Introduction to Matplotlib and Line Plots

Estimated time needed: **20** minutes

Objectives

After completing this lab you will be able to:

- Create Data Visualization with Python
- Use various Python libraries for visualization

Introduction

The aim of these labs is to introduce you to introduction you to Matplotlib and creating Line Plots. Please make sure that you have completed the previous courses based on python.

Table of Contents

pandas Refresher

The course heavily relies on *pandas* for data wrangling, analysis. Refresh your Panads skill quickly with the lab on Data pre-processing with Pandas

pandas is an essential data analysis toolkit for Python.

We encourage you to spend some time and familiarize yourself with the *pandas* from the website

The Dataset: Immigration to Canada from 1980 to 2013

Dataset Source: International migration flows to and from selected countries - The 2015 revision. In this lab, we will focus on the Canadian immigration data.

We have already **pre-processed** the data, we will use the **clean data** saved in the csv format for this lab. The Canada Immigration dataset can be fetched from here.

Next, we'll do is import two key data analysis modules: *pandas* and *numpy*

In [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*'s `read_csv()` method.

In [2]:
```
df_can = pd.read_csv('https://cf-courses-data.s3.us.cloud-object-storage.appdomain.clou

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.

In [3]:
```
df_can.head()
# tip: You can specify the number of rows you'd like to see as follows: df_can.head(10)
```

Out[3]:

	Country	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	...	2005	2006
0	Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	...	3436	3009
1	Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	...	1223	856
2	Algeria	Africa	Northern Africa	Developing regions	80	67	71	69	63	44	...	3626	4807
3	American Samoa	Oceania	Polynesia	Developing regions	0	1	0	0	0	0	...	0	1
4	Andorra	Europe	Southern Europe	Developed regions	0	0	0	0	0	0	...	0	1

5 rows × 39 columns

Let's set Country as the index, it will help you to plot the charts easily, by refering to the country names as index value

In [4]:
```
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_ind
```

In [5]:
```
#Let's check
df_can.head(3)
```

Out[5]:

Country	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986	...	2005	2(
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	496	...	3436	3(
Albania	Europe	Southern Europe	Developed regions	1	0	0	0	0	0	1	...	1223	
Algeria	Africa	Northern Africa	Developing regions	80	67	71	69	63	44	69	...	3626	4

3 rows × 38 columns

In [8]:
```
# optional: to remove the name of the index
df_can.index.name = None
df_can.head(1)
```

Out[8]:

	Continent	Region	DevName	1980	1981	1982	1983	1984	1985	1986	...	2005	2(
Afghanistan	Asia	Southern Asia	Developing regions	16	39	39	47	71	340	496	...	3436	3(

1 rows × 38 columns

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:

In [9]:
```
# useful for plotting later on
years = list(map(str, range(1980, 2014)))
years
```

Out[9]:
```
['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']
```

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:

In [10]:
```
# we are using the inline backend
%matplotlib inline

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

*optional: check if Matplotlib is loaded.

In [11]:
```
print('Matplotlib version: ', mpl.__version__)  # >= 2.0.0
```

```
Matplotlib version:  3.5.3
```

*optional: apply a style to Matplotlib.

In [12]:
```
print(plt.style.available)
mpl.style.use(['ggplot']) # optional: for ggplot-like style
```

```
['Solarize_Light2', '_classic_test_patch', '_mpl-gallery', '_mpl-gallery-nogrid', 'bmh',
'classic', 'dark_background', 'fast', 'fivethirtyeight', 'ggplot', 'grayscale', 'seabor
n', 'seaborn-bright', 'seaborn-colorblind', 'seaborn-dark', 'seaborn-dark-palette', 'sea
born-darkgrid', 'seaborn-deep', 'seaborn-muted', 'seaborn-notebook', 'seaborn-paper', 's
eaborn-pastel', 'seaborn-poster', 'seaborn-talk', 'seaborn-ticks', 'seaborn-white', 'sea
born-whitegrid', '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 about 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.

In [13]:
```
#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
years = list(map(str, range(1980, 2014)))
#creating data series
haiti = df_can.loc['Haiti', years] # passing in years 1980 - 2013 to exclude the 'total
haiti.head()
```

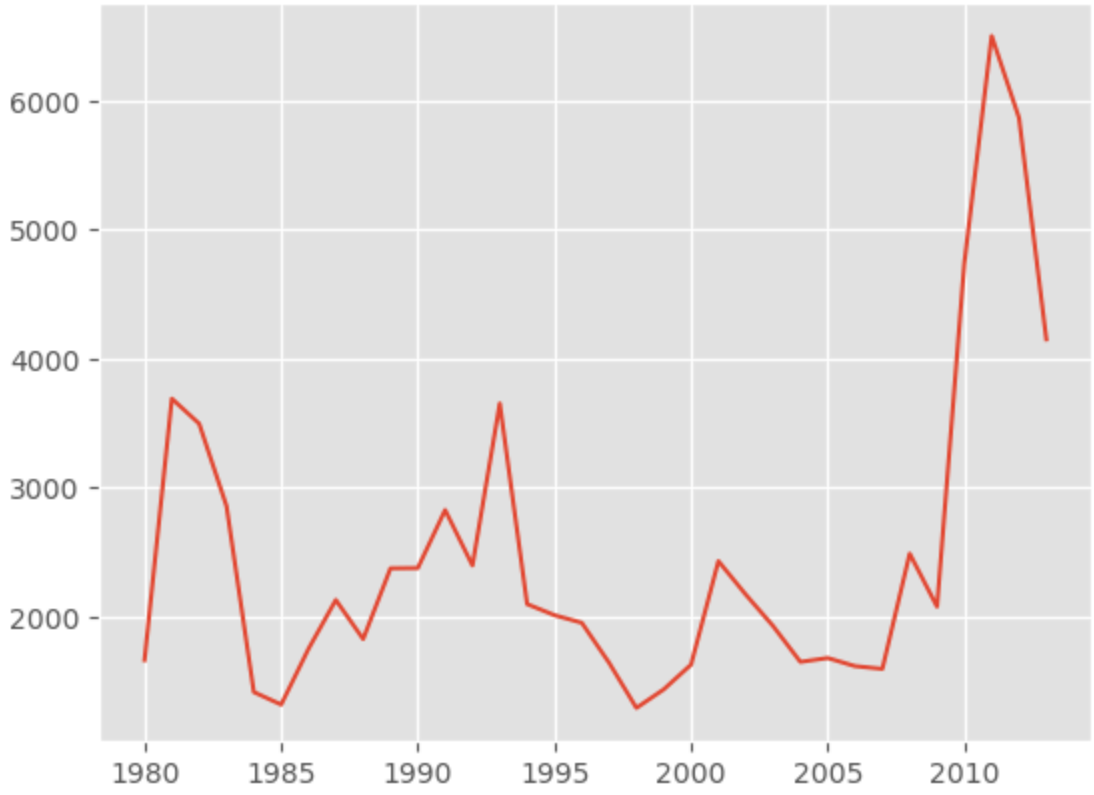
Out[13]:
```
1980    1666
1981    3692
```

```
1982    3498
1983    2860
1984    1418
Name: Haiti, dtype: object
```

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

In [14]:
```
haiti.plot()
```

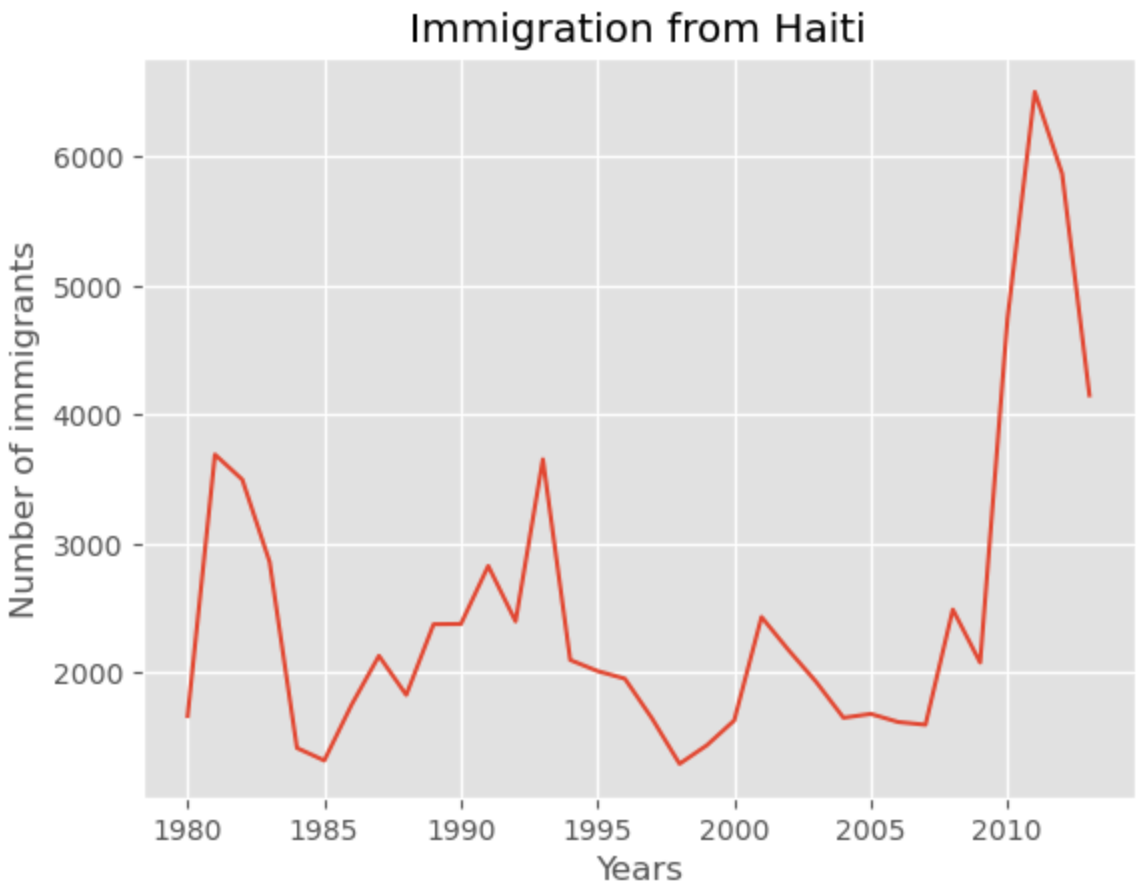
Out[14]: <AxesSubplot:>



pandas automatically populated the x-axis with the index values (years), and the y-axis with the column values (population).

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

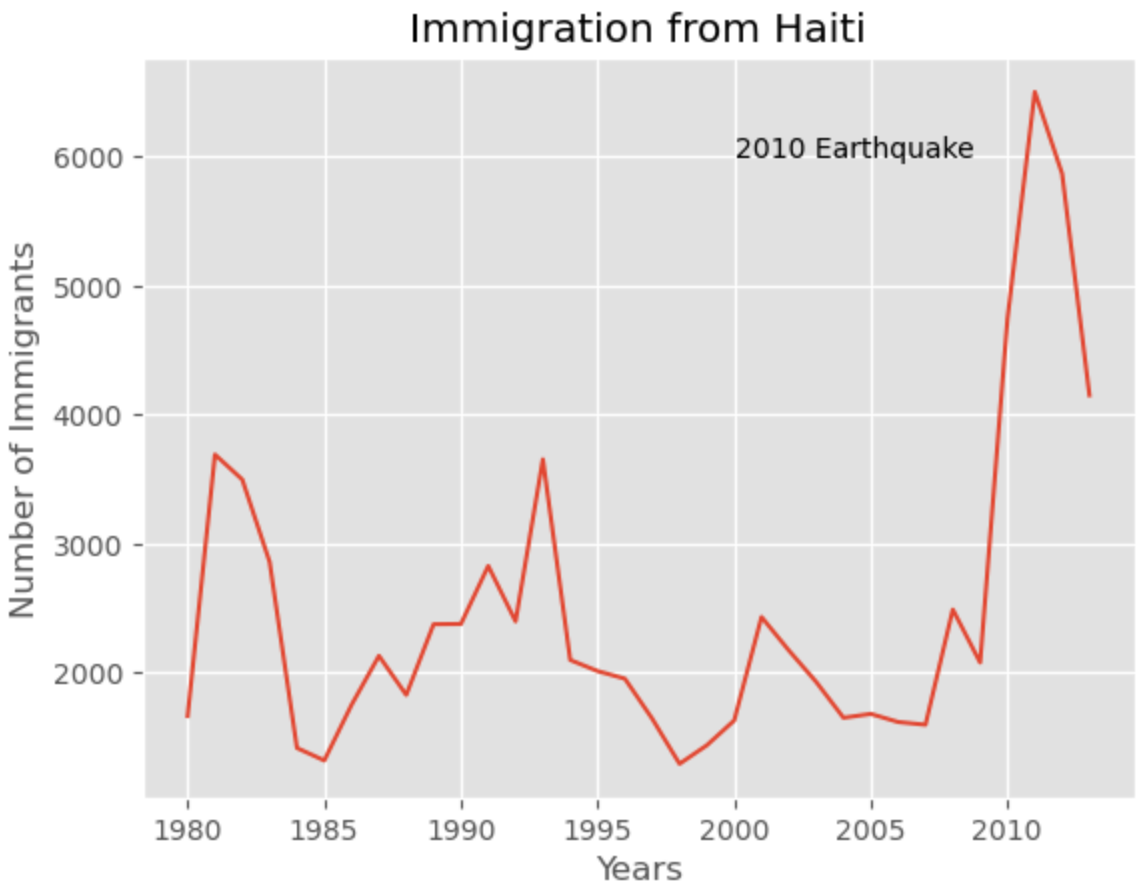
In [15]:
```
haiti.plot(kind='line')

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.

However, notice that years are of type *string*. Let's change the type of the index values to *integer* first.

In [19]:
```
haiti.index = haiti.index.map(int)
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 the dataframe.

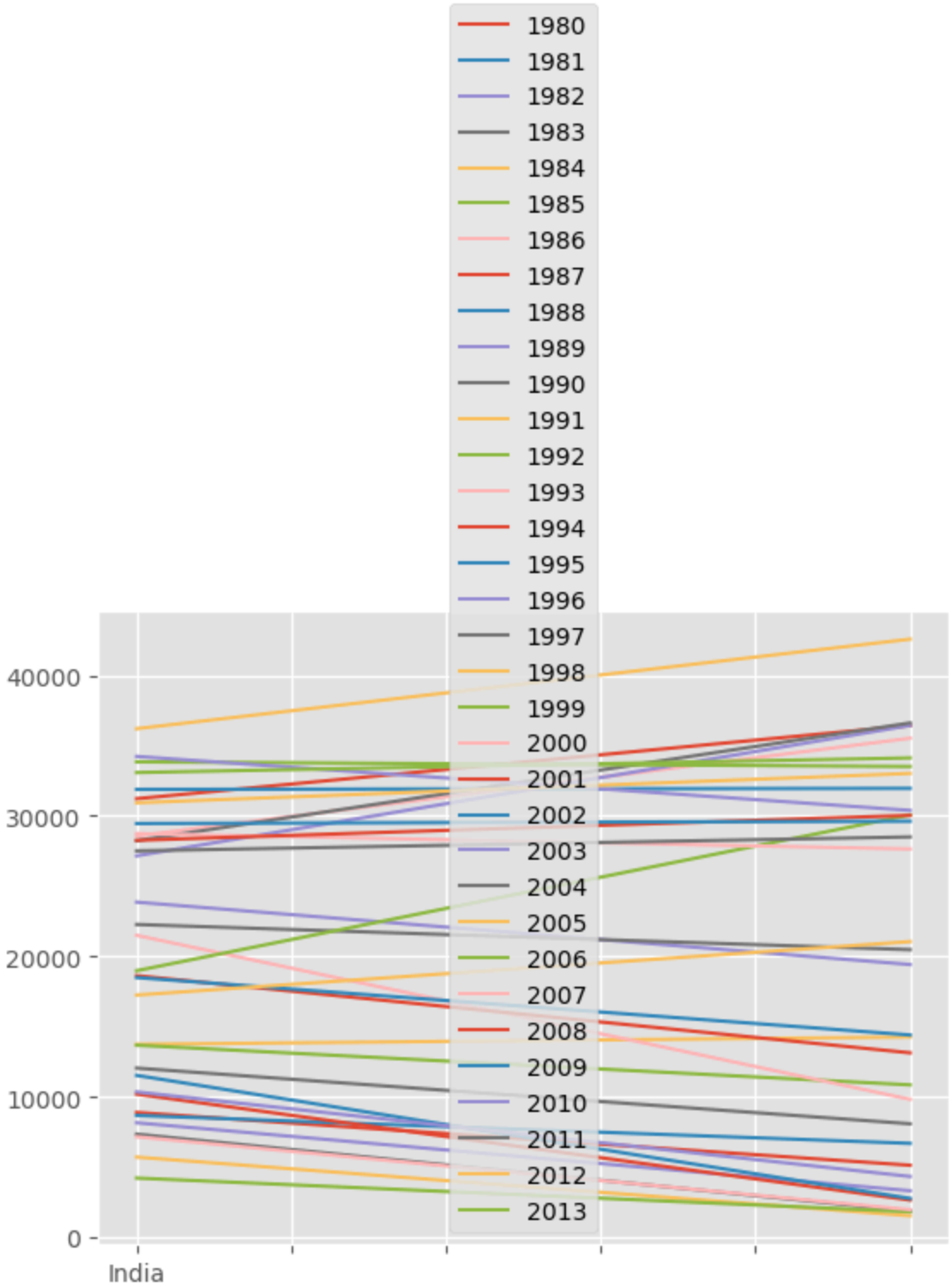
In [20]:
```
china = df_can.loc['China', years]
india = df_can.loc['India', years]

#or

df_CI = df_can.loc[['India', 'China'], years]
```

▶ Click here for a sample python solution

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

In [22]:
```
df_CI.plot(kind='line')
```

Out[22]: <AxesSubplot:>



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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.

In [23]:
```
df_CI = df_CI.transpose()
df_CI.head()
```

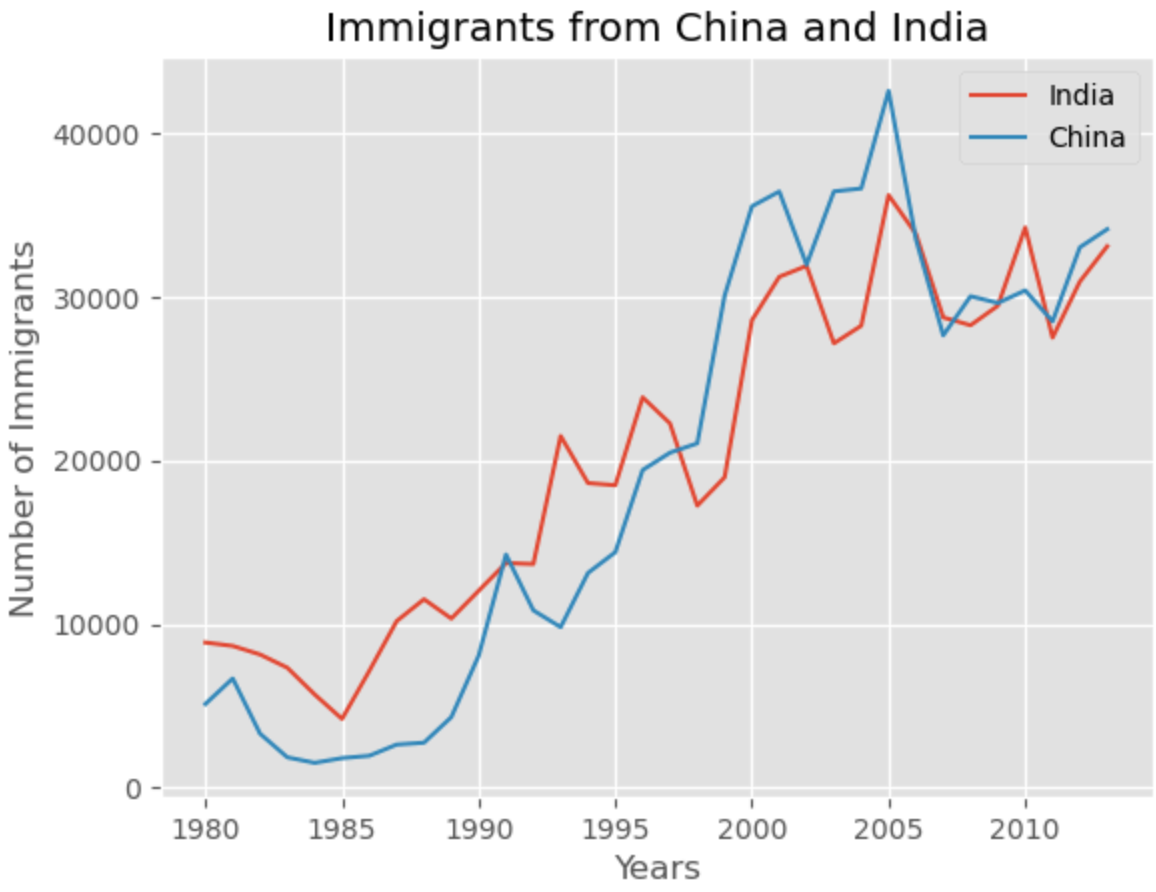
Out[23]:

	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.

In [25]:

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

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

plt.show()
```



▶ Click here for a sample python 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.

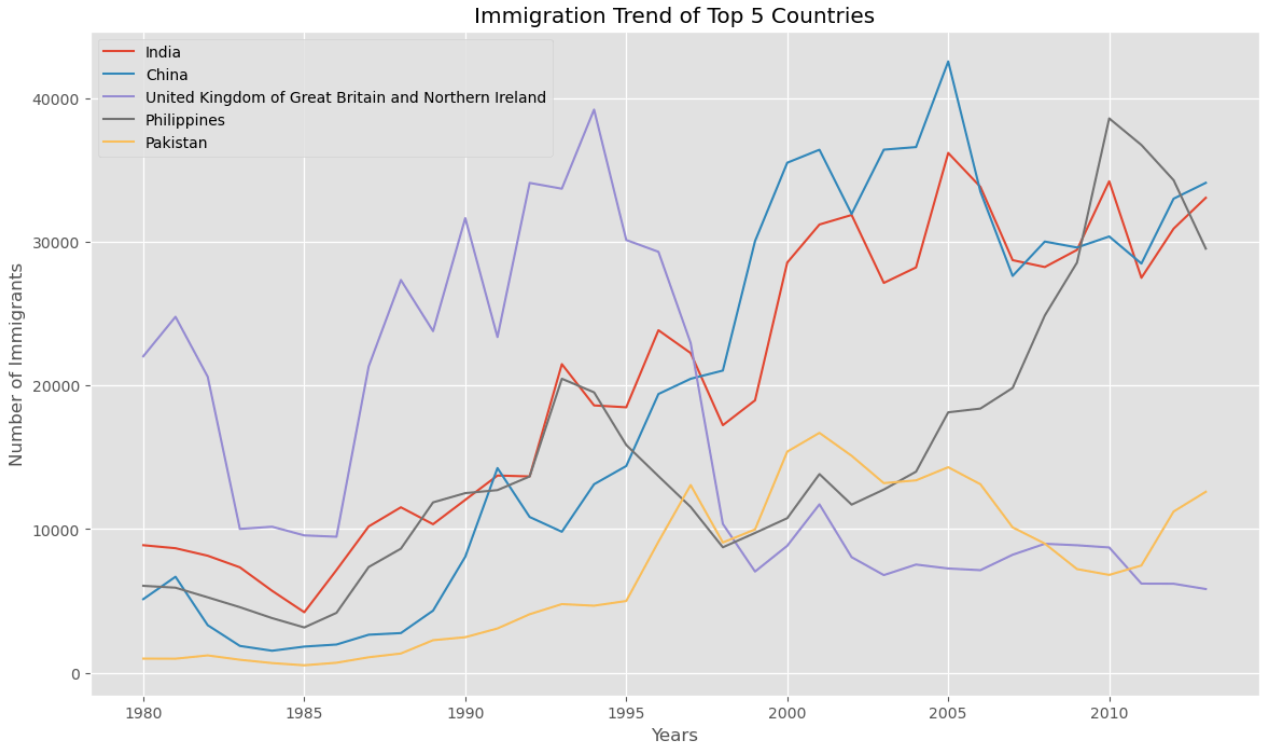
In [36]:
```
df_can.sort_values(by='Total', ascending=False, axis=0, inplace=True)
df_top5 = df_can.head(5)
df_top5 = df_top5[years].transpose()
print(df_top5)
```

```
      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
```

In [39]:

```
df_top5.index = df_top5.index.map(int) # let's change the index values of df_top5 to ty
df_top5.plot(kind='line', figsize=(14, 8)) # pass a tuple (x, y) size

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

plt.show()
```



▶ Click here for a sample python 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!

Author

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Other Contributors

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<!--

Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2023-06-08	2.5	Dr. Pooja	Updated to work with clean data csv file
2021-05-29	2.4	Weiqing Wang	Fixed typos and code spells.
2021-01-20	2.3	Lakshmi Holla	Changed TOC cell markdown
2020-11-20	2.2	Lakshmi Holla	Changed IBM box URL
2020-11-03	2.1	Lakshmi Holla	Changed URL and info method
2020-08-27	2.0	Lavanya	Moved Lab to course repo in GitLab

--!>

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In [ ]: