# Plotting directly with Matplotlib

Estimated time needed: **45** minutes

## Objectives

After completing this lab you will be able to:

- Create and customize basic plots directly with Matplotlib on dataset

## Table of Contents

# Import Libraries

Import the `matplotlib` library.

In [1]:

```
#Import Primary Modules:
import numpy as np  # useful for many scientific computing in Python
import pandas as pd # primary data structure library

# use the inline backend to generate the plots within the browser
%matplotlib inline

import matplotlib as mpl
import matplotlib.pyplot as plt

# check for latest version of Matplotlib
print('Matplotlib version: ', mpl.__version__) # >= 2.0.0
```

```
<ipython-input-1-e4135780338e>:3: DeprecationWarning:
Pyarrow will become a required dependency of pandas in the next major release of pandas (pandas 3.0),
(to allow more performant data types, such as the Arrow string type, and better interoperability with other libraries)
but was not found to be installed on your system.
If this would cause problems for you,
please provide us feedback at https://github.com/pandas-dev/pandas/issues/54466

  import pandas as pd # primary data structure library
Matplotlib version:  3.5.2
```

# Fetching Data

Dataset: Immigration to Canada from 1980 to 2013 - International migration flows to and from selected countries - The 2015 revision from United Nation's website.
In this lab, we will focus on the Canadian Immigration data and use the *already cleaned dataset* and can be fetched from here.

You can refer to the lab on data pre-processing wherein this dataset is cleaned for a quick refresh your Panads skill Data pre-processing with Pandas

In [2]:

```
from js import fetch
import io

URL = "https://cf-courses-data.s3.us.cloud-object-storage.appdomain.cloud/IBMDeveloperSkillsNetwork-DV0101EN-SkillsNetwork/Data%20Files/Canada.csv"
resp = await fetch(URL)
text = io.BytesIO((await resp.arrayBuffer()).to_py())
df_can = pd.read_csv(text)
print('Data read into a pandas dataframe!')
```

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

Let's take a look at the first five items in our dataset.

In [3]:

```
df_can.head()
```

Out[3]:

| | Country | Continent | Region | DevName | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | ... | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Afghanistan | Asia | Southern Asia | Developing regions | 16 | 39 | 39 | 47 | 71 | 340 | ... | 3436 | 3009 | 2652 | 2111 | 1746 | 1758 | 2203 | 2635 | 2004 | 58639 |
| **1** | Albania | Europe | Southern Europe | Developed regions | 1 | 0 | 0 | 0 | 0 | 0 | ... | 1223 | 856 | 702 | 560 | 716 | 561 | 539 | 620 | 603 | 15699 |
| **2** | Algeria | Africa | Northern Africa | Developing regions | 80 | 67 | 71 | 69 | 63 | 44 | ... | 3626 | 4807 | 3623 | 4005 | 5393 | 4752 | 4325 | 3774 | 4331 | 69439 |
| **3** | American Samoa | Oceania | Polynesia | Developing regions | 0 | 1 | 0 | 0 | 0 | 0 | ... | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| **4** | Andorra | Europe | Southern Europe | Developed regions | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 15 |

5 rows × 39 columns

Let's find out how many entries there are in our dataset.

In [4]:

```
# print the dimensions of the dataframe
print(df_can.shape)
```

```
(195, 39)
```

Set the country name as index - useful for quickly looking up countries using .loc method.

In [5]:

```
df_can.set_index('Country', inplace=True)

# Let's view the first five elements and see how the dataframe was changed
df_can.head()
```

Out[5]:

| | Continent | Region | DevName | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | ... | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Country** | | | | | | | | | | | | | | | | | | | | | |
| **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 |
| **American Samoa** | Oceania | Polynesia | Developing regions | 0 | 1 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| **Andorra** | Europe | Southern Europe | Developed regions | 0 | 0 | 0 | 0 | 0 | 0 | 2 | ... | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 15 |

5 rows × 38 columns

Notice now the country names now serve as indices.

In [6]:

```
print('data dimensions:', df_can.shape)
```

```
data dimensions: (195, 38)
```

In [7]:

```
# finally, let's create a list of years from 1980 - 2013
# this will come in handy when we start plotting the data
years = list(map(str, range(1980, 2014)))
#years = np.arange(1980,2014)
```

# Line Plot

A line plot displays the relationship between two continuous variables over a continuous interval, showing the trend or pattern of the data.

Let's created a line plot to visualize the immigrants (to Canada) trend during 1980 to 2013.
We need the Total of year-wise immigrants,

We will create a new dataframe for only columns containing the years
then, we will apply sum() on the dataframe

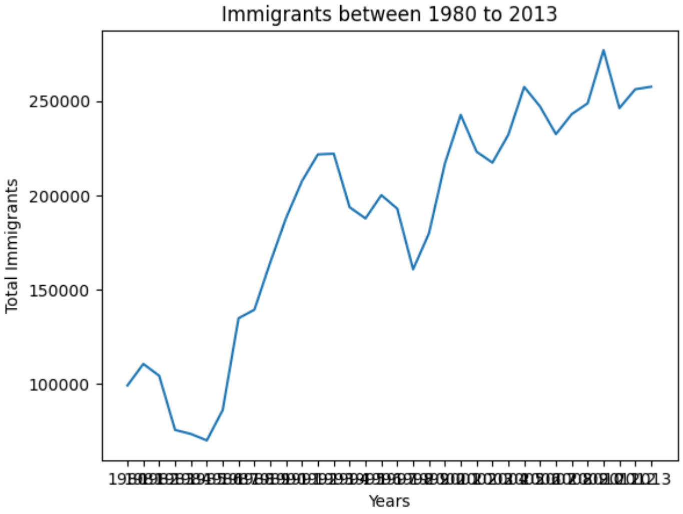
You can do create a line plot directly on **axes** by calling plot function **plot()**

In [8]:

```
#As years is in the array format, you will be required to map it to str for plotting
#y=list(map(str, years))

#creating df with only years columns from 1980 - 2013
df_line=df_can[years]

#Applying sum to get total immigrants year-wise
total_immigrants=df_line.sum()
total_immigrants.head()
```

```
Out[8]: 1980     99137
        1981    110563
        1982    104271
        1983     75550
        1984     73417
        dtype: int64
```

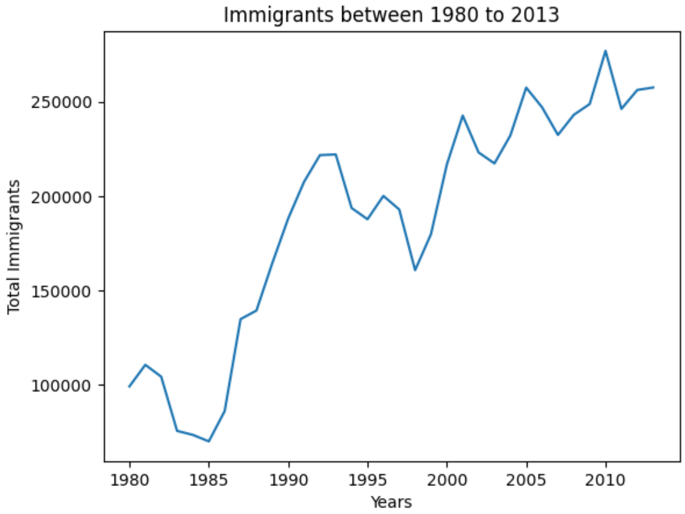
```
In [9]: #Create figure and axes
        fig, ax = plt.subplots()

        # Plot the line
        ax.plot(total_immigrants)

        #Setting up the Title
        ax.set_title('Immigrants between 1980 to 2013')
        #Setting up the Labels
        ax.set_xlabel('Years')
        ax.set_ylabel('Total Immigrants')

        #Display the plot
        plt.show()
```



The plot function 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.

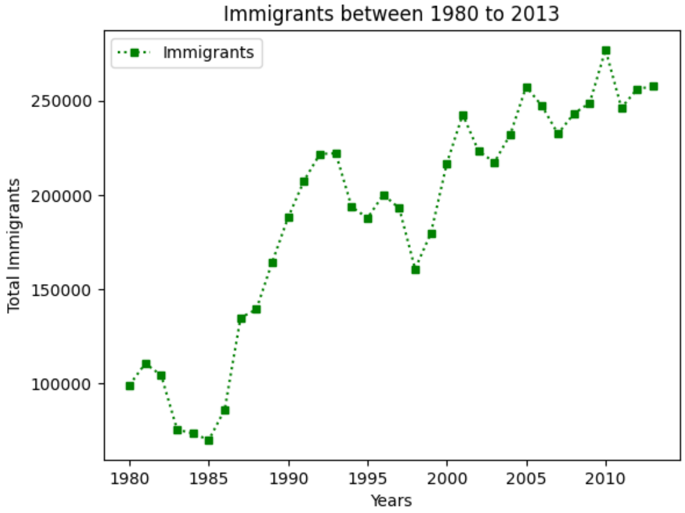
```
In [10]: #Create figure and axes
         fig, ax = plt.subplots()

         #Changing the index type to integer
         total_immigrants.index = total_immigrants.index.map(int)

         # Plot the line
         ax.plot(total_immigrants)

         #Setting up the Title
         ax.set_title('Immigrants between 1980 to 2013')

         #Setting up the Labels
         ax.set_xlabel('Years')
         ax.set_ylabel('Total Immigrants')

         #Display the plot
         plt.show()
```



Let's now customize the above plot's appearance

In [11]:

```
#Create figure and axes
fig, ax = plt.subplots()

#Changing the index type to integer
total_immigrants.index = total_immigrants.index.map(int)

# Customizing the appearance of Plot
ax.plot(total_immigrants,
        marker='s', #Including markers in squares shapes
        markersize=5, #Setting the size of the marker
        color='green', #Changing the color of the line
        linestyle="dotted") #Changing the line style to a Dotted line
#Setting up the Title
ax.set_title('Immigrants between 1980 to 2013')

#Setting up the Labels
ax.set_xlabel('Years')
ax.set_ylabel('Total Immigrants')
ax.legend(['Immigrants'])

plt.show()
```

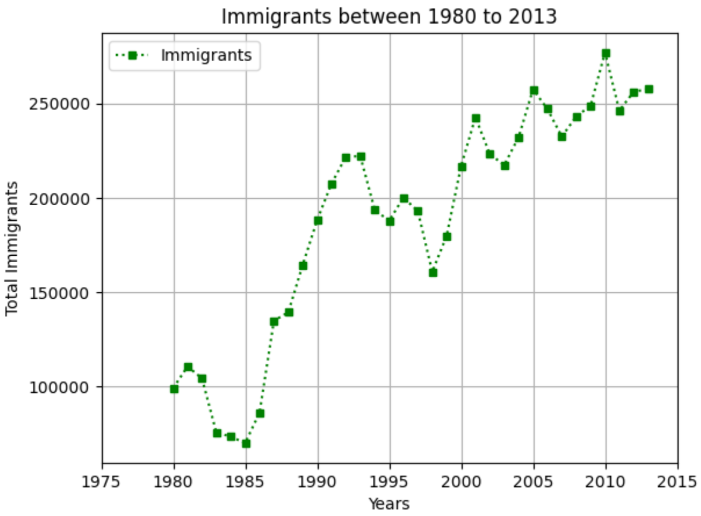


Let's include the background grid, a legend and try to change the limits on the axis

In [12]:

```
#Create figure and axes
fig, ax = plt.subplots()

# Plot the line
ax.plot(total_immigrants,
        marker='s', #Including markers in squares shapes
        markersize=5, #Setting the size of the marker
        color='green', #Changing the color of the line
        linestyle="dotted") #Changing the line style to a Dotted line

#Setting up the Title
ax.set_title('Immigrants between 1980 to 2013')

#Setting up the Labels
```

```
ax.set_xlabel('Years')
ax.set_ylabel('Total Immigrants')

#limits on x-axis
plt.xlim(1975, 2015)  #or ax.set_xlim()

#Enabling Grid
plt.grid(True)  #or ax.grid()

#Legend
plt.legend(["Immigrants"]) #or ax.legend()

#Display the plot
plt.show()
```



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

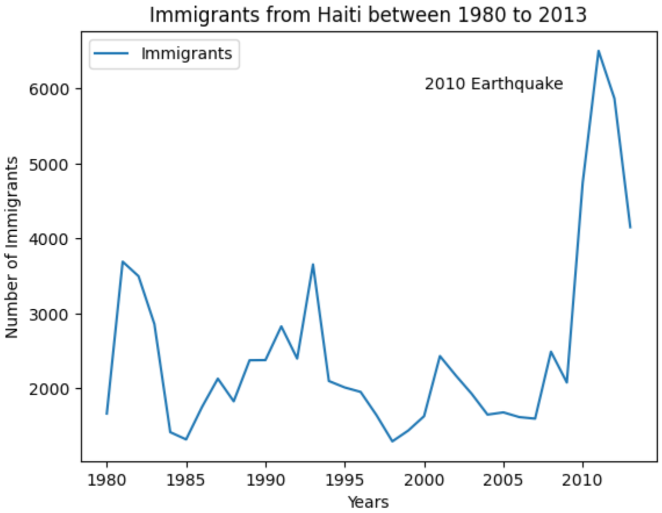
You be required to create a dataframe where the name of the 'Country' is equal to 'Haiti' and years from 1980 - 2013
Also you will be required to transpose the new dataframe in to a series for plotting
Might also have to change the type of index of the series to integer for a better look of the plot
Then create fig and ax and call function plot() on the data.

▸ Click here for a sample python solution

In [13]:
```
df_can.reset_index(inplace=True)
haiti=df_can[df_can['Country']=='Haiti']
haiti=haiti[years].T
haiti.index = haiti.index.map(int)
```

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 *ax.annotate()* method.

In [14]:
```
fig, ax = plt.subplots()

ax.plot(haiti)

#Setting up the Title
ax.set_title('Immigrants from Haiti between 1980 to 2013')

#Setting up the Labels
ax.set_xlabel('Years')
ax.set_ylabel('Number of Immigrants')

#Enabling Grid and ticks
#plt.grid(True)  #or ax.grid()
#ax.set_xticks(list(range(n, m, s)))

#Legend
plt.legend(["Immigrants"]) #or ax.legend()

ax.annotate('2010 Earthquake',xy=(2000, 6000))
plt.show()
```



You can also specify the ticks to be displayed on the plot like this - ax.set_xticks(list(range(1980, 2015,5)))

---

# Scatter Plot

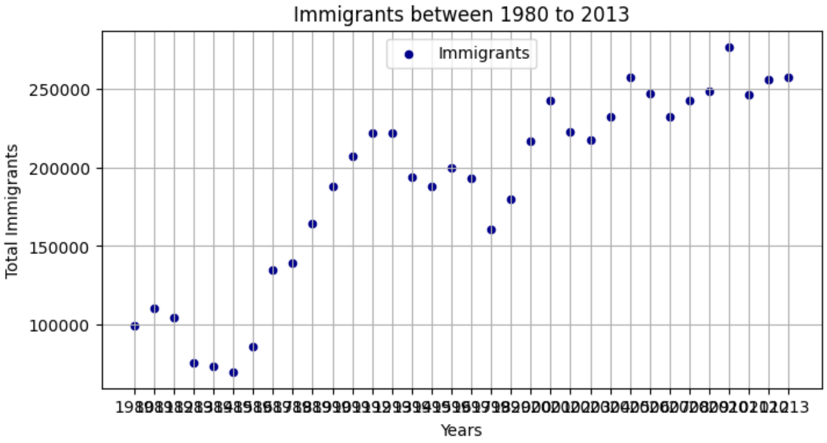
A scatter plot visualizes the relationship between two continuous variables, displaying individual data points as dots on a two-dimensional plane, allowing for the examination of patterns, clusters, and correlations.

Let's created a *Scatter plot* to visualize the immigrants (to Canada) trend during 1980 to 2013.
We need the Total of year-wise immigrants,

We will create a new dataframe for only columns containing the years
then, we will apply sum() on the dataframe

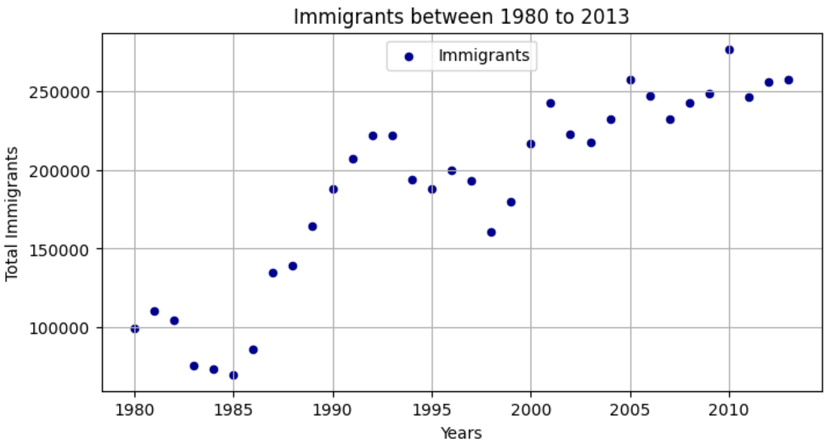
You can do create a scatter plot directly on **ax** by calling plot function **scatter()**

In [15]:
```
#Create figure and axes
fig, ax = plt.subplots(figsize=(8, 4))

# Customizing Scatter Plot
ax.scatter(years, total_immigrants,
           marker='o', #setting up the markers
           s = 20, #setting up the size of the markers
           color='darkblue')#the color for the marker

#add title
plt.title('Immigrants between 1980 to 2013')
#add labels
plt.xlabel('Years')
plt.ylabel('Total Immigrants')
#including grid
plt.grid(True)

#Legend at upper center of the figure
ax.legend(["Immigrants"], loc='upper center')

#Display the plot
plt.show()
```



In [16]:

```
#Create figure and axes
fig, ax = plt.subplots(figsize=(8, 4))

total_immigrants.index = total_immigrants.index.map(int)

# Customizing Scatter Plot
ax.scatter(total_immigrants.index, total_immigrants,
           marker='o', #setting up the markers
           s = 20, #setting up the size of the markers
           color='darkblue')#the color for the marker

#add title
plt.title('Immigrants between 1980 to 2013')
#add labels
plt.xlabel('Years')
plt.ylabel('Total Immigrants')
#including grid
plt.grid(True)

#Legend at upper center of the figure
ax.legend(["Immigrants"], loc='upper center')

#Display the plot
plt.show()
```



### Refer to the matplotlib documentation and change the marker and its size, color in the above code to see the difference in the appearance of the plot

---

## Bar Plot

A bar plot represents categorical data with rectangular bars, where the height of each bar corresponds to the value of a specific category, making it suitable for comparing values across different categories.

Let's create a bar plot to visualize the top 5 countries that contribued the most immigrants to Canada from 1980 to 2013.

Apply sort_values function on the 'Total' column of our data

We will create a new dataframe for only columns containing the years
then, we will apply sum() on the dataframe and can create a separatedataframe for top five countries

You can further use the names of the countries to label each bar on the plot

In [17]:

```
#Sorting the dataframe on 'Total' in descending order
df_can.sort_values(['Total'], ascending=False, axis=0, inplace=True)

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

#resetting the index back to original way
df_bar_5=df_top5.reset_index()

#Creating alist of names of the top 5 countries
label=list(df_bar_5.Country)
label
```

Out[17]:

```
['India',
 'China',
 'United Kingdom of Great Britain and Northern Ireland',
 'Philippines',
 'Pakistan']
```

The third name is too lengthy to fit on the x-axis as label. Let's fix this using indexing

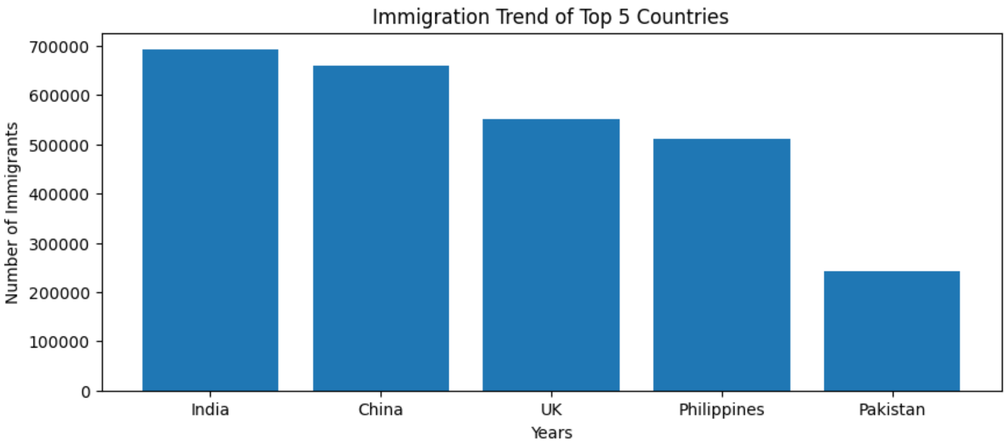
In [18]:

```
label[2]='UK'
```

```
label
```

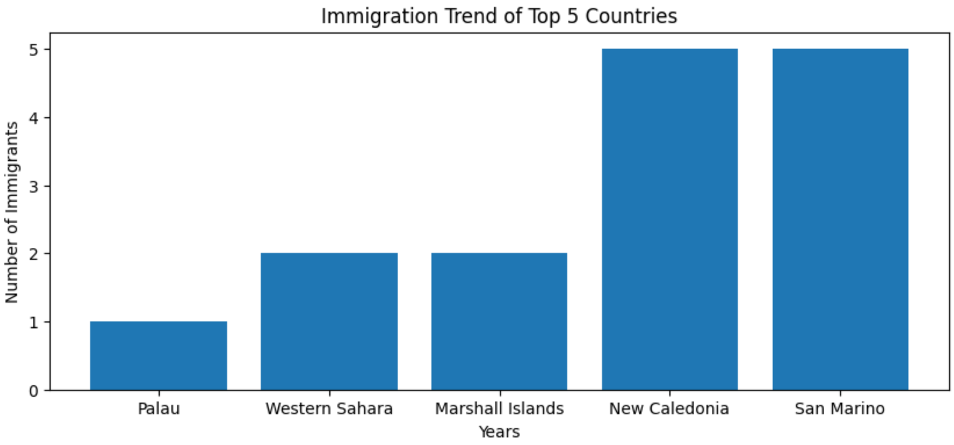
```
Out[18]:  ['India', 'China', 'UK', 'Philippines', 'Pakistan']
```

```
In [19]: fig, ax = plt.subplots(figsize=(10, 4))

ax.bar(label,df_bar_5['Total'], label=label)
ax.set_title('Immigration Trend of Top 5 Countries')
ax.set_ylabel('Number of Immigrants')
ax.set_xlabel('Years')

plt.show()
```



Question: Create a bar plot of the 5 countries that contributed the **least** to immigration to Canada **from** 1980 to 2013.

```
In [20]: df_can.sort_values(by="Total", ascending=True, axis=0, inplace=True)
df_least5 = df_can.head(5)
df_bar5 = df_least5.reset_index()

label = list(df_bar5.Country)
fig, ax = plt.subplots(figsize=(10, 4))

ax.bar(label,df_bar5['Total'], label=label)
ax.set_title('Immigration Trend of Top 5 Countries')
ax.set_ylabel('Number of Immigrants')
ax.set_xlabel('Years')

plt.show()
```



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## Histogram

A histogram is a way of representing the *frequency* distribution of numeric dataset. The way it works is it partitions the x-axis into *bins*, assigns each data point in our dataset to a bin, and then counts the number of data points that have been assigned to each bin. So the y-axis is the frequency or the number of data points in each bin. Note that we can change the bin size and usually one needs to tweak it so that the distribution is displayed nicely.

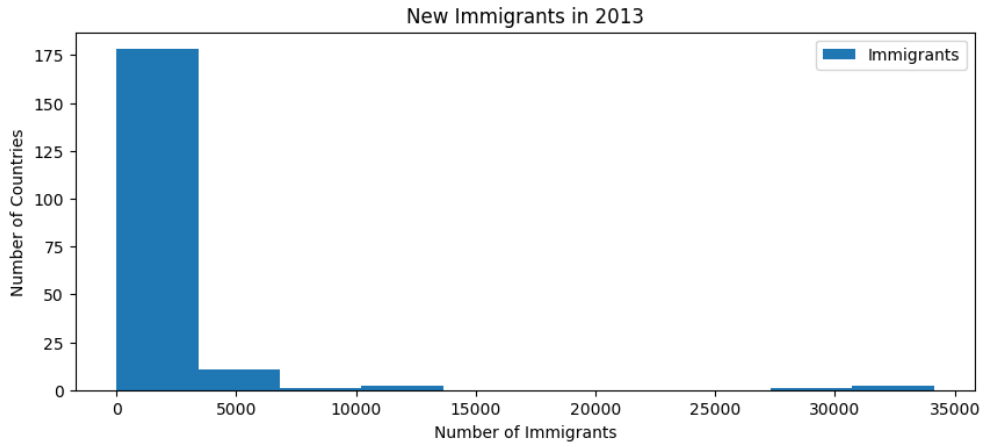
Let's find out the frequency distribution of the number (population) of new immigrants from the various countries to Canada in 2013?

```
In [21]: df_country = df_can.groupby(['Country'])['2013'].sum().reset_index()

#Create figure and axes
```

```
fig, ax = plt.subplots(figsize=(10, 4))
ax.hist(df_country['2013'])
ax.set_title('New Immigrants in 2013')
ax.set_xlabel('Number of Immigrants')
ax.set_ylabel('Number of Countries')
ax.legend(['Immigrants'])

#Display the plot
plt.show()
```



Our plot doesnot match with the bars

By default, the `histrogram` method breaks up the dataset into 10 bins. The figure below summarizes the bin ranges and the frequency distribution of immigration in 2013

The hist function retuns list of arrays with 1. counts and 2. bins. we can fetch that using unpacking functionality

and further use the bins as x-ticks

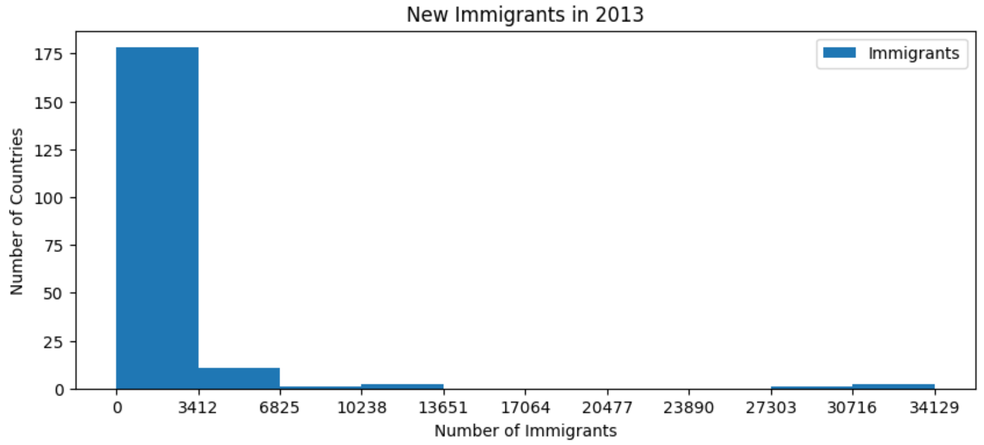
In [22]:

```
# Plot the bar
fig, ax = plt.subplots(figsize=(10, 4))
count = ax.hist(df_country['2013'])

#you can check the arrays in count with indexing count[0] for count, count[1] for bins

ax.set_title('New Immigrants in 2013')
ax.set_xlabel('Number of Immigrants')
ax.set_ylabel('Number of Countries')
ax.set_xticks(list(map(int,count[1])))
ax.legend(['Immigrants'])

#Display the plot
plt.show()
```



We can also plot multiple histograms on the same plot. For example, let's try to answer the following questions using a histogram.

What is the immigration distribution for Denmark, Norway, and Sweden for years 1980 - 2013?

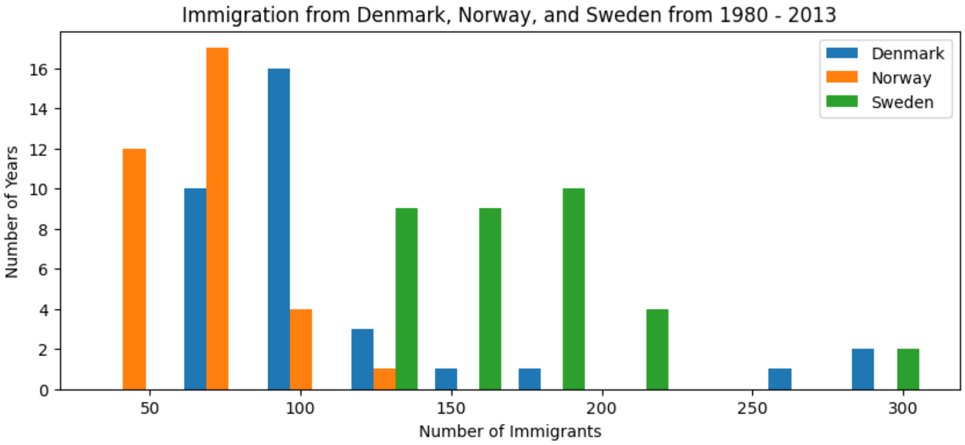
In [23]:

```
# let's quickly view the dataset
df=df_can.groupby(['Country'])[years].sum()
df_dns=df.loc[['Denmark', 'Norway', 'Sweden'], years]
df_dns=df_dns.T
df_dns.head()
```

Out[23]:

| Country | Denmark | Norway | Sweden |
|---|---|---|---|
| **1980** | 272 | 116 | 281 |
| **1981** | 293 | 77 | 308 |
| **1982** | 299 | 106 | 222 |
| **1983** | 106 | 51 | 176 |
| **1984** | 93 | 31 | 128 |

In [24]:
```
#Create figure and axes
fig, ax = plt.subplots(figsize=(10, 4))
ax.hist(df_dns)
ax.set_title('Immigration from Denmark, Norway, and Sweden from 1980 - 2013')
ax.set_xlabel('Number of Immigrants')
ax.set_ylabel('Number of Years')
ax.legend(['Denmark', 'Norway', 'Sweden'])
#Display the plot
plt.show()
```

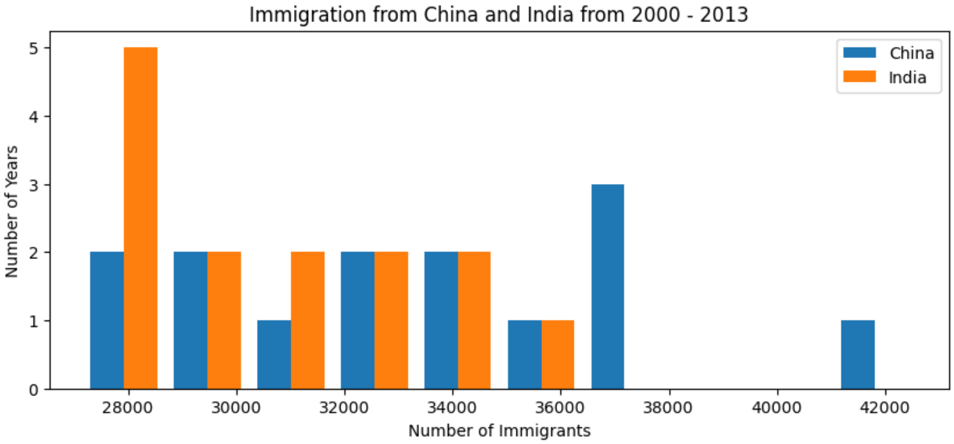


## Question: What is the immigration distribution for China and India for years 2000 to 2013?

In [26]:
```
df_cit = df_can.groupby(['Country'])[years].sum()
yr = list(map(str,range(2000, 2014)))
df_ci = df_cit.loc[['China', 'India'], yr]
df_ci = df_ci.T

fig, ax = plt.subplots(figsize=(10, 4))
ax.hist(df_ci)
ax.set_title('Immigration from China and India from 2000 - 2013')
ax.set_xlabel('Number of Immigrants')
ax.set_ylabel('Number of Years')
ax.legend(['China', 'India'])

plt.show()
```



▸ Click here for a sample python solution

# Pie Chart

A pie chart represents the proportion or percentage distribution of different categories in a dataset using sectors of a circular pie.

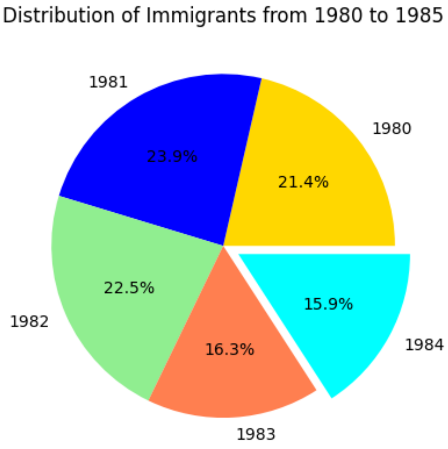
Let's create a pie chart representing the 'Total Immigrants' for the year 1980 to 1985

In [27]:
```
fig,ax=plt.subplots()

#Pie on immigrants
ax.pie(total_immigrants[0:5], labels=years[0:5],
       colors = ['gold','blue','lightgreen','coral','cyan'],
       autopct='%1.1f%%',explode = [0,0,0,0,0.1]) #using explode to highlight the lowest

ax.set_aspect('equal')  # Ensure pie is drawn as a circle

plt.title('Distribution of Immigrants from 1980 to 1985')
#plt.legend(years[0:5]), include legend, if you donot want to pass the labels
plt.show()
```



## Question: Create a pie chart representing the total immigrants proportion for each continent

First, you will have to group the data over continents and get the sum on total. Then you can pass this data to the pie function

In [28]:
```
#Creating data for plotting pie
df_con = df_can.groupby('Continent')['Total'].sum().reset_index()
label = list(df_con.Continent)
label[3] = 'LAC'
label[4] = 'NA'
df_con
```

Out[28]:

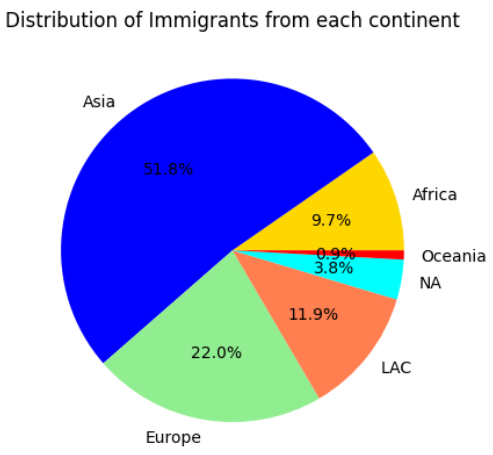
| | Continent | Total |
|---|---|---|
| **0** | Africa | 618948 |
| **1** | Asia | 3317794 |
| **2** | Europe | 1410947 |
| **3** | Latin America and the Caribbean | 765148 |
| **4** | Northern America | 241142 |
| **5** | Oceania | 55174 |

In [34]:
```
fig,ax=plt.subplots()

ax.pie(df_con.Total, labels=label,
       colors = ['gold','blue','lightgreen','coral','cyan','red'],
       autopct='%1.1f%%')

ax.set_aspect('equal')

plt.title('Distribution of Immigrants from each continent')
plt.show()
```



▸ Click here for a sample python solution

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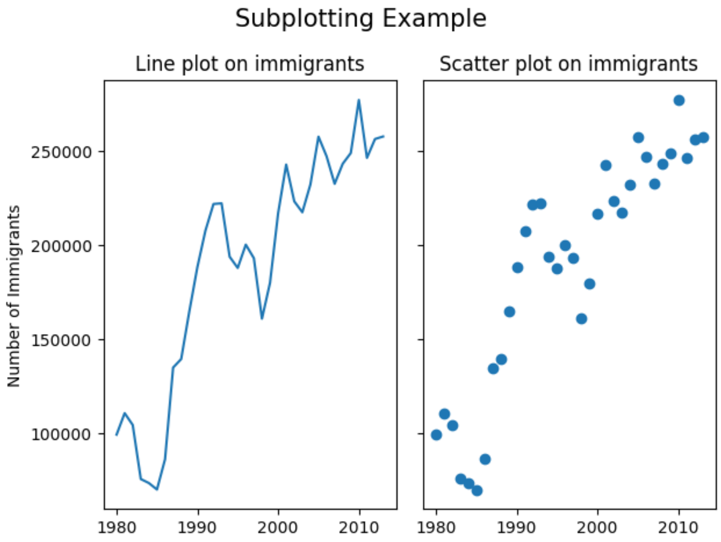
## Sub-plotting

Let us explore how to display more than one plot on the same figure and specify the number of rows and columns to be created to the subplots function.

For instance, let’s create a line and scatter plot in one row
plt.subplots()
You can use the same functions using which you plotte lne and scatter plots at the start of this lab
Both the subplots will be sharing the same y-axis as the data in the y-axis is the same. So, assign the ‘Sharey’ parameter as True in the code below. Also notice the use of 'suptitle'

In [35]:

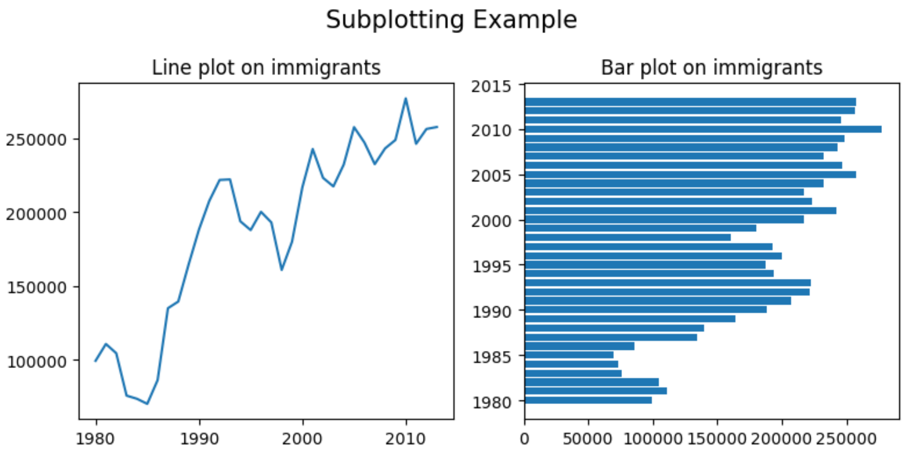
```python
# Create a figure with two axes in a row

fig, axs = plt.subplots(1, 2, sharey=True)

#Plotting in first axes - the left one
axs[0].plot(total_immigrants)
axs[0].set_title("Line plot on immigrants")

#Plotting in second axes - the right one
axs[1].scatter(total_immigrants.index, total_immigrants)
axs[1].set_title("Scatter plot on immigrants")

axs[0].set_ylabel("Number of Immigrants")

#Adding a Title for the Overall Figure
fig.suptitle('Subplotting Example', fontsize=15)

# Adjust spacing between subplots
fig.tight_layout()


# Show the figure
plt.show()
```



You can also implement the subplotting with **add_subplot()** as below:-

In [36]:

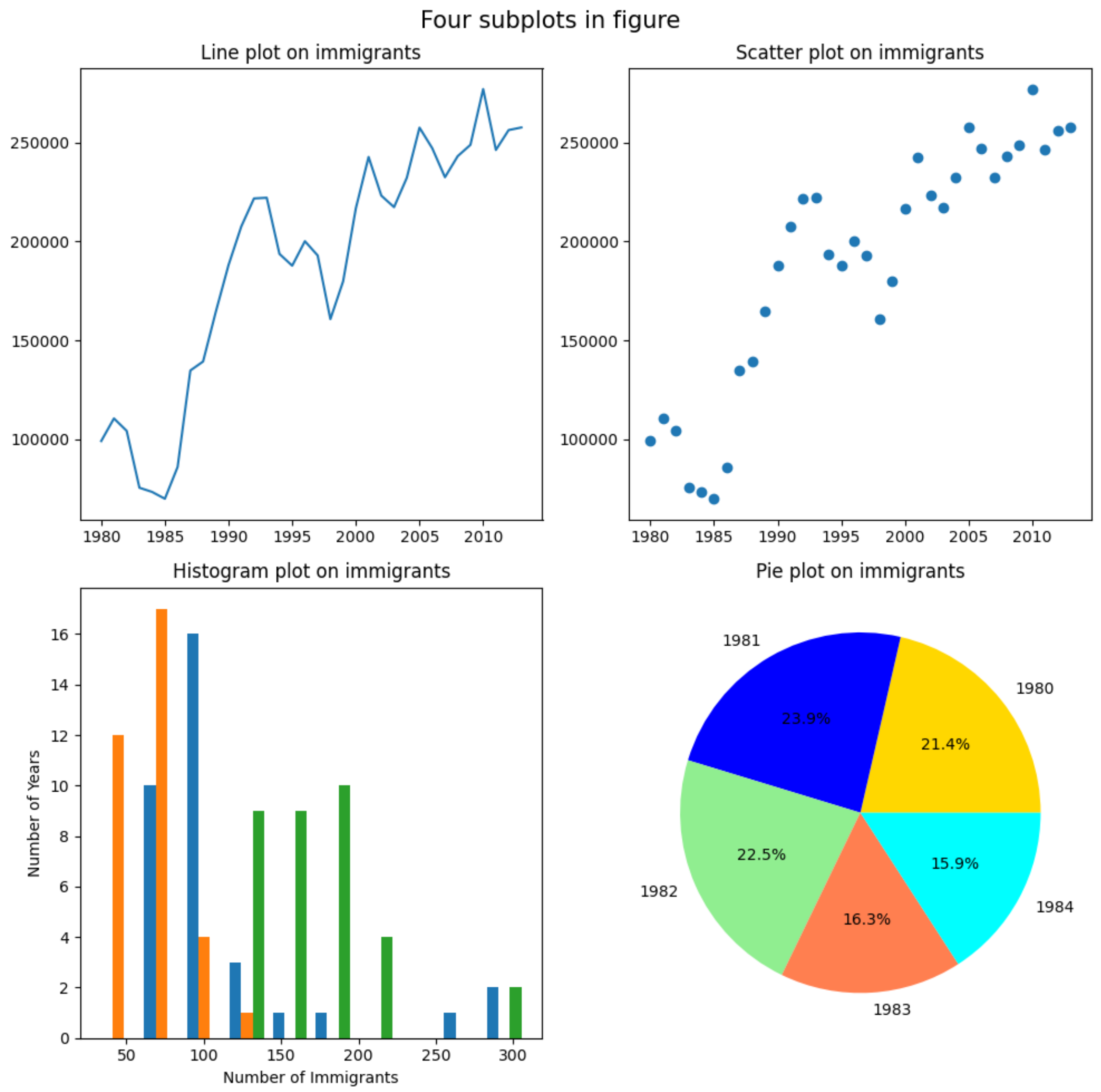
```python
# Create a figure with Four axes - two rows, two columns
fig = plt.figure(figsize=(8,4))

# Add the first subplot (top-left)
axs1 = fig.add_subplot(1, 2, 1)
#Plotting in first axes - the left one
axs1.plot(total_immigrants)
axs1.set_title("Line plot on immigrants")

# Add the second subplot (top-right)
axs2 = fig.add_subplot(1, 2, 2)
#Plotting in second axes - the right one
axs2.barh(total_immigrants.index, total_immigrants) #Notice the use of 'barh' for creating horizontal bar plot
axs2.set_title("Bar plot on immigrants")

#Adding a Title for the Overall Figure
fig.suptitle('Subplotting Example', fontsize=15)

# Adjust spacing between subplots
fig.tight_layout()


# Show the figure
plt.show()
```



Question: Choose any four plots, which you have developed in this lab, with subplotting display them in a 2x2 display

In [37]:

```python
fig = plt.figure(figsize=(10,10))

axs1 = fig.add_subplot(2, 2, 1)
axs1.plot(total_immigrants)
axs1.set_title("Line plot on immigrants")

axs2 = fig.add_subplot(2, 2, 2)
axs2.scatter(total_immigrants.index, total_immigrants)
axs2.set_title("Scatter plot on immigrants")

axs3 = fig.add_subplot(2, 2, 3)
axs3.hist(df_dns)
axs3.set_title("Histogram plot on immigrants")
axs3.set_xlabel('Number of Immigrants')
axs3.set_ylabel('Number of Years')

axs4 = fig.add_subplot(2, 2, 4)
axs4.pie(total_immigrants[0:5], labels=years[0:5],
           colors = ['gold','blue','lightgreen','coral','cyan'],
           autopct='%1.1f%%')
axs4.set_aspect('equal')
axs4.set_title("Pie plot on immigrants")

fig.suptitle('Four subplots in figure', fontsize=15)

# Adjust spacing between subplots
fig.tight_layout()


# Show the figure
plt.show()
```



▸ Click here for a sample python solution

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Congratulations! you have completed this lab!

## Author

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## Other Contributors