Introduction to Matplotlib and Line Plots

Introduction

The aim of these labs is to introduce you to data visualization with Python as concrete and as consistent as possible. Speaking of consistency, because there is no *best* data visualization library avaiblable for Python - up to creating these labs - we have to introduce different libraries and show their benefits when we are discussing new visualization concepts. Doing so, we hope to make students well-rounded with visualization libraries and concepts so that they are able to judge and decide on the best visualitzation technique and tool for a given problem *and* audience.

Please make sure that you have completed the prerequisites for this course, namely **Python for Data Science** and **Data Analysis with Python**, which are part of this specialization.

Note: The majority of the plots and visualizations will be generated using data stored in *pandas* dataframes. Therefore, in this lab, we provide a brief crash course on *pandas*. However, if you are interested in learning more about the *pandas* library, detailed description and explanation of how to use it and how to clean, munge, and process data stored in a *pandas* dataframe are provided in our course **Data Analysis with Python**, which is also part of this specialization.

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Exploring Datasets with *pandas*

pandas is an essential data analysis toolkit for Python. From their website:

> *pandas* is a Python package providing fast, flexible, and expressive data structures designed to make working with "relational" or "labeled" data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, **real world** data analysis in Python.

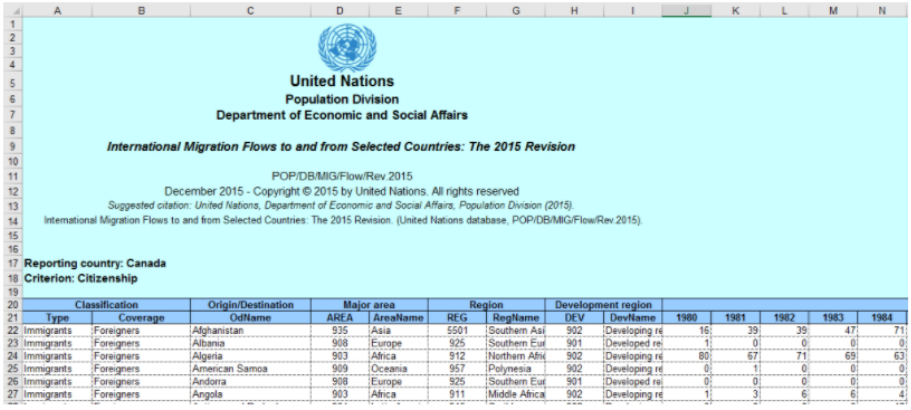
The course heavily relies on *pandas* for data wrangling, analysis, and visualization. We encourage you to spend some time and familizare yourself with the *pandas* API Reference: http://pandas.pydata.org/pandas-docs/stable/api.html.

The Dataset: Immigration to Canada from 1980 to 2013

Dataset Source: International migration flows to and from selected countries - The 2015 revision.

The dataset contains annual data on the flows of international immigrants as recorded by the countries of destination. The data presents both inflows and outflows according to the place of birth, citizenship or place of previous / next residence both for foreigners and nationals. The current version presents data pertaining to 45 countries.

In this lab, we will focus on the Canadian immigration data.



United Nations
Population Division
Department of Economic and Social Affairs

International Migration Flows to and from Selected Countries: The 2015 Revision

POP/DB/MIG/Flow/Rev.2015
December 2015 - Copyright © 2015 by United Nations. All rights reserved
Suggested citation: United Nations, Department of Economic and Social Affairs, Population Division (2015).
International Migration Flows to and from Selected Countries: The 2015 Revision. (United Nations database, POP/DB/MIG/Flow/Rev.2015).

Reporting country: Canada
Criterion: Citizenship

Classification		Origin/Destination	Major area		Region		Development region						
Type	Coverage	OdName	AREA	AreaName	REG	RegName	DEV	DevName	1980	1981	1982	1983	1984
Immigrants	Foreigners	Afghanistan	935	Asia	5501	Southern Asi	902	Developing re	16	39	39	47	71
Immigrants	Foreigners	Albania	908	Europe	925	Southern Eur	901	Developed re	1	0	0	0	0
Immigrants	Foreigners	Algeria	903	Africa	912	Northern Afri	902	Developing re	80	67	71	69	63
Immigrants	Foreigners	American Samoa	909	Oceania	957	Polynesia	902	Developing re	0	1	0	0	0
Immigrants	Foreigners	Andorra	908	Europe	925	Southern Eur	901	Developed re	0	0	0	0	0
Immigrants	Foreigners	Angola	903	Africa	911	Middle Africa	902	Developing re	1	3	6	6	4

For sake of simplicity, Canada's immigration data has been extracted and uploaded to one of IBM servers. You can fetch the data from here.

---

pandas Basics

The first thing we'll do is import two key data analysis modules: *pandas* and **Numpy**.

[1]:
```
import numpy as np  # useful for many scientific computing in Python
import pandas as pd # primary data structure library
```

Let's download and import our primary Canadian Immigration dataset using *pandas* `read_excel()` method. Normally, before we can do that, we would need to download a module which *pandas* requires to read in excel files. This module is **xlrd**. For your convenience, we have pre-installed this module, so you would not have to worry about that. Otherwise, you would need to run the following line of code to install the **xlrd** module:

```
!conda install -c anaconda xlrd --yes
```

Now we are ready to read in our data.

[5]:
```
df_can = pd.read_excel('https://s3-api.us-geo.objectstorage.softlayer.net/cf-courses-data/CognitiveClass/DV0101EN/labs/Data_Files/Canada.xlsx',
                       sheet_name='Canada by Citizenship',
                       skiprows=range(20),
                       skipfooter=2)

print ('Data read into a pandas dataframe!')
```

```
Data read into a pandas dataframe!
```

Let's view the top 5 rows of the dataset using the `head()` function.

[6]:
```
df_can.head()
# tip: You can specify the number of rows you'd like to see as follows: df_can.head(10)
```

[6]:

	Type	Coverage	OdName	AREA	AreaName	REG	RegName	DEV	DevName	1980	...	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	Immigrants	Foreigners	Afghanistan	935	Asia	5501	Southern Asia	902	Developing regions	16	...	2978	3436	3009	2652	2111	1746	1758	2203	2635	2004
1	Immigrants	Foreigners	Albania	908	Europe	925	Southern Europe	901	Developed regions	1	...	1450	1223	856	702	560	716	561	539	620	603
2	Immigrants	Foreigners	Algeria	903	Africa	912	Northern Africa	902	Developing regions	80	...	3616	3626	4807	3623	4005	5393	4752	4325	3774	4331
3	Immigrants	Foreigners	American Samoa	909	Oceania	957	Polynesia	902	Developing regions	0	...	0	0	1	0	0	0	0	0	0	0
4	Immigrants	Foreigners	Andorra	908	Europe	925	Southern Europe	901	Developed regions	0	...	0	0	1	1	0	0	0	0	1	1

5 rows × 43 columns

We can also veiw the bottom 5 rows of the dataset using the `tail()` function.

[7]:
```
df_can.tail()
```

[7]:

	Type	Coverage	OdName	AREA	AreaName	REG	RegName	DEV	DevName	1980	...	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
190	Immigrants	Foreigners	Viet Nam	935	Asia	920	South-Eastern Asia	902	Developing regions	1191	...	1816	1852	3153	2574	1784	2171	1942	1723	1731	2112
191	Immigrants	Foreigners	Western Sahara	903	Africa	912	Northern Africa	902	Developing regions	0	...	0	0	1	0	0	0	0	0	0	0
192	Immigrants	Foreigners	Yemen	935	Asia	922	Western Asia	902	Developing regions	1	...	124	161	140	122	133	128	211	160	174	217
193	Immigrants	Foreigners	Zambia	903	Africa	910	Eastern Africa	902	Developing regions	11	...	56	91	77	71	64	60	102	69	46	59
194	Immigrants	Foreigners	Zimbabwe	903	Africa	910	Eastern Africa	902	Developing regions	72	...	1450	615	454	663	611	508	494	434	437	407

5 rows × 43 columns

When analyzing a dataset, it's always a good idea to start by getting basic information about your dataframe. We can do this by using the `info()` method.

[8]:
```
df_can.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 195 entries, 0 to 194
Data columns (total 43 columns):
Type        195 non-null object
Coverage    195 non-null object
OdName      195 non-null object
AREA        195 non-null int64
AreaName    195 non-null object
REG         195 non-null int64
RegName     195 non-null object
DEV         195 non-null int64
DevName     195 non-null object
1980        195 non-null int64
```

To get the list of column headers we can call upon the dataframe's `.columns` parameter.

[9]:
```
df_can.columns.values
```

[9]:
```
array(['Type', 'Coverage', 'OdName', 'AREA', 'AreaName', 'REG', 'RegName',
       'DEV', 'DevName', 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987,
       1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998,
       1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009,
       2010, 2011, 2012, 2013], dtype=object)
```

Similarly, to get the list of indicies we use the `.index` parameter.

[10]:
```
df_can.index.values
```

[10]:
```
array([  0,   1,   2,   3,   4,   5,   6,   7,   8,   9,  10,  11,  12,
        13,  14,  15,  16,  17,  18,  19,  20,  21,  22,  23,  24,  25,
        26,  27,  28,  29,  30,  31,  32,  33,  34,  35,  36,  37,  38,
        39,  40,  41,  42,  43,  44,  45,  46,  47,  48,  49,  50,  51,
        52,  53,  54,  55,  56,  57,  58,  59,  60,  61,  62,  63,  64,
        65,  66,  67,  68,  69,  70,  71,  72,  73,  74,  75,  76,  77,
        78,  79,  80,  81,  82,  83,  84,  85,  86,  87,  88,  89,  90,
        91,  92,  93,  94,  95,  96,  97,  98,  99, 100, 101, 102, 103,
       104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116,
       117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129,
       130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142,
       143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155,
       156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168,
```

Note: The default type of index and columns is NOT list.

[11]:
```
print(type(df_can.columns))
print(type(df_can.index))
```

```
<class 'pandas.core.indexes.base.Index'>
<class 'pandas.core.indexes.range.RangeIndex'>
```

To get the index and columns as lists, we can use the `tolist()` method.

To get the index and columns as lists, we can use the `tolist()` method.

[12]:
```
df_can.columns.tolist()
df_can.index.tolist()

print (type(df_can.columns.tolist()))
print (type(df_can.index.tolist()))
```

```
<class 'list'>
<class 'list'>
```

To view the dimensions of the dataframe, we use the `.shape` parameter.

[13]:
```
# size of dataframe (rows, columns)
df_can.shape
```

[13]:
```
(195, 43)
```

Note: The main types stored in *pandas* objects are *float, int, bool, datetime64[ns]* and *datetime64[ns, tz] (in >= 0.17.0), timedelta[ns], category (in >= 0.15.0)*, and *object* (string). In addition these dtypes have item sizes, e.g. int64 and int32.

Let's clean the data set to remove a few unnecessary columns. We can use *pandas* `drop()` method as follows:

[14]:
```
# in pandas axis=0 represents rows (default) and axis=1 represents columns.
df_can.drop(['AREA','REG','DEV','Type','Coverage'], axis=1, inplace=True)
df_can.head(2)
```

[14]:

	OdName	AreaName	RegName	DevName	1980	1981	1982	1983	1984	1985	...	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
0	Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	...	2978	3436	3009	2652	2111	1746	1758	2203	2635	2004
1	Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	...	1450	1223	856	702	560	716	561	539	620	603

2 rows × 38 columns

Let's rename the columns so that they make sense. We can use `rename()` method by passing in a dictionary of old and new names as follows:

[15]:
```
df_can.rename(columns={'OdName':'Country', 'AreaName':'Continent', 'RegName':'Region'}, inplace=True)
df_can.columns
```

[15]:
```
Index([  'Country', 'Continent',    'Region',   'DevName',        1980,
              1981,        1982,        1983,        1984,        1985,
              1986,        1987,        1988,        1989,        1990,
              1991,        1992,        1993,        1994,        1995,
              1996,        1997,        1998,        1999,        2000,
              2001,        2002,        2003,        2004,        2005,
              2006,        2007,        2008,        2009,        2010,
              2011,        2012,        2013],
      dtype='object')
```

We will also add a 'Total' column that sums up the total immigrants by country over the entire period 1980 - 2013, as follows:

[16]:
```
df_can['Total'] = df_can.sum(axis=1)
```

We can check to see how many null objects we have in the dataset as follows:

[17]:
```
df_can.isnull().sum()
```

[17]:
```
Country      0
Continent    0
Region       0
DevName      0
1980         0
1981         0
1982         0
1983         0
1984         0
1985         0
1986         0
1987         0
1988         0
```

Finally, let's view a quick summary of each column in our dataframe using the `describe()` method.

[18]:
```
df_can.describe()
```

[18]:

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	...	2005	2006	200
count	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	195.000000	...	195.000000	195.000000	195.00000
mean	508.394872	566.989744	534.723077	387.435897	376.497436	358.861538	441.271795	691.133333	714.389744	843.241026	...	1320.292308	1266.958974	1191.8205
std	1949.588546	2152.643752	1866.997511	1204.333597	1198.246371	1079.309600	1225.576630	2109.205607	2443.606788	2555.048874	...	4425.957828	3926.717747	3443.5424
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	...	0.000000	0.000000	0.0000
25%	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.500000	0.500000	1.000000	1.000000	...	28.500000	25.000000	31.00000
50%	13.000000	10.000000	11.000000	12.000000	13.000000	17.000000	18.000000	26.000000	34.000000	44.000000	...	210.000000	218.000000	198.00000
75%	251.500000	295.500000	275.000000	173.000000	181.000000	197.000000	254.000000	434.000000	409.000000	508.500000	...	832.000000	842.000000	899.00000
max	22045.000000	24796.000000	20620.000000	10015.000000	10170.000000	9564.000000	9470.000000	21337.000000	27359.000000	23795.000000	...	42584.000000	33848.000000	28742.00000

8 rows × 35 columns

---

pandas Intermediate: Indexing and Selection (slicing)

Select Column

There are two ways to filter on a column name:

Method 1: Quick and easy, but only works if the column name does NOT have spaces or special characters.

```
df.column_name
    (returns series)
```

Method 2: More robust, and can filter on multiple columns.

```
df['column']
    (returns series)
```

```
df[['column 1', 'column 2']]
    (returns dataframe)
```

Example: Let's try filtering on the list of countries ('Country').

[19]:
```
df_can.Country  # returns a series
```

[19]:
```
0         Afghanistan
1             Albania
2             Algeria
3      American Samoa
4             Andorra
           ...
190          Viet Nam
191    Western Sahara
192             Yemen
193            Zambia
194          Zimbabwe
Name: Country, Length: 195, dtype: object
```

Let's try filtering on the list of countries ('OdName') and the data for years: 1980 - 1985.

[20]:
```
df_can[['Country', 1980, 1981, 1982, 1983, 1984, 1985]] # returns a dataframe
# notice that 'Country' is string, and the years are integers.
# for the sake of consistency, we will convert all column names to string later on.
```

[20]:

	Country	1980	1981	1982	1983	1984	1985
0	Afghanistan	16	39	39	47	71	340
1	Albania	1	0	0	0	0	0
2	Algeria	80	67	71	69	63	44
3	American Samoa	0	1	0	0	0	0
4	Andorra	0	0	0	0	0	0
...	...	...	...	...	...	...	...
190	Viet Nam	1191	1829	2162	3404	7583	5907
191	Western Sahara	0	0	0	0	0	0
192	Yemen	1	2	1	6	0	18
193	Zambia	11	17	11	7	16	9
194	Zimbabwe	72	114	102	44	32	29

195 rows × 7 columns

Select Row

There are main 3 ways to select rows:

```
df.loc[label]
    #filters by the labels of the index/column
df.iloc[index]
    #filters by the positions of the index/column
```

Before we proceed, notice that the defaul index of the dataset is a numeric range from 0 to 194. This makes it very difficult to do a query by a specific country. For example to search for data on Japan, we need to know the corressponding index value.

This can be fixed very easily by setting the 'Country' column as the index using `set_index()` method.

[21]:
```
df_can.set_index('Country', inplace=True)
# tip: The opposite of set is reset. So to reset the index, we can use df_can.reset_index()
```

[22]:
```
df_can.head(3)
```

[22]:

Country	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986	...	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	496	...	3436	3009	2652	2111	1746	1758	2203	2635	2004	58639
Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	1	...	1223	856	702	560	716	561	539	620	603	15699
Algeria	Africa	Northern Africa	Developing regions	80	67	71	69	63	44	69	...	3626	4807	3623	4005	5393	4752	4325	3774	4331	69439

3 rows × 38 columns

[23]:
```
# optional: to remove the name of the index
df_can.index.name = None
```

Example: Let's view the number of immigrants from Japan (row 87) for the following scenarios: 1. The full row data (all columns) 2. For year 2013 3. For years 1980 to 1985

[24]:
```
# 1. the full row data (all columns)
print(df_can.loc['Japan'])

# alternate methods
print(df_can.iloc[87])
print(df_can[df_can.index == 'Japan'].T.squeeze())
```

```
Continent               Asia
Region           Eastern Asia
DevName      Developed regions
1980                       701
1981                       756
1982                       598
1983                       309
1984                       246
1985                       198
1986                       248
1987                       422
1988                       324
1989                       494
```

[26]:
```
# 2. for year 2013
print(df_can.loc['Japan', 2013])

# alternate method
print(df_can.iloc[87, 36]) # year 2013 is the last column, with a positional index of 36
```

```
982
982
```

[27]:
```
# 3. for years 1980 to 1985
print(df_can.loc['Japan', [1980, 1981, 1982, 1983, 1984, 1984]])
print(df_can.iloc[87, [3, 4, 5, 6, 7, 8]])
```

```
1980    701
1981    756
1982    598
1983    309
1984    246
1984    246
Name: Japan, dtype: object
```

Column names that are integers (such as the years) might introduce some confusion. For example, when we are referencing the year 2013, one might confuse that when the 2013th positional index.

To avoid this ambuigity, let's convert the column names into strings: '1980' to '2013'.

[28]:
```
df_can.columns = list(map(str, df_can.columns))
# [print (type(x)) for x in df_can.columns.values] #<-- uncomment to check type of column headers
```

Since we converted the years to string, let's declare a variable that will allow us to easily call upon the full range of years:

[29]:
```
# useful for plotting later on
years = list(map(str, range(1980, 2014)))
years
```

[29]:
```
['1980',
 '1981',
 '1982',
 '1983',
 '1984',
 '1985',
 '1986',
 '1987',
 '1988',
 '1989',
 '1990',
 '1991',
 '1992',
 '1993',
 '1994',
 '1995',
 '1996',
 '1997',
 '1998',
 '1999',
 '2000',
 '2001',
 '2002',
 '2003',
 '2004',
 '2005',
 '2006',
 '2007',
 '2008',
 '2009',
 '2010',
 '2011',
 '2012',
 '2013']
```

Filtering based on a criteria

To filter the dataframe based on a condition, we simply pass the condition as a boolean vector.

For example, Let's filter the dataframe to show the data on Asian countries (AreaName = Asia).

[30]:
```
# 1. create the condition boolean series
condition = df_can['Continent'] == 'Asia'
print(condition)
```

```
Afghanistan       True
Albania          False
Algeria          False
American Samoa   False
Andorra          False
                 ...
Viet Nam          True
Western Sahara   False
Yemen             True
Zambia           False
Zimbabwe         False
Name: Continent, Length: 195, dtype: bool
```

[31]:
```
# 2. pass this condition into the dataFrame
df_can[condition]
```

[31]:

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986	...	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	496	...	3436	3009	2652	2111	1746	1758	2203	2635	2004	58639
Armenia	Asia	Western Asia	Developing regions	0	0	0	0	0	0	0	...	224	218	198	205	267	252	236	258	207	3310
Azerbaijan	Asia	Western Asia	Developing regions	0	0	0	0	0	0	0	...	359	236	203	125	165	209	138	161	57	2649
Bahrain	Asia	Western Asia	Developing regions	0	2	1	1	1	3	0	...	12	12	22	9	35	28	21	39	32	475
Bangladesh	Asia	Southern Asia	Developing regions	83	84	86	81	98	92	486	...	4171	4014	2897	2939	2104	4721	2694	2640	3789	65568
Bhutan	Asia	Southern Asia	Developing regions	0	0	0	0	1	0	0	...	5	10	7	36	865	1464	1879	1075	487	5876
Brunei Darussalam	Asia	South-Eastern Asia	Developing regions	79	6	8	2	2	4	12	...	4	5	11	10	5	12	6	3	6	600
Cambodia	Asia	South-Eastern Asia	Developing regions	12	19	26	33	10	7	8	...	370	529	460	354	203	200	196	233	288	6538
China	Asia	Eastern Asia	Developing regions	5123	6682	3308	1863	1527	1816	1960	...	42584	33518	27642	30037	29622	30391	28502	33024	34129	659962
China, Hong Kong Special Administrative	Asia	Eastern Asia	Developing regions	0	0	0	0	0	0	0	...	729	712	674	897	657	623	591	728	774	9327

Region																					
China, Macao Special Administrative Region	Asia	Eastern Asia	Developing regions	0	0	0	0	0	0	0	...	21	32	16	12	21	21	13	33	29	284
Cyprus	Asia	Western Asia	Developing regions	132	128	84	46	46	43	48	...	7	9	4	7	6	18	6	12	16	1126
Democratic People's Republic of Korea	Asia	Eastern Asia	Developing regions	1	1	3	1	4	3	0	...	14	10	7	19	11	45	97	66	17	388
Georgia	Asia	Western Asia	Developing regions	0	0	0	0	0	0	0	...	114	125	132	112	128	126	139	147	125	2068
India	Asia	Southern Asia	Developing regions	8880	8670	8147	7338	5704	4211	7150	...	36210	33848	28742	28261	29456	34235	27509	30933	33087	691904
Indonesia	Asia	South-Eastern Asia	Developing regions	186	178	252	115	123	100	127	...	632	613	657	661	504	712	390	395	387	13150
Iran (Islamic Republic of)	Asia	Southern Asia	Developing regions	1172	1429	1822	1592	1977	1648	1794	...	5837	7480	6974	6475	6580	7477	7479	7534	11291	175923
Iraq	Asia	Western Asia	Developing regions	262	245	260	380	428	231	265	...	2226	1788	2406	3543	5450	5941	6196	4041	4918	69789
Israel	Asia	Western Asia	Developing regions	1403	1711	1334	541	446	680	1212	...	2446	2625	2401	2562	2316	2755	1970	2134	1945	66508
Japan	Asia	Eastern Asia	Developed regions	701	756	598	309	246	198	248	...	1067	1212	1250	1284	1194	1168	1265	1214	982	27707
Jordan	Asia	Western Asia	Developing regions	177	160	155	113	102	179	181	...	1940	1827	1421	1581	1235	1831	1635	1206	1255	35406
Kazakhstan	Asia	Central Asia	Developing regions	0	0	0	0	0	0	0	...	506	408	436	394	431	377	381	462	348	8490
Kuwait	Asia	Western Asia	Developing regions	1	0	8	2	1	4	4	...	66	35	62	53	68	67	58	73	48	2025
Kyrgyzstan	Asia	Central Asia	Developing regions	0	0	0	0	0	0	0	...	173	161	135	168	173	157	159	278	123	2353
Lao People's Democratic Republic	Asia	South-Eastern Asia	Developing regions	11	6	16	16	7	17	21	...	42	74	53	32	39	54	22	25	15	1089
Lebanon	Asia	Western Asia	Developing regions	1409	1119	1159	789	1253	1683	2576	...	3709	3802	3467	3566	3077	3432	3072	1614	2172	115359
Malaysia	Asia	South-Eastern Asia	Developing regions	786	816	813	448	384	374	425	...	593	580	600	658	640	802	409	358	204	24417
Maldives	Asia	Southern Asia	Developing regions	0	0	0	1	0	0	0	...	0	0	2	1	7	4	3	1	1	30
Mongolia	Asia	Eastern Asia	Developing regions	0	0	0	0	0	0	0	...	59	64	82	59	118	169	103	68	99	952
Myanmar	Asia	South-Eastern Asia	Developing regions	80	62	46	31	41	23	18	...	210	953	1887	975	1153	556	368	193	262	9245
Nepal	Asia	Southern Asia	Developing regions	1	1	6	1	2	4	13	...	607	540	511	581	561	1392	1129	1185	1308	10222
Oman	Asia	Western Asia	Developing regions	0	0	0	8	0	0	0	...	14	18	16	10	7	14	10	13	11	224
Pakistan	Asia	Southern Asia	Developing regions	978	972	1201	900	668	514	691	...	14314	13127	10124	8994	7217	6811	7468	11227	12603	241600
Philippines	Asia	South-Eastern Asia	Developing regions	6051	5921	5249	4562	3801	3150	4166	...	18139	18400	19837	24887	28573	38617	36765	34315	29544	511391
Qatar	Asia	Western Asia	Developing regions	0	0	0	0	0	0	1	...	11	2	5	9	6	18	3	14	6	157
Republic of Korea	Asia	Eastern Asia	Developing regions	1011	1456	1572	1081	847	962	1208	...	5832	6215	5920	7294	5874	5537	4588	5316	4509	142581
Saudi Arabia	Asia	Western Asia	Developing regions	0	0	1	4	1	2	5	...	198	252	188	249	246	330	278	286	267	3425
Singapore	Asia	South-Eastern Asia	Developing regions	241	301	337	169	128	139	205	...	392	298	690	734	366	805	219	146	141	14579
Sri Lanka	Asia	Southern Asia	Developing regions	185	371	290	197	1086	845	1838	...	4930	4714	4123	4756	4547	4422	3309	3338	2394	148358
State of Palestine	Asia	Western Asia	Developing regions	0	0	0	0	0	0	0	...	453	627	441	481	400	654	555	533	462	6512
Syrian Arab Republic	Asia	Western Asia	Developing regions	315	419	409	269	264	385	493	...	1458	1145	1056	919	917	1039	1005	650	1009	31485
Tajikistan	Asia	Central Asia	Developing regions	0	0	0	0	0	0	0	...	85	46	44	15	50	52	47	34	39	503
Thailand	Asia	South-Eastern Asia	Developing regions	56	53	113	65	82	66	78	...	575	500	487	519	512	499	396	296	400	9174
Turkey	Asia	Western Asia	Developing regions	481	874	706	280	338	202	257	...	2065	1638	1463	1122	1238	1492	1257	1068	729	31781
Turkmenistan	Asia	Central Asia	Developing regions	0	0	0	0	0	0	0	...	40	26	37	13	20	30	20	20	14	310
United Arab Emirates	Asia	Western Asia	Developing regions	0	2	2	1	2	0	5	...	31	42	37	33	37	86	60	54	46	836
Uzbekistan	Asia	Central Asia	Developing regions	0	0	0	0	0	0	0	...	330	262	284	215	288	289	162	235	167	3368
Viet Nam	Asia	South-Eastern Asia	Developing regions	1191	1829	2162	3404	7583	5907	2741	...	1852	3153	2574	1784	2171	1942	1723	1731	2112	97146
Yemen	Asia	Western Asia	Developing regions	1	2	1	6	0	18	7	...	161	140	122	133	128	211	160	174	217	2985

49 rows × 38 columns

[32]:
```
# we can pass mutliple criteria in the same line.
# let's filter for AreaNAme = Asia and RegName = Southern Asia
```

```
df_can[(df_can['Continent']=='Asia') & (df_can['Region']=='Southern Asia')]

# note: When using 'and' and 'or' operators, pandas requires we use '&' and '|' instead of 'and' and 'or'
# don't forget to enclose the two conditions in parentheses
```

[32]:

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986	...	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	496	...	3436	3009	2652	2111	1746	1758	2203	2635	2004	58639
Bangladesh	Asia	Southern Asia	Developing regions	83	84	86	81	98	92	486	...	4171	4014	2897	2939	2104	4721	2694	2640	3789	65568
Bhutan	Asia	Southern Asia	Developing regions	0	0	0	0	1	0	0	...	5	10	7	36	865	1464	1879	1075	487	5876
India	Asia	Southern Asia	Developing regions	8880	8670	8147	7338	5704	4211	7150	...	36210	33848	28742	28261	29456	34235	27509	30933	33087	691904
Iran (Islamic Republic of)	Asia	Southern Asia	Developing regions	1172	1429	1822	1592	1977	1648	1794	...	5837	7480	6974	6475	6580	7477	7479	7534	11291	175923
Maldives	Asia	Southern Asia	Developing regions	0	0	0	1	0	0	0	...	0	0	2	1	7	4	3	1	1	30
Nepal	Asia	Southern Asia	Developing regions	1	1	6	1	2	4	13	...	607	540	511	581	561	1392	1129	1185	1308	10222
Pakistan	Asia	Southern Asia	Developing regions	978	972	1201	900	668	514	691	...	14314	13127	10124	8994	7217	6811	7468	11227	12603	241600
Sri Lanka	Asia	Southern Asia	Developing regions	185	371	290	197	1086	845	1838	...	4930	4714	4123	4756	4547	4422	3309	3338	2394	148358

9 rows × 38 columns

Before we proceed: let's review the changes we have made to our dataframe.

[33]:
```
print('data dimensions:', df_can.shape)
print(df_can.columns)
df_can.head(2)
```

```
data dimensions: (195, 38)
Index(['Continent', 'Region', 'DevName', '1980', '1981', '1982', '1983',
       '1984', '1985', '1986', '1987', '1988', '1989', '1990', '1991', '1992',
       '1993', '1994', '1995', '1996', '1997', '1998', '1999', '2000', '2001',
       '2002', '2003', '2004', '2005', '2006', '2007', '2008', '2009', '2010',
       '2011', '2012', '2013', 'Total'],
      dtype='object')
```

[33]:

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986	...	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	496	...	3436	3009	2652	2111	1746	1758	2203	2635	2004	58639
Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	1	...	1223	856	702	560	716	561	539	620	603	15699

Visualizing Data using Matplotlib

Matplotlib: Standard Python Visualization Library

The primary plotting library we will explore in the course is Matplotlib. As mentioned on their website:

> Matplotlib is a Python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms. Matplotlib can be used in Python scripts, the Python and IPython shell, the jupyter notebook, web application servers, and four graphical user interface toolkits.

If you are aspiring to create impactful visualization with python, Matplotlib is an essential tool to have at your disposal.

Matplotlib.Pyplot

One of the core aspects of Matplotlib is `matplotlib.pyplot`. It is Matplotlib's scripting layer which we studied in details in the videos about Matplotlib. Recall that it is a collection of command style functions that make Matplotlib work like MATLAB. Each `pyplot` function makes some change to a figure: e.g., creates a figure, creates a plotting area in a figure, plots some lines in a plotting area, decorates the plot with labels, etc. In this lab, we will work with the scripting layer to learn how to generate line plots. In future labs, we will get to work with the Artist layer as well to experiment first hand how it differs from the scripting layer.

Let's start by importing `Matplotlib` and `Matplotlib.pyplot` as follows:

[34]:
```
# we are using the inline backend
%matplotlib inline

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

*optional: check if Matplotlib is loaded.

[35]:
```
print ('Matplotlib version: ', mpl.__version__) # >= 2.0.0
```

```
Matplotlib version:  3.1.1
```

*optional: apply a style to Matplotlib.

[36]:
```
print(plt.style.available)
mpl.style.use(['ggplot']) # optional: for ggplot-like style
```

```
['Solarize_Light2', '_classic_test', 'bmh', 'classic', 'dark_background', 'fast', 'fivethirtyeight', 'ggplot', 'grayscale', 'seaborn-bright', 'seaborn-colorblind', 'seaborn-dark-palette', 'seaborn-dark', 'seaborn-darkgrid', 'seaborn-deep', 'seaborn-muted', 'seaborn-notebook', 'seaborn-paper', 'seaborn-pastel', 'seaborn-poster', 'seaborn-talk', 'seaborn-ticks', 'seaborn-white', 'seaborn-whitegrid', 'seaborn', 'tableau-colorblind10']
```

Plotting in *pandas*

Fortunately, pandas has a built-in implementation of Matplotlib that we can use. Plotting in *pandas* is as simple as appending a `.plot()` method to a series or dataframe.

Documentation:

- Plotting with Series
- Plotting with Dataframes

Line Pots (Series/Dataframe)

What is a line plot and why use it?

A line chart or line plot is a type of plot which displays information as a series of data points called 'markers' connected by straight line segments. It is a basic type of chart common in many fields. Use line plot when you have a continuous data set. These are best suited for trend-based visualizations of data over a period of time.

Let's start with a case study:

In 2010, Haiti suffered a catastrophic magnitude 7.0 earthquake. The quake caused widespread devastation and loss of life and aout three million people were affected by this natural disaster. As part of Canada's humanitarian effort, the Government of Canada stepped up its effort in accepting refugees from Haiti. We can quickly visualize this effort using a `Line` plot:

Question: Plot a line graph of immigration from Haiti using `df.plot()`.

First, we will extract the data series for Haiti.

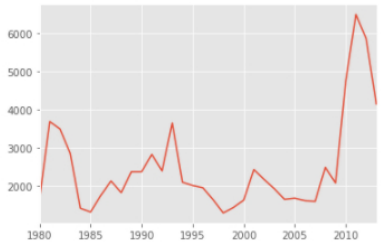
[37]:
```
haiti = df_can.loc['Haiti', years] # passing in years 1980 - 2013 to exclude the 'total' column
haiti.head()
```

[37]:
```
1980    1666
1981    3692
1982    3498
1983    2860
1984    1418
Name: Haiti, dtype: object
```

Next, we will plot a line plot by appending `.plot()` to the `haiti` dataframe.

[38]:
```
haiti.plot()
```

[38]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f07e0e595f8>
```



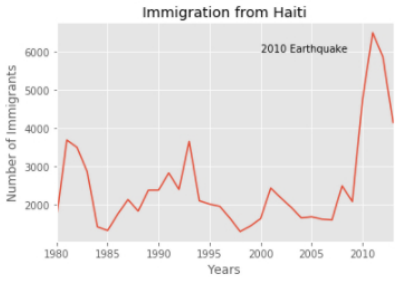
pandas automatically populated the x-axis with the index values (years), and the y-axis with the column values (population). However, notice how the years were not displayed because they are of type *string*. Therefore, let's change the type of the index values to *integer* for plotting.

Also, let's label the x and y axis using `plt.title()`, `plt.ylabel()`, and `plt.xlabel()` as follows:

[39]:
```
haiti.index = haiti.index.map(int) # let's change the index values of Haiti to type integer for plotting
haiti.plot(kind='line')

plt.title('Immigration from Haiti')
plt.ylabel('Number of immigrants')
plt.xlabel('Years')

plt.show() # need this line to show the updates made to the figure
```

We can clearly notice how number of immigrants from Haiti spiked up from 2010 as Canada stepped up its efforts to accept refugees from Haiti. Let's annotate this spike in the plot by using the `plt.text()` method.

[40]:
```
haiti.plot(kind='line')

plt.title('Immigration from Haiti')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')

# annotate the 2010 Earthquake.
# syntax: plt.text(x, y, label)
plt.text(2000, 6000, '2010 Earthquake') # see note below

plt.show()
```



With just a few lines of code, you were able to quickly identify and visualize the spike in immigration!

Quick note on x and y values in `plt.text(x, y, label)`:

Since the x-axis (years) is type 'integer', we specified x as a year. The y axis (number of immigrants) is type 'integer', so we can just specify the value y = 6000.

```
plt.text(2000, 6000, '2010 Earthquake') # years stored as type int
```

If the years were stored as type 'string', we would need to specify x as the index position of the year. Eg 20th index is year 2000 since it is the 20th year with a base year of 1980.

```
plt.text(20, 6000, '2010 Earthquake') # years stored as type int
```

We will cover advanced annotation methods in later modules.

We can easily add more countries to line plot to make meaningful comparisons immigration from different countries.

Question: Let's compare the number of immigrants from India and China from 1980 to 2013.

Step 1: Get the data set for China and India, and display dataframe.

[41]:
```
### type your answer here
df_CI = df_can.loc[['India', 'China'], years]
df_CI.head()
```

[41]:

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	...	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
India	8880	8670	8147	7338	5704	4211	7150	10189	11522	10343	...	28235	36210	33848	28742	28261	29456	34235	27509	30933	33087
China	5123	6682	3308	1863	1527	1816	1960	2643	2758	4323	...	36619	42584	33518	27642	30037	29622	30391	28502	33024	34129

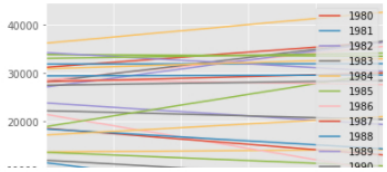
2 rows × 34 columns

Double-click **here** for the solution.

Step 2: Plot graph. We will explicitly specify line plot by passing in `kind` parameter to `plot()`.

[42]:
```
### type your answer here

df_CI.plot(kind='line')
```

[42]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f07e082aa90>
```



Double-click **here** for the solution.

That doesn't look right...

Recall that *pandas* plots the indices on the x-axis and the columns as individual lines on the y-axis. Since `df_CI` is a dataframe with the `country` as the index and `years` as the columns, we must first transpose the dataframe using `transpose()` method to swap the row and columns.

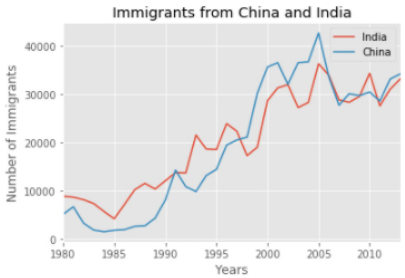
[43]:
```
df_CI = df_CI.transpose()
df_CI.head()
```

[43]:

	India	China
1980	8880	5123
1981	8670	6682
1982	8147	3308
1983	7338	1863
1984	5704	1527

pandas will auomatically graph the two countries on the same graph. Go ahead and plot the new transposed dataframe. Make sure to add a title to the plot and label the axes.

[46]:
```
### type your answer here


df_CI.index = df_CI.index.map(int) # let's change the index values of df_CI to type integer for plotting
df_CI.plot(kind='line')

plt.title('Immigrants from China and India')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')


plt.show()
```



Double-click **here** for the solution.

From the above plot, we can observe that the China and India have very similar immigration trends through the years.

Note: How come we didn't need to transpose Haiti's dataframe before plotting (like we did for df_CI)?

That's because `haiti` is a series as opposed to a dataframe, and has the years as its indices as shown below.

```
print(type(haiti))
print(haiti.head(5))
```

```
class 'pandas.core.series.Series'
1980 1666
1981 3692
1982 3498
1983 2860
1984 1418
Name: Haiti, dtype: int64
```

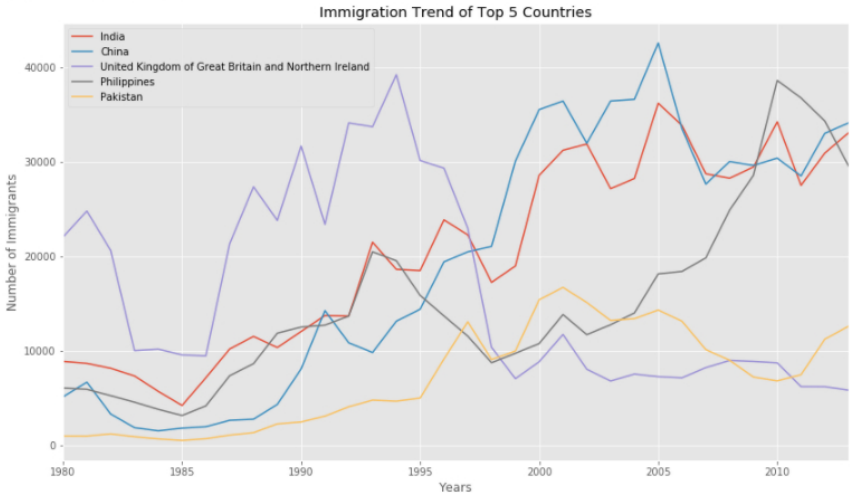
Line plot is a handy tool to display several dependent variables against one independent variable. However, it is recommended that no more than 5-10 lines on a single graph; any more than that and it becomes difficult to interpret.

Question: Compare the trend of top 5 countries that contributed the most to immigration to Canada.

[51]:
```
df_can.sort_values(by='Total', ascending=False, axis=0, inplace=True)


# get the top 5 entries
df_top5 = df_can.head(5)


# transpose the dataframe
df_top5 = df_top5[years].transpose()


print(df_top5)



df_top5.index = df_top5.index.map(int)
df_top5.plot(kind='line', figsize=(14, 8))


plt.title('Immigration Trend of Top 5 Countries')
plt.ylabel('Number of Immigrants')
plt.xlabel('Years')


plt.show()
```

```
      India  China  United Kingdom of Great Britain and Northern Ireland  \
1980   8880   5123                                              22045
1981   8670   6682                                              24796
1982   8147   3308                                              20620
1983   7338   1863                                              10015
1984   5704   1527                                              10170
1985   4211   1816                                               9564
1986   7150   1960                                               9470
1987  10189   2643                                              21337
1988  11522   2758                                              27359
1989  10343   4323                                              23795
1990  12041   8076                                              31668
1991  13734  14255                                              23380
1992  13673  10846                                              34123
1993  21496   9817                                              33720
1994  18620  13128                                              39231
1995  18489  14398                                              30145
1996  23859  19415                                              29322
1997  22268  20475                                              22965
1998  17241  21049                                              10367
1999  18974  30069                                               7045
2000  28572  35529                                               8840
2001  31223  36434                                              11728
2002  31889  31961                                               8046
2003  27155  36439                                               6797
2004  28235  36619                                               7533
2005  36210  42584                                               7258
2006  33848  33518                                               7140
2007  28742  27642                                               8216
2008  28261  30037                                               8979
2009  29456  29622                                               8876
2010  34235  30391                                               8724
2011  27509  28502                                               6204
2012  30933  33024                                               6195
2013  33087  34129                                               5827

      Philippines  Pakistan
1980         6051       978
1981         5921       972
1982         5249      1201
1983         4562       900
1984         3801       668
1985         3150       514
1986         4166       691
1987         7360      1072
1988         8639      1334
1989        11865      2261
1990        12509      2470
1991        12718      3079
1992        13670      4071
1993        20479      4777
1994        19532      4666
1995        15864      4994
1996        13692      9125
1997        11549     13073
1998         8735      9068
1999         9734      9979
```

```
2000    10763    15400
2001    13836    16708
2002    11707    15110
2003    12758    13205
2004    14004    13399
2005    18139    14314
2006    18400    13127
2007    19837    10124
2008    24887     8994
2009    28573     7217
2010    38617     6811
2011    36765     7468
2012    34315    11227
2013    29544    12603
```



Double-click **here** for the solution.

Other Plots

Congratulations! you have learned how to wrangle data with python and create a line plot with Matplotlib. There are many other plotting styles available other than the default Line plot, all of which can be accessed by passing `kind` keyword to `plot()`. The full list of available plots are as follows:

- `bar` for vertical bar plots
- `barh` for horizontal bar plots
- `hist` for histogram
- `box` for boxplot
- `kde` or `density` for density plots
- `area` for area plots
- `pie` for pie plots
- `scatter` for scatter plots
- `hexbin` for hexbin plot

Thank you for completing this lab!

This notebook was originally created by Jay Rajasekharan with contributions from Ehsan M. Kermani, and Slobodan Markovic.

This notebook was recently revised by Alex Aklson. I hope you found this lab session interesting. Feel free to contact me if you have any questions!

This notebook is part of a course on **Coursera** called *Data Visualization with Python*. If you accessed this notebook outside the course, you can take this course online by clicking here.
