1433 | 4.61 | 4.67 | 2.91 |
| 10 | 0.51 | Ideal | E | VS2 | 62.1 | 54 | 1608 | 5.13 | 5.15 | 3.19 |

Showing 1 to 10 of 1,000 entries Previous 1 2 3 4 5 … 100 Next

Type all of the table??????

# Pandas- DataFrames

- A DataFrame is a collection of Series
- The DataFrame is the way Pandas represents a table
- Series is the data-structure Pandas use to represent a column.
- Built on top of the Numpy library
- Access individual records of the table
- Handling of missing values
- Databases operations between DataFrames.

# Pandas-Read

```
import pandas as pd
data = pd.read_csv('data/gapminder_gdp_oceania.csv')
print(data)
```

```
data.info() data = pd.read_csv('data/gapminder_gdp_oceania.csv',
index_col='country’)

print(data.columns)
print(data.T)
print(data.describe())
```

# Pandas-Practice

- Read the data in gapminder_gdp_americas.csv into a variable called americas and display its summary statistics.

- What method call will display the first three rows of this data?

- What method call will display the last three columns of this data?

# Pandas-Practice

- Read the data in gapminder_gdp_americas.csv into a variable called americas and display its summary statistics.
  - americas = pd.read_csv('data/gapminder_gdp_americas.csv', index_col='country')
  - americas.describe()

- What method call will display the first three **rows** of this data?
  - americas.head(n=3)

- What method call will display the last three **columns** of this data?
  - americas_flipped = americas.T
  - americas_flipped.tail(n=3)
  - americas_flipped.tail(n=3).T

# Pandas- DataFrame

- Use DataFrame.iloc[..., ...] to select values by their (entry) position

- data = pd.read_csv('data/gapminder_gdp_europe.csv', index_col='country')

- **print**(data.iloc[0, 0])
- **print**(data.loc["Albania", "gdpPercap_1952"])
-

-

# Pandas-DataFrame

- Use : on its own to mean all columns or all rows.
- **print**(data.loc["Albania", :])

- **print**(data.loc[:, "gdpPercap_1952"])

# Pandas- DataFrame

- Select multiple columns or rows using DataFrame.loc and a named slice.

- **print**(data.loc['Italy':'Poland', 'gdpPercap_1962':'gdpPercap_1972'])

# Pandas-DataFrame

```
# Use a subset of data to keep output readable.
subset = data.loc['Italy':'Poland', 'gdpPercap_1962':'gdpPercap_1972']
 print('Subset of data:\n', subset)

 # Which values were greater than 10000 ?
print('\nWhere are values large?\n', subset > 10000)

mask = subset > 10000
print(subset[mask])


print(subset[subset > 10000].describe())
```

# Pandas-DataFrame Practice

1. Write an expression to find the Per Capita GDP of Serbia in 2007.
2. Do the two statements below produce the same output?

```
print(df.iloc[0:2, 0:2])
print(df.loc['Albania':'Belgium', 'gdpPercap_1952':'gdpPercap_1962’])
```

3. GDP per capita for all countries in 1982.
4. GDP per capita for Denmark for all years.
5. GDP per capita for all countries for years *after* 1985.
6. GDP per capita for each country in 2007 as a multiple of GDP per capita for that country in 1952.

# Pandas-DataFrame Practice

1. Write an expression to find the Per Capita GDP of Serbia in 2007.
   - **print**(df.loc['Serbia', 'gdpPercap_2007’])

2. Do the two statements below produce the same output?

```
print(df.iloc[0:2, 0:2])
print(df.loc['Albania':'Belgium', 'gdpPercap_1952':'gdpPercap_1962’])
```

   - No, they do not produce the same output!
   - numerical slice, 0:2, *omits* the final index (i.e. index 2)
   - named slice, ‘gdpPercap_1952’:’gdpPercap_1962’, *includes* the final element.

# Pandas-DataFrame Practice

1. GDP per capita for all countries in 1982.
   - data['gdpPercap_1982']
2. GDP per capita for Denmark for all years.
   - data.loc['Denmark',:]
3. GDP per capita for all countries for years *after* 1985.
   - data.loc[:,'gdpPercap_1985’:]
4. GDP per capita for each country in 2007 as a multiple of GDP per capita for that country in 1952.
   - data['gdpPercap_2007']/data['gdpPercap_1952']

# Keypoints

- Use the Pandas library to get basic statistics out of tabular data.
- Use index_col to specify that a column's values should be used as row headings.
- Use DataFrame.info to find out more about a dataframe.
- The DataFrame.columns variable stores information about the dataframe's columns.
- Use DataFrame.T to transpose a dataframe.
- Use DataFrame.describe to get summary statistics about data.

# Keypoints

- Use DataFrame.iloc[..., ...] to select values by integer location.
- Use `:` on its own to mean all columns or all rows.
- Select multiple columns or rows using DataFrame.loc and a named slice.
- Result of slicing can be used in further operations.
- Use comparisons to select data based on value.
- Select values or NaN using a Boolean mask.

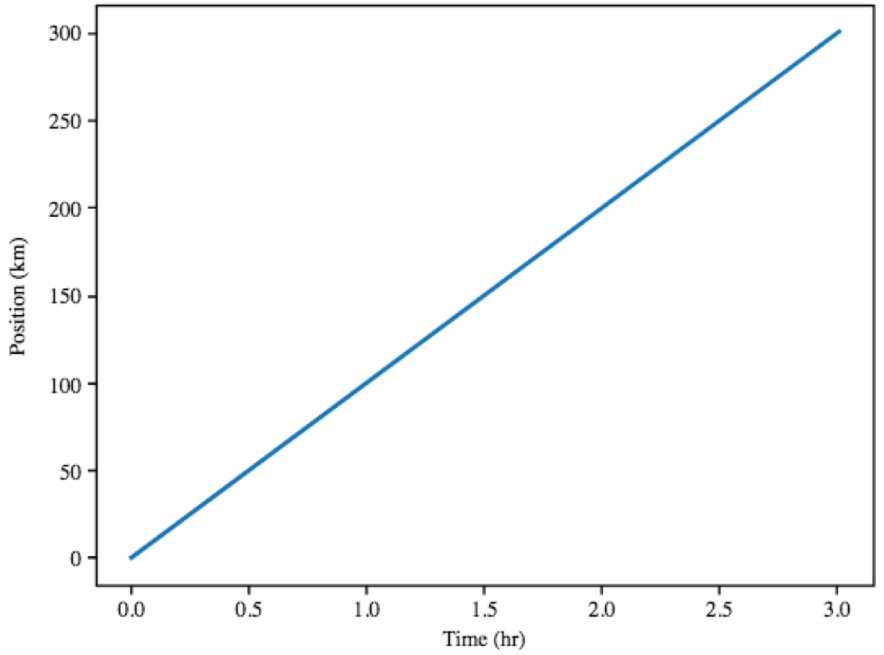
# Matplotlib

```
import matplotlib.pyplot as plt
```

https://matplotlib.org/stable/index.html
https://matplotlib.org/stable/gallery/index.html

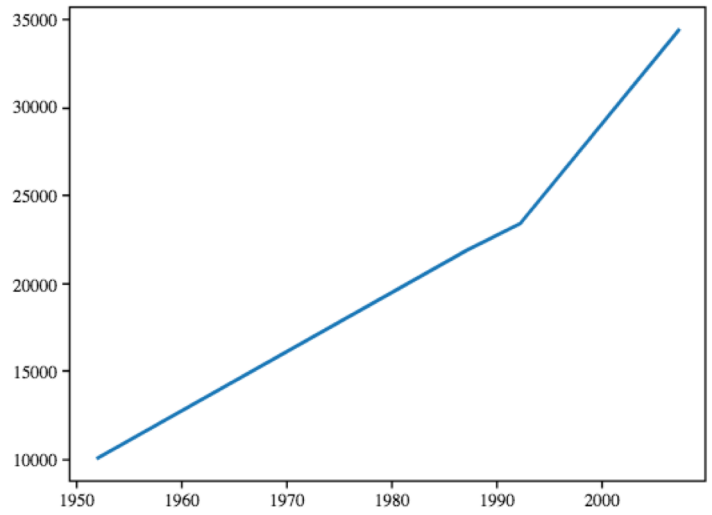
# Plotting

```
time = [0, 1, 2, 3] position = [0, 100, 200, 300]
plt.plot(time, position)
plt.xlabel('Time (hr)’)
plt.ylabel('Position (km)’)
plt.show()
```

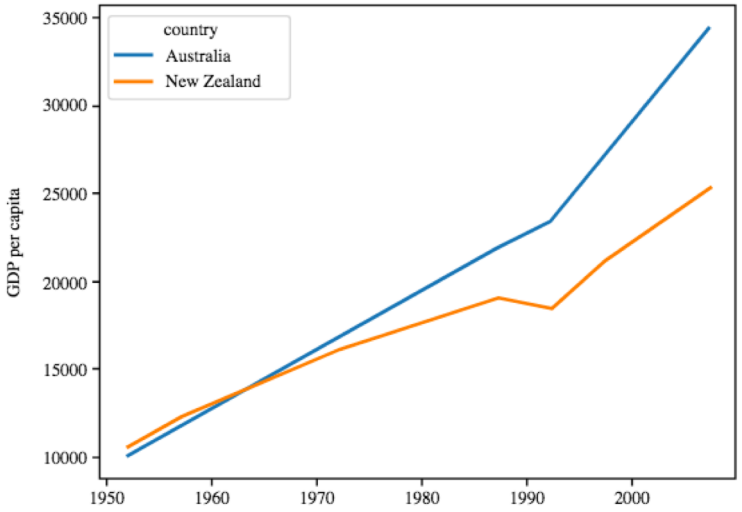


# Plotting + DataFrame

```
import pandas as pd
data =
pd.read_csv('data/gapminder_gdp_oceania.csv'
, index_col='country')
years = data.columns.str.strip('gdpPercap_')
data.columns = years.astype(int)
data.loc['Australia'].plot()
```



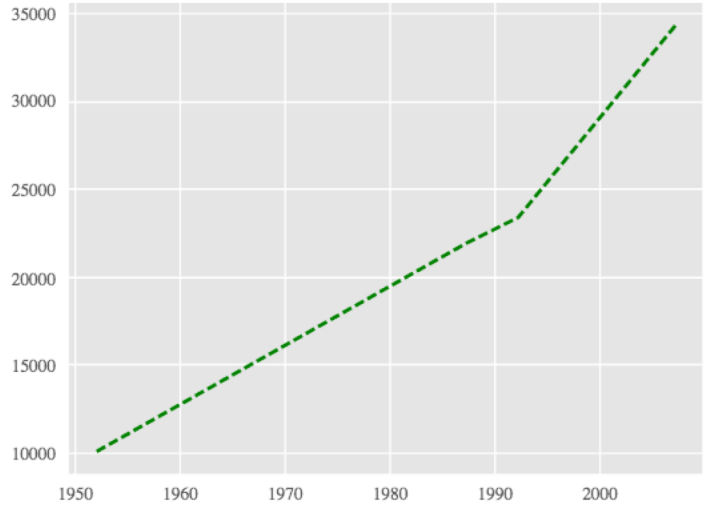

```
data.T.plot()
plt.ylabel('GDP per capita')
```



# Plotting + DataFrames

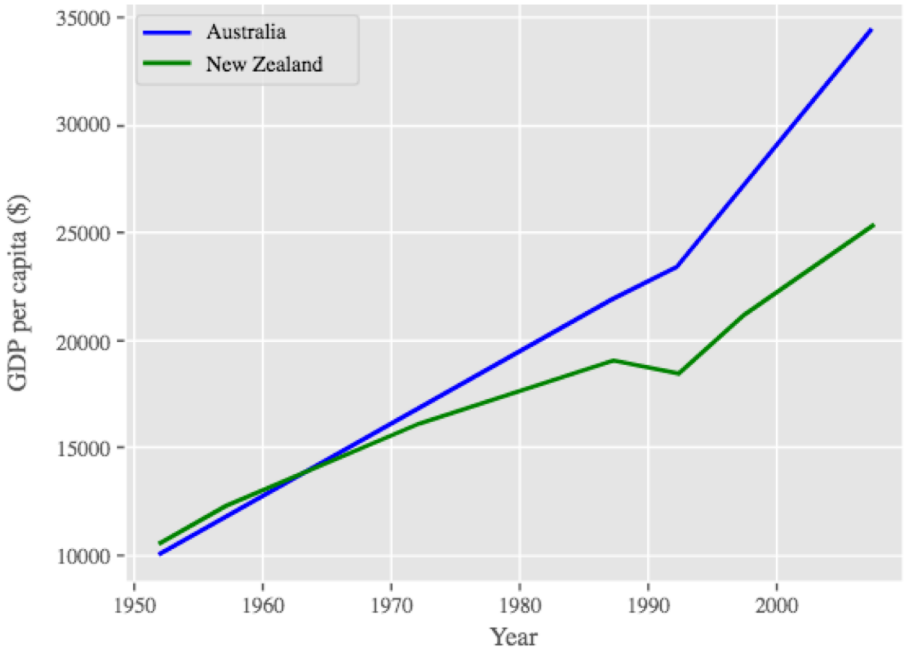
```
plt.style.use('ggplot’)
data.T.plot(kind='bar’)
plt.ylabel('GDP per capita')
```


```
years = data.columns
gdp_australia = data.loc['Australia’]
plt.plot(years, gdp_australia, 'g--')
```



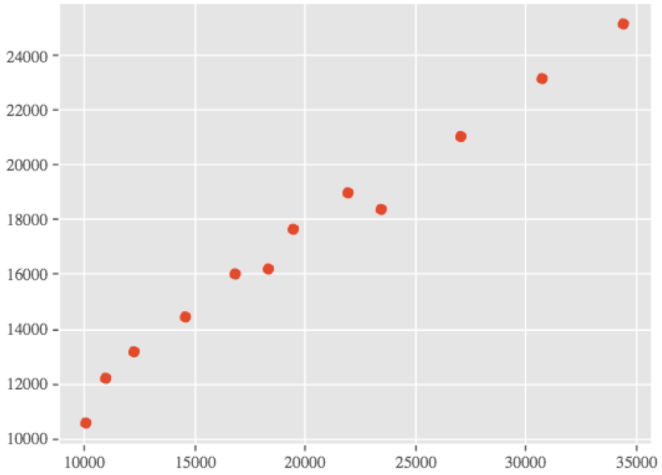
# Plotting

```
# Select two countries' worth of data.
gdp_australia = data.loc['Australia']
gdp_nz = data.loc['New Zealand']

plt.plot(years, gdp_australia, 'b-', label='Australia')
plt.plot(years, gdp_nz, 'g-', label='New Zealand')

plt.legend(loc='upper left')
plt.xlabel('Year')
plt.ylabel('GDP per capita ($)')
```

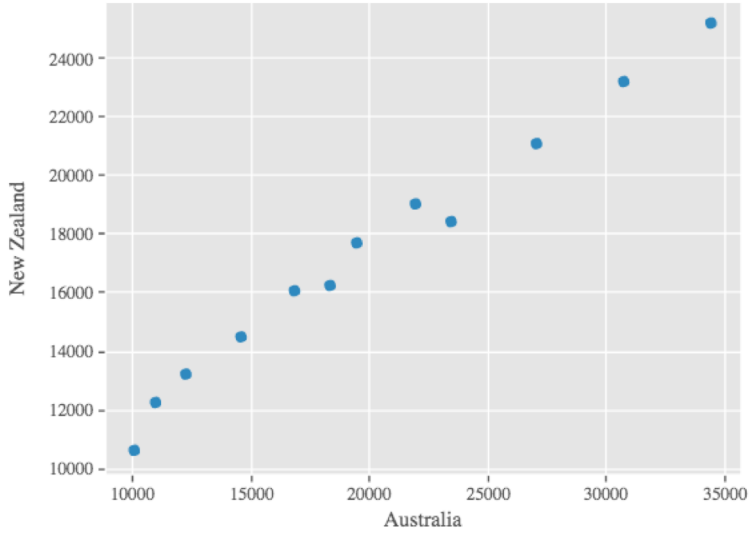


# Plotting

plt.scatter(gdp_australia, gdp_nz)



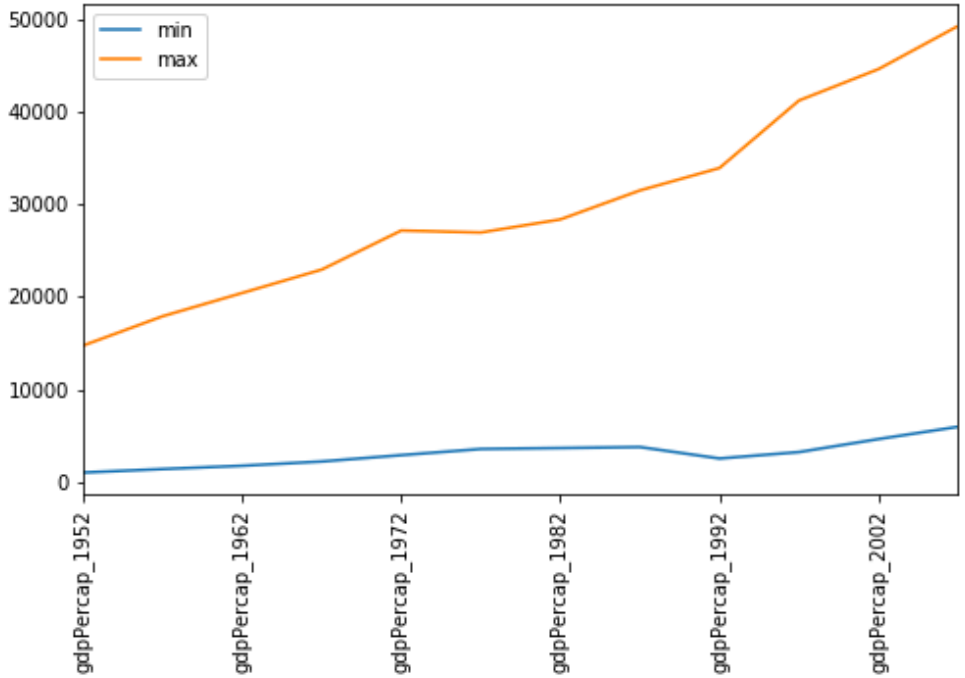

data.T.plot.scatter(x = 'Australia', y = 'New Zealand')



# Plotting-Practice

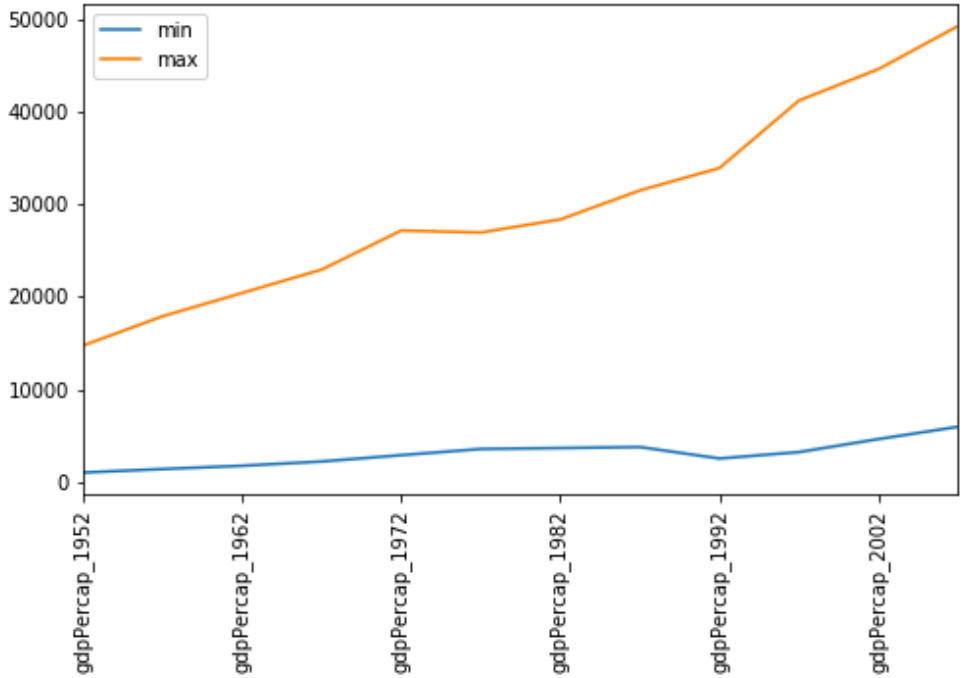
Fill in the blanks below to plot the minimum GDP per capita over time for all the countries in Europe. Modify it again to plot the maximum GDP per capita over time for Europe.

```
data_europe = pd.read_csv('data/gapmind
index_col='country’)

data_europe.____.plot(label='min’)
data_europe.____
plt.legend(loc='best’)
plt.xticks(rotation=90)
```



# Plotting-Practice

```
data_europe = pd.read_csv('data/gapminder_gdp_europe.csv',
index_col='country’)

data_europe.min().plot(label='min’)
data_europe.max().plot(label='max’)
plt.legend(loc='best’)
plt.xticks(rotation=90)
```



# Plotting-Saving

- plt.savefig('my_figure.png’)
- plt refer to a global figure variable and after a figure has been displayed to the screen
- *Make sure you call plt.savefig before the plot is displayed to the* screen,
- fig = plt.gcf() *# get current figure*
- data.plot(kind='bar’)
- fig.savefig('my_figure.png')

# Keypoints

- matplotlib is the most widely used scientific plotting library in Python.
- Plot data directly from a Pandas dataframe.
- Select and transform data, then plot it.
- Many styles of plot are available: see the Python Graph Gallery for more options.
- Can plot many sets of data together.