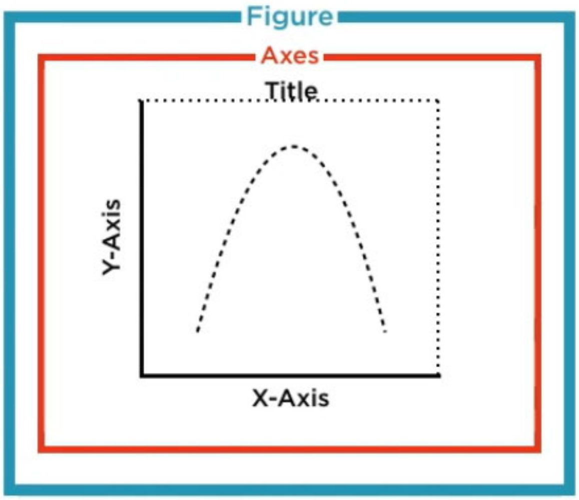
Basic Plotting using Matplotlib

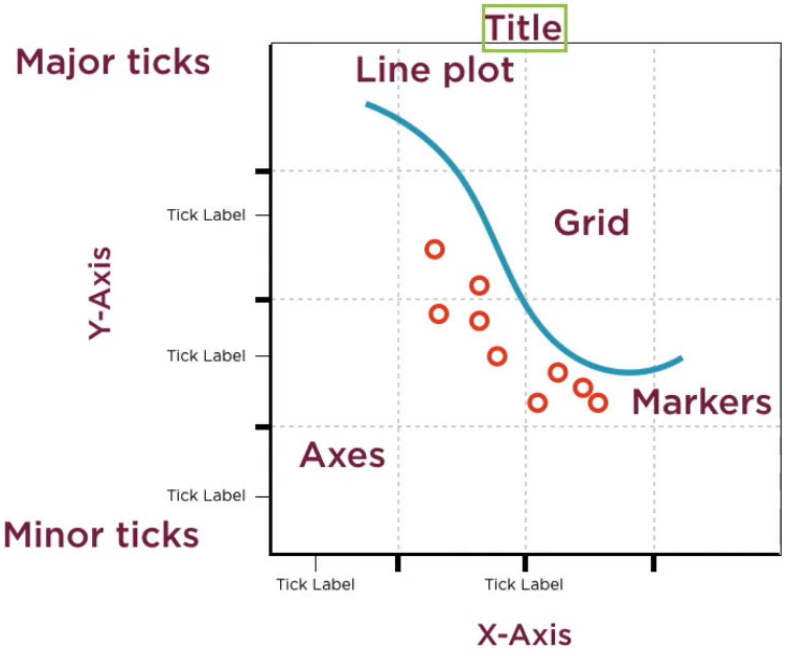
Matplotlib is a Python 2D plotting library. Matplotlib starts with aim to provide Matlab-like plotting feature to Python. It offers rich list of plotting types (https://matplotlib.org/tutorials/introductory/sample_plots.html).

1. Introduction and Setup ¶

Matplotlib Figure Hierarchy



Anatomy of Figure



Setup Notebook

The `%matplotlib` is a magic function to configure how Matplotlib works Jupyter Noteboiok to present graph.

There are quite a number of options, but following 2 are most commonly used.

- `%matplotlib inline` : draw static images and store them in the notebook.
- `%matplotlib notebook` : interactive plots with zoom and resizing features embedded within the notebook

In [1]:

```
%matplotlib inline
```

Import libraries `pandas` and `matplotlib.pyplot` .

In [2]:

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

1. Pandas Basic Plotting API

The `plot()` and `plot.xx()` in Pandas are wrapper functions which call matplotlib functions.

- They are friendlier to use.
- But only offer partial functionalities.

Trigonometry

Initialize x and y values.

In [3]:

```
x = np.linspace(0,np.pi*2, 50)
y = np.sin(x)
z = np.cos(x)*2
```

Create a dataframe from x and y.

In [4]:

```
df = pd.DataFrame({'x':x, 'y':y, 'z':z})
df.head()
```

Out[4]:

	x	y	z
0	0.000000	0.000000	2.000000
1	0.128228	0.127877	1.983580
2	0.256457	0.253655	1.934590
3	0.384685	0.375267	1.853834
4	0.512913	0.490718	1.742637

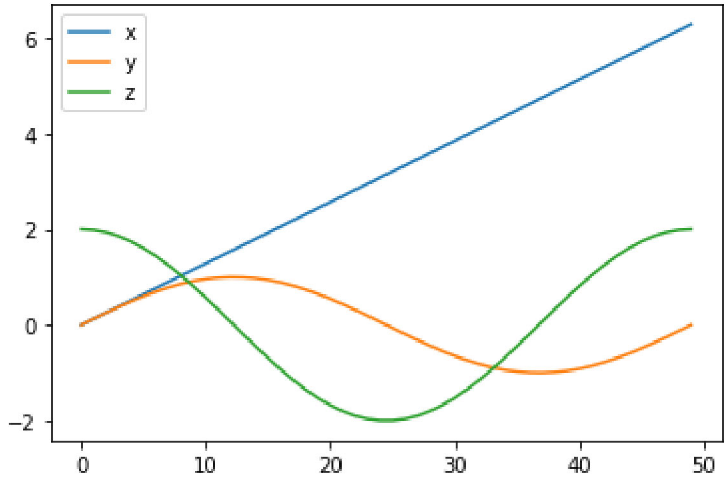
Plot the graph. But it plots all columns on the graph with `index` as x-axis, which is not what we want.

In [5]:

```
df.plot()
```

Out[5]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x264e62b1988>
```



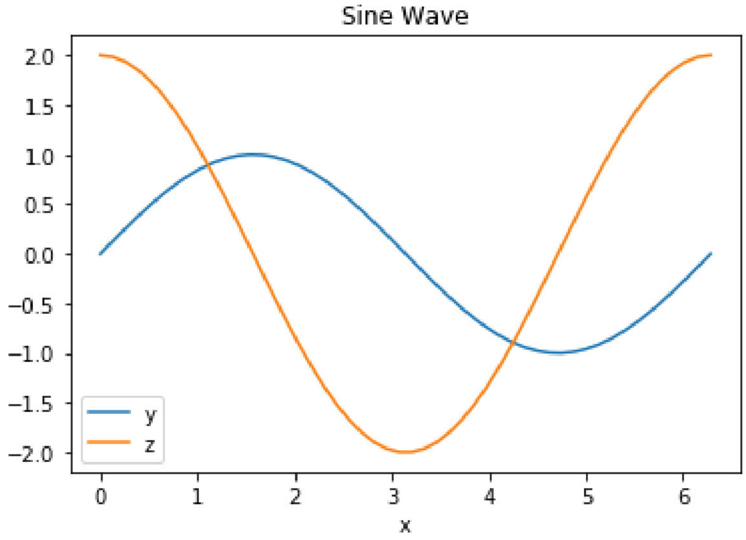
We can specify the columns for `x` and `y` . We can also set title of the graph.

In [6]:

```
df.plot(x='x', title='Sine Wave')
```

Out[6]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x264e6a560c8>
```



Environment Data (Line Graph)

These 3 CSV files are downloaded from https://data.gov.sg (https://data.gov.sg) website.

- air-pollutant-carbon-monoxide.csv
- air-pollutant-ozone.csv
- air-pollutant-sulphur-dioxide.csv

Load the 3 csv files into respective dataframe.

- Set index column
- Rename column with long name.

In [7]:

```python
df1 = pd.read_csv('data/air-pollutant-carbon-monoxide.csv')
df1.set_index('year', inplace=True)
df1.rename(columns={'co_max_8hour_mean':'co'}, inplace=True)
df1.head()
```

Out[7]:

```
       co
year
2000  3.7
2001  4.2
2002  2.7
2003  3.2
2004  2.8
```

In [8]:

```python
df2 = pd.read_csv('data/air-pollutant-ozone.csv')
df2.set_index('year', inplace=True)
df2.rename(columns={'ozone_maximum_8hour_mean':'ozone'}, inplace=True)
df2.head()
```

Out[8]:

```
      ozone
year
2000    112
2001    133
2002    131
2003    118
2004    146
```

In [9]:

```python
df3 = pd.read_csv('data/air-pollutant-sulphur-dioxide.csv')
df3.set_index('year', inplace=True)
df3.rename(columns={'sulphur_dioxide_mean':'sulphur_dioxide'}, inplace=
df3.head()
```

Out[9]:

```
      sulphur_dioxide
year
2000               22
2001               22
2002               18
2003               15
2004               14
```

Merge 3 dataframes together on their index, which is the year.

In [10]:

```
df = df1.merge(df2, left_index=True, right_index=True)
df = df.merge(df3, left_index=True, right_index=True)
df.head()
```

Out[10]:

	co	ozone	sulphur_dioxide
year			
2000	3.7	112	22
2001	4.2	133	22
2002	2.7	131	18
2003	3.2	118	15
2004	2.8	146	14

Plot all 3 columns in the same graph.

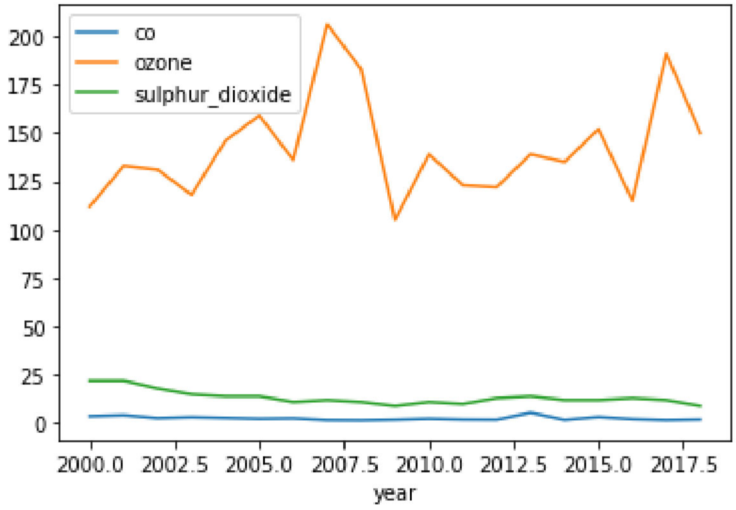
- As 3 series are of different range, they are not suitable to share same y-axis.

In [11]:

```
df.plot()
```

Out[11]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x264e6b09f08>
```



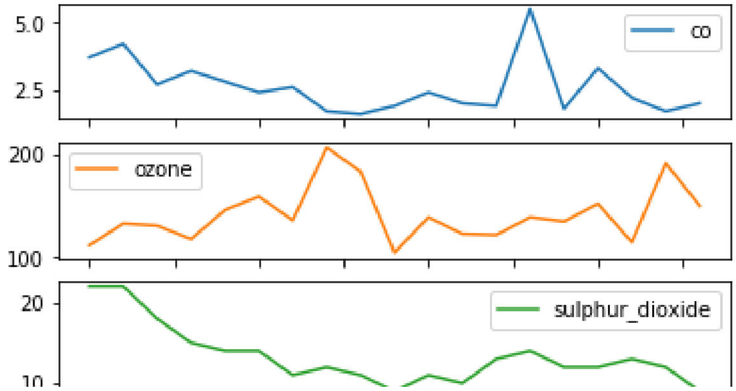
It is better to plot them on different subplots.

In [12]:

```
df.plot(subplots=True)
```

Out[12]:

```
array([<matplotlib.axes._subplots.AxesSubplot object at 0x00000264E6AC8A0
8>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x00000264E6BC1C0
8>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x00000264E6B9C14
8>],
      dtype=object)
```



Fine tune to the plot with following parameters.

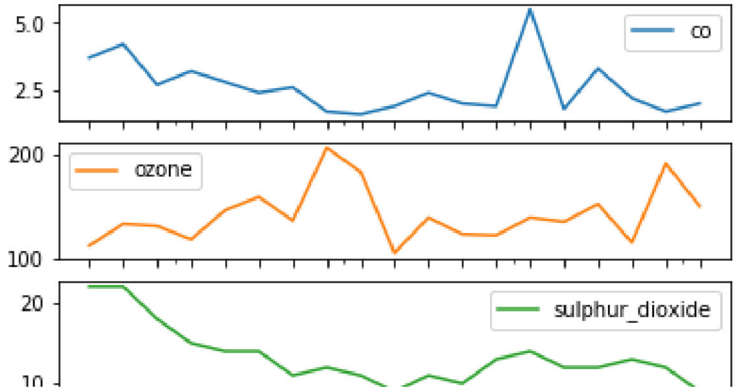
- Use `xticks` parameter to specify the ticks on x-axis so that it doesn't show decimal values.
- Use `rot` to rotate `xticks` by some degree so that they don't overlap each other.

In [13]:

```
df.plot(subplots=True, xticks=df.index, rot=45)
```

Out[13]:

```
array([<matplotlib.axes._subplots.AxesSubplot object at 0x00000264E6CB10C
8>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x00000264E6CE6F8
8>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x00000264E6CCC24
8>],
      dtype=object)
```



Student Marks (Bar Chart and Boxplot)

Load dataset from csv file `data/class1_test1.tsv` .

In [14]:

```python
df1 = pd.read_csv('data/class1_test1.tsv', sep='\t')
print(df1.shape)
```

```
(9, 4)
```

In [15]:

```python
df1.set_index('name', inplace=True)
df1.head()
```

Out[15]:

	english	maths	science
name			
Aaron	70	46	47
Adrian	72	40	95
Alby	49	65	64
Abner	86	40	96
Benett	50	98	69

Average Marks of Students

Find the average mark of each student.

- Need to set `axis=1`

In [16]:

```python
df1.mean(axis=1)
```

Out[16]:

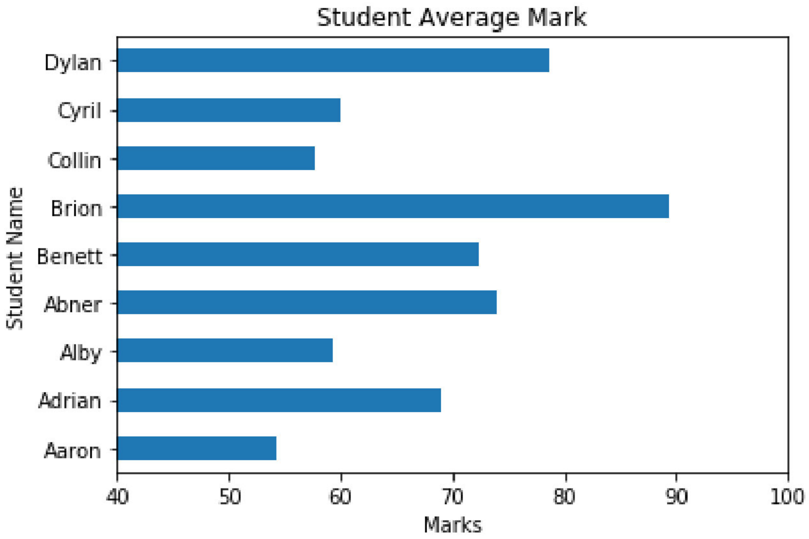
```
name
Aaron      54.333333
Adrian     69.000000
Alby       59.333333
Abner      74.000000
Benett     72.333333
Brion      89.333333
Collin     57.666667
Cyril      60.000000
Dylan      78.666667
dtype: float64
```

In [17]:

```python
ax = df1.mean(axis=1).plot.barh()
ax.set_title('Student Average Mark')
ax.set_xlabel('Marks')
ax.set_xlim(40,100)
ax.set_ylabel('Student Name')
```

Out[17]:

```
Text(0, 0.5, 'Student Name')
```



Average and All Subjects

Can we plot all subjects' marks together with average mark?

Add a column `Average` to dataframe.

In [18]:

```
df1['Average'] = df1.mean(axis=1).apply(int)
df1.head()
```

Out[18]:

name	english	maths	science	Average
Aaron	70	46	47	54
Adrian	72	40	95	69
Alby	49	65	64	59
Abner	86	40	96	74
Benett	50	98	69	72

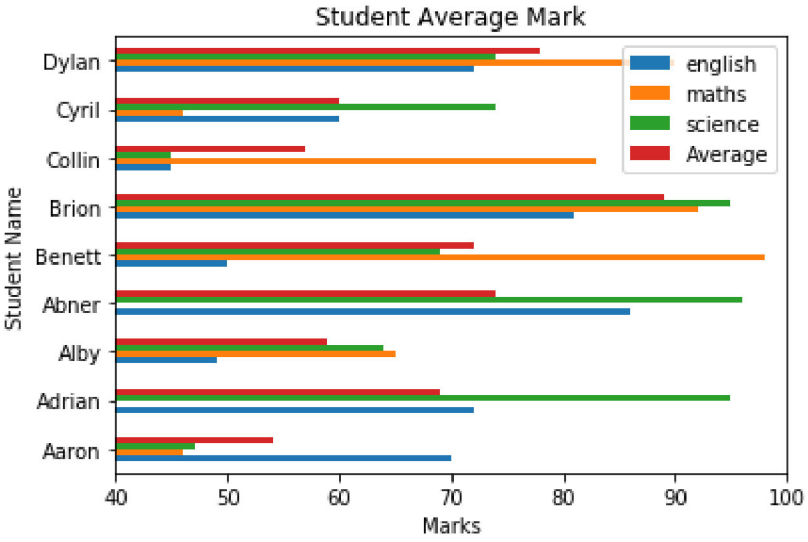
Plot the dataframe with all columns.

In [19]:

```
ax = df1.plot.barh()
ax.set_title('Student Average Mark')
ax.set_xlabel('Marks')
ax.set_xlim(40,100)
ax.set_ylabel('Student Name')
```

Out[19]:

```
Text(0, 0.5, 'Student Name')
```



Concatenate Dataframes

In [20]:

```
df2 = pd.read_csv('data/class2_test1.tsv', sep='\t')
df2.set_index('name', inplace=True)
print(df2.shape)
```

```
(9, 3)
```

Concatenate the two dataframes and set its index to `name` .

In [21]:

```
df = pd.concat([df1, df2])
df.drop('Average', axis=1, inplace=True)
df.head()
```

Out[21]:

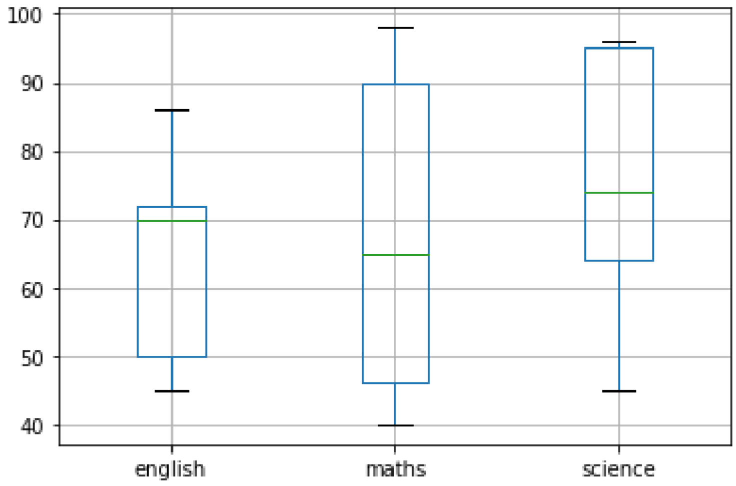
name	english	maths	science
Aaron	70	46	47
Adrian	72	40	95
Alby	49	65	64
Abner	86	40	96
Benett	50	98	69

In [22]:

```
df.plot.box(grid=True)
```

Out[22]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x264e7faa6c8>
```



Bar Chart (Olympics Medals)

In [23]:

```
df = pd.read_csv('data/olympics-medals.csv')
```

In [24]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 414 entries, 0 to 413
Data columns (total 4 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   NOC      414 non-null    object 
 1   Country  414 non-null    object 
 2   Total    334 non-null    float64
 3   Medal    414 non-null    object 
dtypes: float64(1), object(3)
memory usage: 13.1+ KB
```

There are `NaN` values in the dataframe. Let's replace them with 0.

In [25]:

```
df.fillna(0, inplace=True)
```

Convert `Total` column from float to integer.

In [26]:

```
df['Total'] = df['Total'].astype(int)
```

Filter only data related to Gold medal.

In [27]:

```
df1 = df[ df['Medal']== 'Gold' ]
```

Sort them by `Total` column in descending order.

In [28]:

```python
df1.sort_values('Total', ascending=False)
```

Out[28]:

	NOC	Country	Total	Medal
0	USA	United States	2088	Gold
1	URS	Soviet Union	838	Gold
2	GBR	United Kingdom	498	Gold
6	ITA	Italy	460	Gold
4	GER	Germany	407	Gold
...	...	...	...	...
109	BER	Bermuda*	0	Gold
110	DJI	Djibouti	0	Gold
111	ERI	Eritrea	0	Gold
112	GUY	Guyana	0	Gold
114	KUW	Kuwait	0	Gold

138 rows × 4 columns

Select only top 10 countries with most Gold medals.

In [29]:

```python
df2 = df1.iloc[:10]
```

Plot bar graph and set axis reference to `ax` .

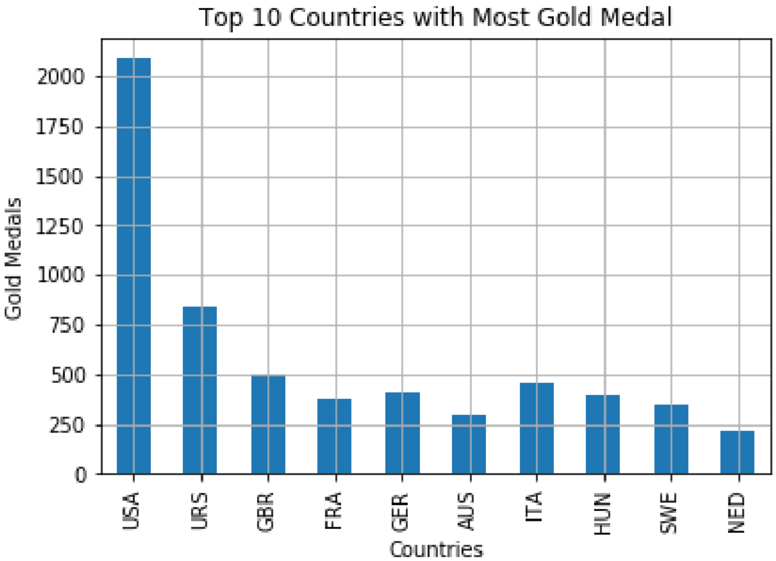
- Use it to set xlabel and ylabel

In [30]:

```
ax = df2.plot.bar(x='NOC',
                  grid=True,
                  legend=False,
                  title='Top 10 Countries with Most Gold Medal')
ax.set_xlabel('Countries')
ax.set_ylabel('Gold Medals')
```

Out[30]:

```
Text(0, 0.5, 'Gold Medals')
```



Save Figure

Charts can be saved using `savefig()` function of Figure object.

- Get figure object from axes.
- Tighten layout so that all labels are inside the figure.
- Save the figure

In [31]:

```
fig = ax.get_figure()
fig.tight_layout()
fig.savefig('medal.png')
```

2. Matplotlib Plotting

Matplotlib provides 2 sets of APIs with same functionalities.

- Pyplot is the low-level API
- Object-oriented API provides more flexible way of plotting using Figure and Axes.

Trigonometry

In [32]:

```python
x = np.linspace(0, np.pi*2, 50)
y = np.sin(x)
z = np.cos(x)*2
```

Create a subplot with 1 axes in the figure.

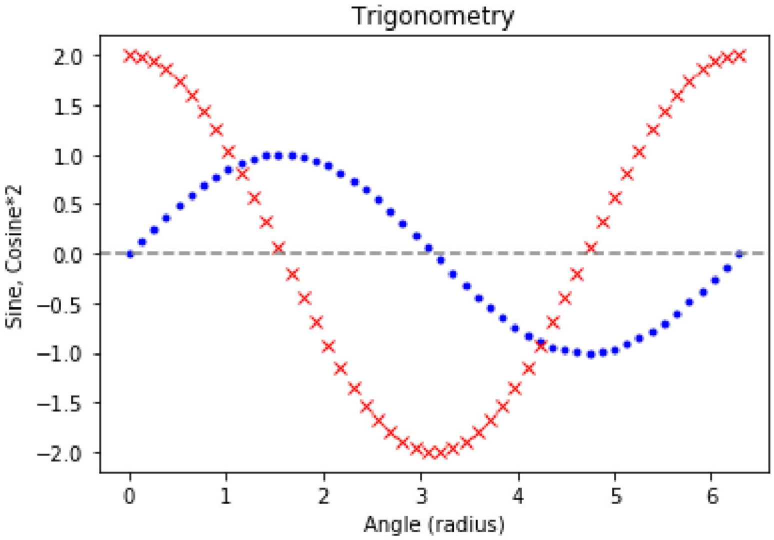
- Each line requires 2 series and 1 optional marker format.

In [33]:

```python
fig, ax = plt.subplots()
ax.set_title('Trigonometry')
ax.plot(x, y, 'b.', x, z, 'rx')
ax.set_xlabel('Angle (radius)')
ax.set_ylabel('Sine, Cosine*2')
# Add a horizontal line
ax.axhline(0, linestyle='--', color='grey')
```

Out[33]:

```
<matplotlib.lines.Line2D at 0x264e81048c8>
```



Environment Data

In [34]:

```
df1 = pd.read_csv('data/air-pollutant-carbon-monoxide.csv')
df1.set_index('year', inplace=True)
df1.rename(columns={'co_max_8hour_mean':'co'}, inplace=True)
df1.head()
```

Out[34]:

	co
year	
2000	3.7
2001	4.2
2002	2.7
2003	3.2
2004	2.8

In [35]:

```
df2 = pd.read_csv('data/air-pollutant-ozone.csv')
df2.set_index('year', inplace=True)
df2.rename(columns={'ozone_maximum_8hour_mean':'ozone'}, inplace=True)
df2.head()
```

Out[35]:

	ozone
year	
2000	112
2001	133
2002	131
2003	118
2004	146

In [36]:

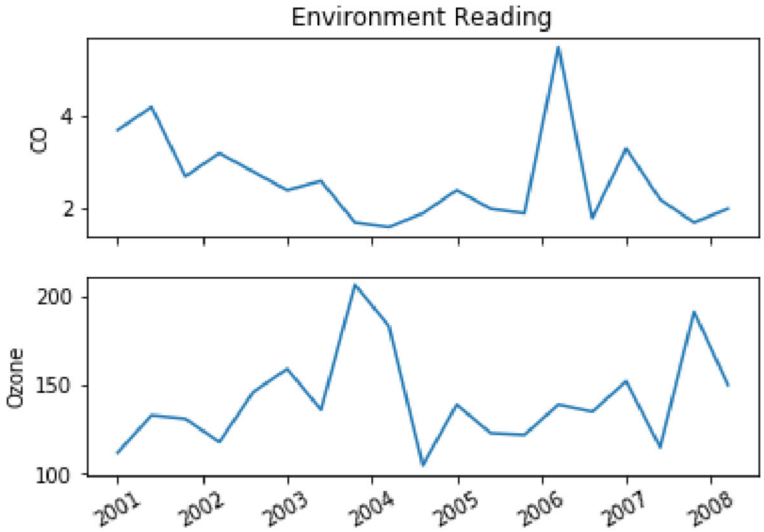
```
df = df1.merge(df2, left_index=True, right_index=True)
df.head()
```

Out[36]:

	co	**ozone**
year		
2000	3.7	112
2001	4.2	133
2002	2.7	131
2003	3.2	118
2004	2.8	146

In [37]:

```python
# Create a figure with 2 rows and 1 columns of axes
fig, ax = plt.subplots(2, 1, sharex=True)
# 1st axes
ax[0].plot(df['co'])
ax[0].set_ylabel('CO')
ax[0].set_title('Environment Reading')
# 2nd axes
ax[1].plot(df['ozone'])
ax[1].set_ylabel('Ozone')
ax[1].set_xticklabels(df.index, rotation=30);
```



Olympics Medals

In [38]:

```python
df = pd.read_csv('data/olympics-medals.csv')
df.head()
```

Out[38]:

	NOC	Country	Total	Medal
0	USA	United States	2088.0	Gold
1	URS	Soviet Union	838.0	Gold
2	GBR	United Kingdom	498.0	Gold
3	FRA	France	378.0	Gold
4	GER	Germany	407.0	Gold

Use `pivot_table()` to create `Gold` , `Silver` and `Bronze` columns.

In [39]:
```
df1 = df.pivot_table(index=['NOC', 'Country'], columns='Medal', values=
df1.head()
```

Out[39]:

	Medal	Bronze	Gold	Silver
NOC	**Country**			
AFG	**Afghanistan**	1.0	NaN	NaN
AHO	**Netherlands Antilles***	NaN	NaN	1.0
ALG	**Algeria**	8.0	4.0	2.0
ANZ	**Australasia**	5.0	20.0	4.0
ARG	**Argentina**	88.0	68.0	83.0

Reset the index and set `NOC` as index.

In [40]:
```
df1.reset_index(inplace=True)
df1.set_index('NOC', inplace=True)
```

Convert data type of medal columns to integer.

In [41]:
```
df1.fillna(0, inplace=True)
df1 = df1[['Gold', 'Silver', 'Bronze']].astype(int)
```

Sort the dataframe by medals.

In [42]:
```
df1.sort_values(['Gold','Silver', 'Bronze'], ascending=False, inplace=T
```

Get the top 10 countries.

In [43]:
```
df2 = df1.iloc[:10]
```

Plot the graph.

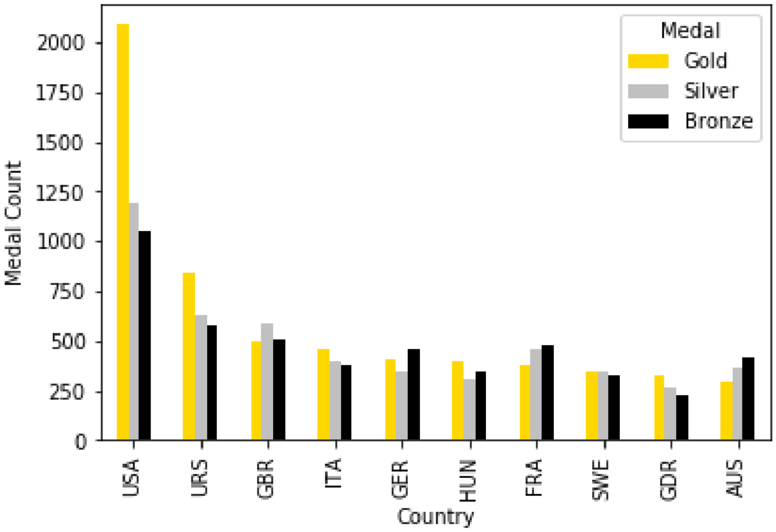
- Set color for each bar.
- Use `ax` to change `xlabel` and `ylabel` .

In [44]:

```
fig, ax = plt.subplots()
df2.plot.bar(color=['gold', 'silver', 'black'], ax=ax)
ax.set_xlabel('Country')
ax.set_ylabel('Medal Count')
```

Out[44]:

```
Text(0, 0.5, 'Medal Count')
```



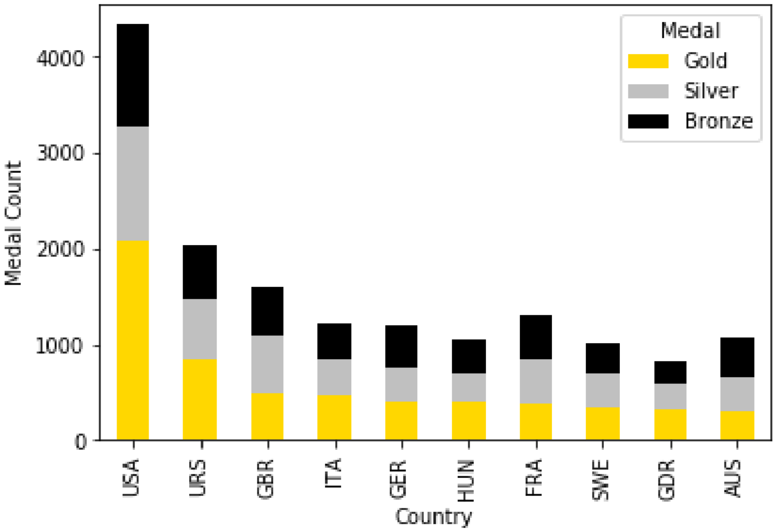
Change `stacked=True` to stack the bars.

In [45]:

```
fig, ax = plt.subplots()
df2.plot.bar(color=['gold', 'silver', 'black'], ax=ax, stacked=True)
ax.set_xlabel('Country')
ax.set_ylabel('Medal Count')
```

Out[45]:

```
Text(0, 0.5, 'Medal Count')
```


Medal
Gold
Silver
Bronze
Medal Count
USA
URS
GBR
ITA
GER
HUN
FRA
SWE
GDR
AUS
Country