Lab_visualisation_questions

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1 Data visualisation in Python

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For a full overview of types of plots using matplotlib, see the gallery at https://matplotlib.org/2.0.2/gallery.html

1.1 Scatterplots

We will be using scottish_hills.csv from https://github.com/ourcodingclub/CC-python-pandas-matplotlib. The file contains all the mountains above 3000 feet (about 914 metres) in Scotland.

We can read this into a variable and see the first 10 lines:

```
In [9]: import pandas as pd

        url = "https://raw.githubusercontent.com/ourcodingclub/" \
        "CC-python-pandas-matplotlib/master/scottish_hills.csv"
        dataframe = pd.read_csv(url)
        print(dataframe.head(10))
```

```
                  Hill Name  Height   Latitude  Longitude    Osgrid
0       A' Bhuidheanach Bheag   936.0  56.870342  -4.199001  NN660775
1                A' Chailleach   997.0  57.693800  -5.128715  NH136714
2                A' Chailleach   929.2  57.109564  -4.179285  NH681041
3  A' Chraileag (A' Chralaig)  1120.0  57.184186  -5.154837  NH094147
4              A' Ghlas-bheinn   918.0  57.255090  -5.303687  NH008231
5                A' Mhaighdean   967.0  57.719644  -5.346720  NH007749
6               A' Mharconaich   973.2  56.857002  -4.290668  NN604762
7                   Am Basteir   934.0  57.247931  -6.202982  NG465253
8                    Am Bodach  1031.8  56.741727  -4.983393  NN176650
9                Am Faochagach   953.0  57.771801  -4.853899  NH303793
```

As explored last week, pandas dataframes can be used for some preliminary data exploration. For instance, let's sort the hills by height:

```
In [10]: sorted_hills = dataframe.sort_values(by=['Height'], ascending=False)
```

```
# Let's have a look at the top 5 to check
print(sorted_hills.head(5))
```

```
                         Hill Name  Height   Latitude  Longitude    Osgrid
92                       Ben Nevis  1344.5  56.796891  -5.003675  NN166712
88   Ben Macdui (Beinn Macduibh)    1309.0  57.070368  -3.669099  NN988989
104                      Braeriach  1296.0  57.078298  -3.728389  NN953999
115                     Cairn Toul  1291.0  57.054397  -3.710773  NN963972
212          Sgor an Lochain Uaine  1258.0  57.058369  -3.725797  NN954976
```

Now let's load matplotlib. Note: if you are using a jupyter notebook you need the inline statement on line 1 below:

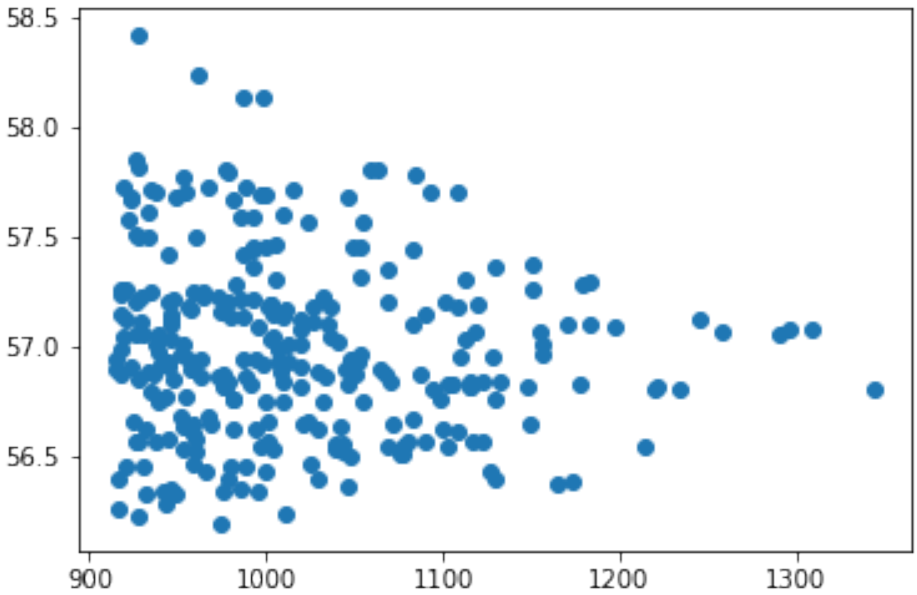
```
In [0]: %matplotlib inline
        import matplotlib.pyplot as plt
```

To save us some time, let's create some shortcut variables, x and y, to register the hight and latitude coordinates of each of the hills.

```
In [0]: x = dataframe.Height
        y = dataframe.Latitude
        z = dataframe.Longitude
```

Now we are ready to start visualising them. Let's create (and save) a scatterplot:

```
In [13]: plt.scatter(x, y)
         plt.savefig("scottish_scatter_plot.png")
```



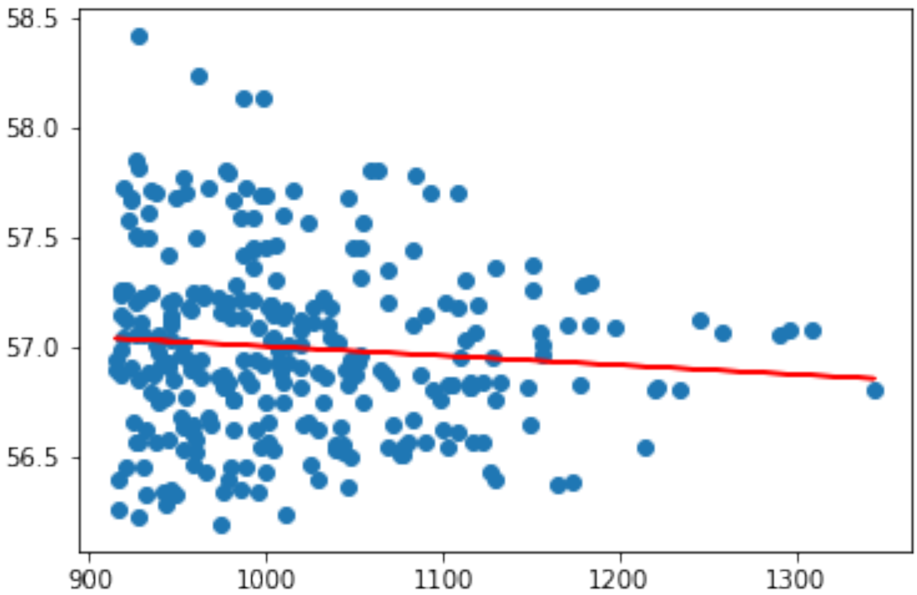
If you are not using iPython, you can use `plt.show()` to display the plot.

Now let's build upon this graph by adding a linear regression line to it.

```
In [0]: from scipy.stats import linregress
        stats = linregress(x, y)

        m = stats.slope
        b = stats.intercept
```

Now we can add the plot of our linear regression by using the equation of a straight line:

```
In [15]: plt.scatter(x, y)
         # The equation of the straight line.
         plt.plot(x, m * x + b, color="red")

Out[15]: [<matplotlib.lines.Line2D at 0x7f87b9e04668>]
```



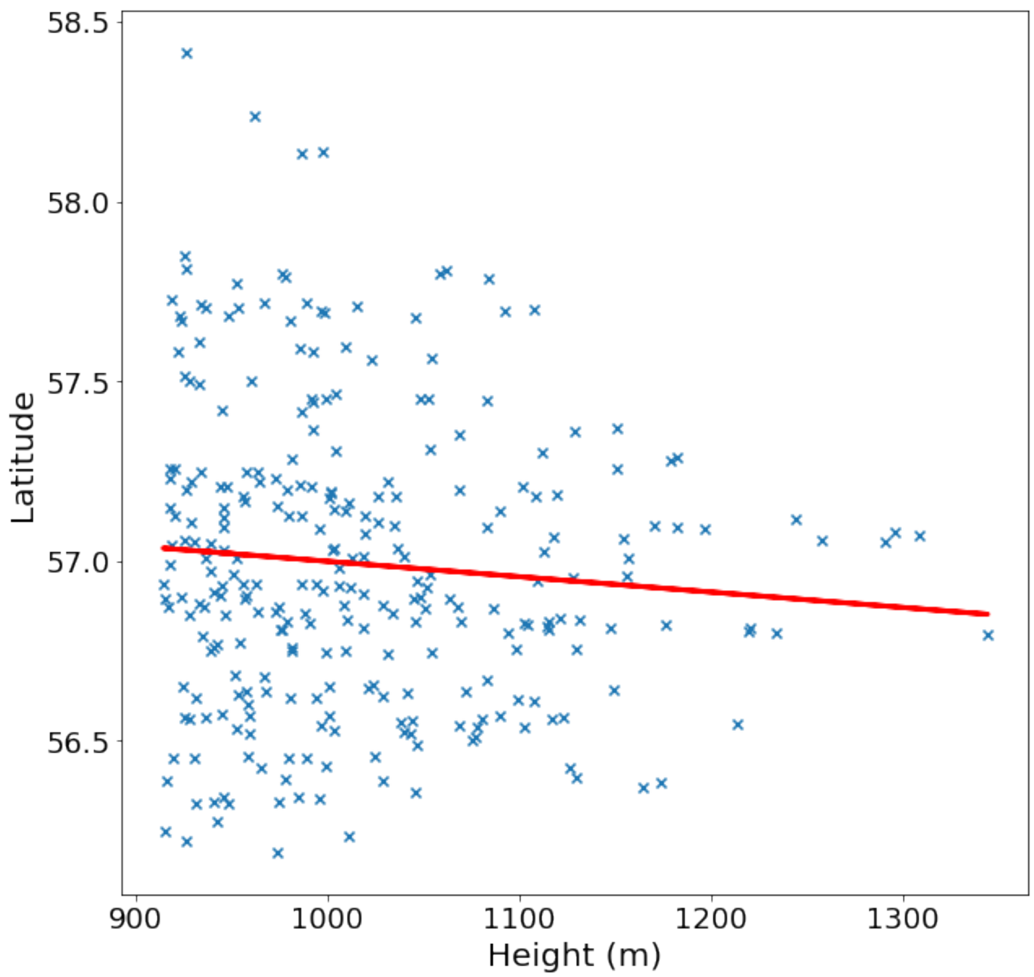
Note, wether this line is statistically significant can be determined using the extra information in the stats object - `stats.rvalue` and `stats.pvalue`.

Now you can make your plot look nicer using arguments such as as fontsize, linewidth, color,. . .

```
In [16]: # Change the default figure size
         plt.figure(figsize=(10,10))
```

```
# Change the default marker for the scatter from circles to x's
plt.scatter(x, y, marker='x')

# Set the linewidth on the regression line to 3px
plt.plot(x, m * x + b, color="red", linewidth=3)

# Add x and y lables, and set their font size
plt.xlabel("Height (m)", fontsize=20)
plt.ylabel("Latitude", fontsize=20)

# Set the font size of the number lables on the axes
plt.xticks(fontsize=18)
plt.yticks(fontsize=18)
```

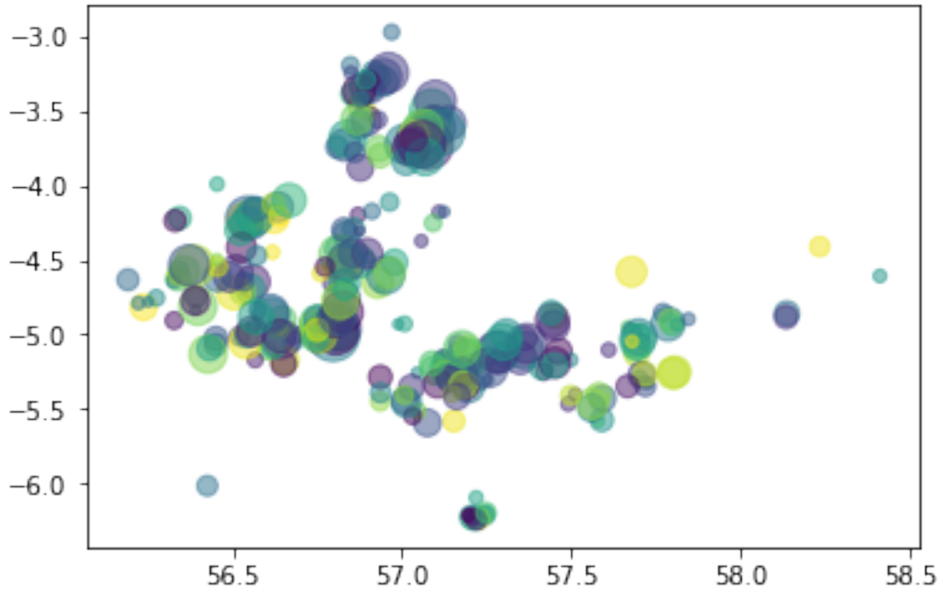
```
Out[16]: (array([56. , 56.5, 57. , 57.5, 58. , 58.5, 59. ]),
          <a list of 7 Text yticklabel objects>)
```



Let's have a look at how the hills our spread out geographically using latitude (y) and longitude (z). Now we can use s = x to say that the size needs to be equal to the height (x). (I added -900 to make the difference between big and small mountains larger)

In [17]:
```
import numpy as np

colors = np.random.rand(len(y))  #generates a different color
                                 # for each different mountain

plt.scatter(y, z, s = (x-900), c=colors, alpha=0.5)
```

Out[17]: <matplotlib.collections.PathCollection at 0x7f87b877a320>

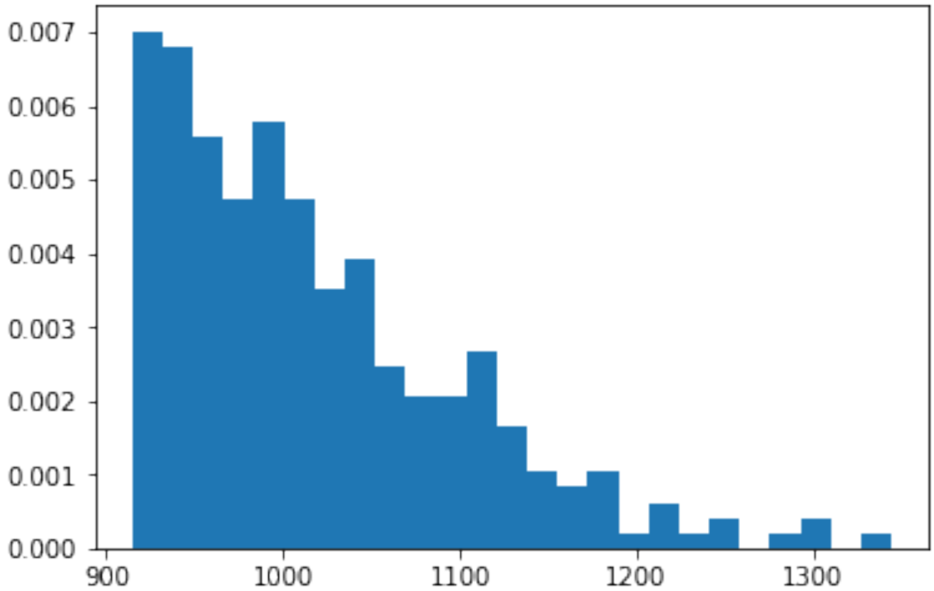


1.2 Histograms

Let's try some other graphs. A full selection is given at the matplotlib website.

Let's start by looking at the distribution of our hills over the latitude (variable y from earlier):

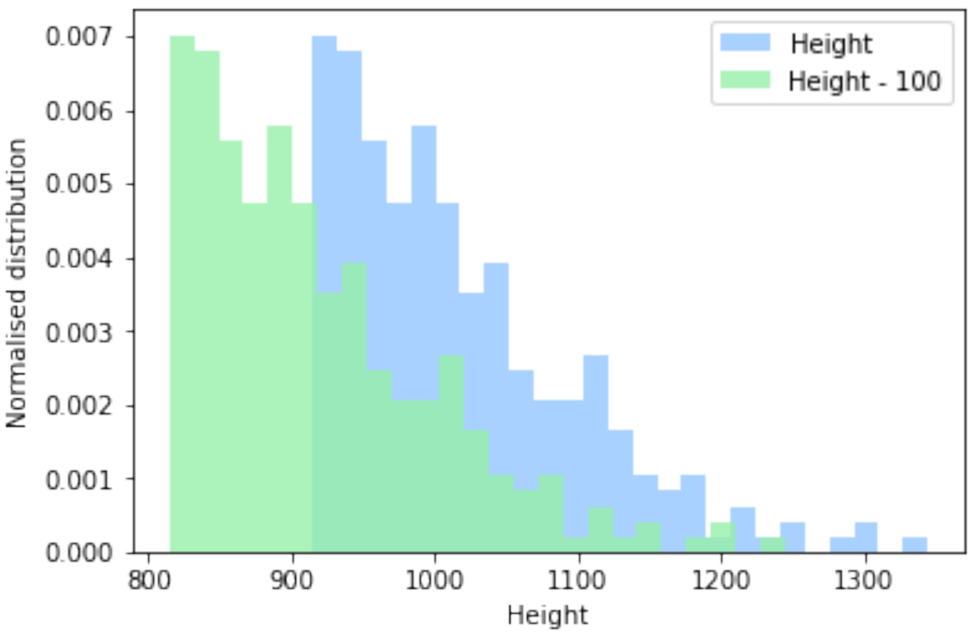
In [19]:
```
plt.hist(x, bins=25, density=True) #bins separates the latitude in
# 25 discrete categories. Density will normalize the data to 1.
# If you get an error, use density instead of normed (newer matplotlib version)

plt.savefig("histogram.png", dpi=25)  # results in 160x120 px image
```



Quickly style your plot with stylesheets, full overview at https://matplotlib.org/gallery/style_sheets/style_sheets_reference.html.

Let's also create a new variable that contains the height of the hills -100m. This to illustrate how to add a second distribution to your graph. In this case, we will make them slightly transparent.

```
In [20]: import numpy as np

         # using a stylesheet:
         plt.style.use('seaborn-pastel')

         #creating the new height variable:
         shifted_x = x - 100

         fig, ax = plt.subplots()
         ax.hist(x, bins=25, density=True, histtype="stepfilled",
                 alpha=0.8,label='Height')
         ax.hist(shifted_x, bins=25, density=True, histtype="stepfilled",
                 alpha=0.8,label='Height - 100')
         ax.legend(prop={'size': 10})

         ax.set_ylabel('Normalised distribution')
         ax.set_xlabel('Height')

Out[20]: Text(0.5, 0, 'Height')
```



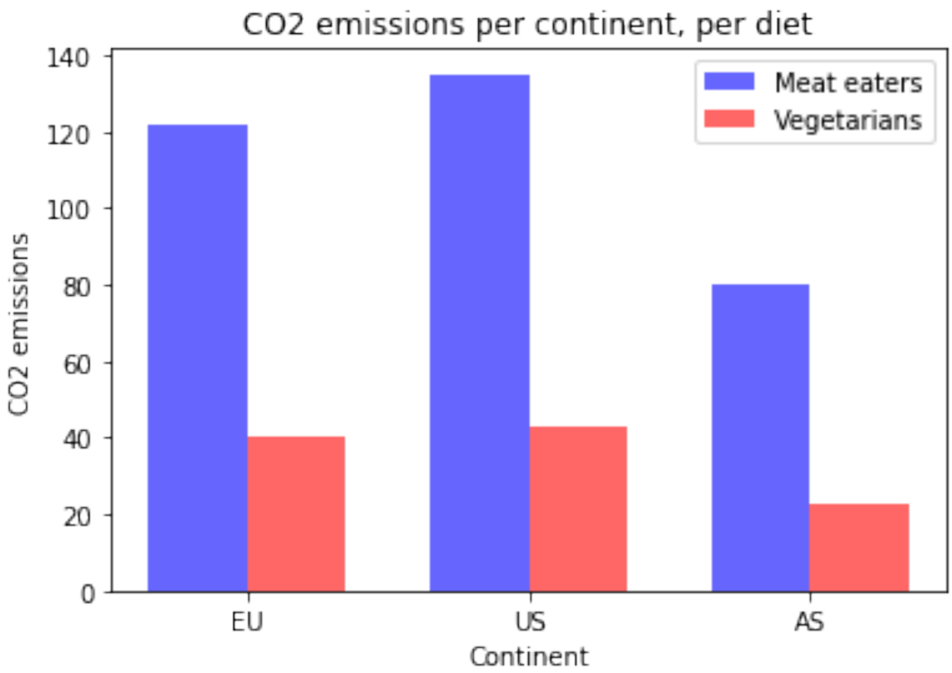
1.3 Bar charts

Plot the average CO2 output of both vegetarians and meat eaters for different continents in a bar plot. The data is given below:

```
In [21]: labels = ['EU', 'US', 'AS']

         meateaters = [122, 135, 80]
         vegetarians = [40, 43, 23]


         # Keep a numeric index for the x-axis lables. This will be the position sof the ticks
         index = np.arange(len(labels))


         fig, ax = plt.subplots()

         bar_width = 0.35
         opacity = 0.6

         rects1 = ax.bar(index, meateaters, bar_width,
                         alpha=opacity, color='b',
                         label='Meat eaters')

         # Note, shift the x postion also with the bar width so that the bar
```

```
# appears next to the previous onеś
rects2 = ax.bar(index + bar_width, vegetarians, bar_width,
                alpha=opacity, color='r',
                label='Vegetarians')


ax.set_xlabel('Continent')
ax.set_ylabel('CO2 emissions')
ax.set_title('CO2 emissions per continent, per diet')

ax.set_xticks(index + bar_width / 2)

ax.set_xticklabels(labels)

ax.legend()
```

Out[21]: <matplotlib.legend.Legend at 0x7f87b8545160>



1.4 Line plots

Let's move on to another type of graph: a simple line plot, but using two vertical axis.

We will create a function to calculate the temperature in celcius given Fahrenheit.

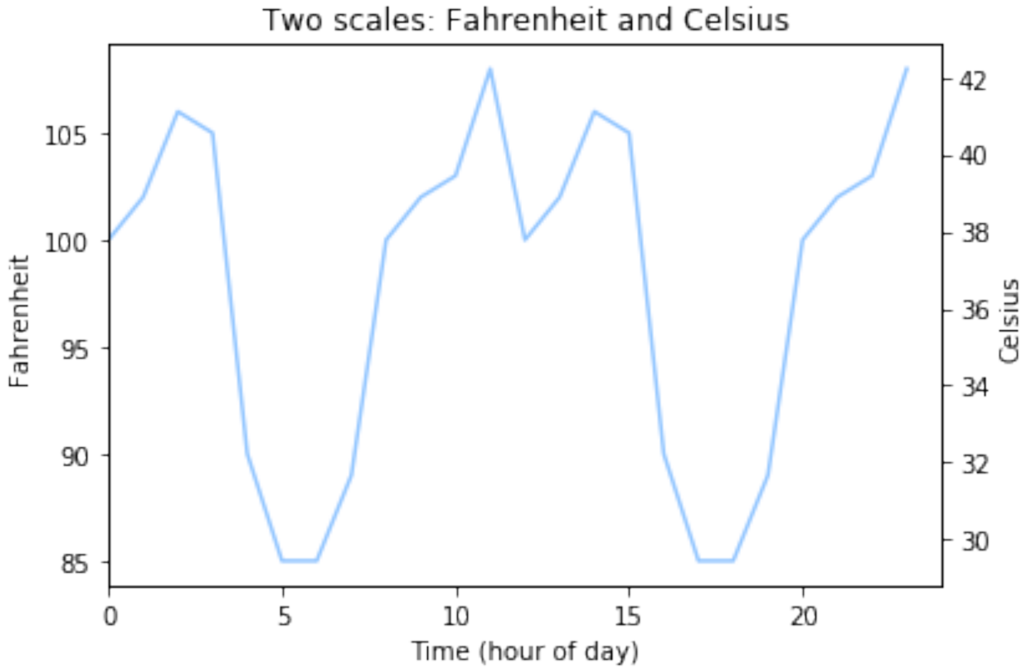
In [0]:
```
def fahrenheit2celsius(temp):
    """
```

```
        Returns temperature in Celsius.
        """
        return (5. / 9.) * (temp - 32)


    # TEMPURATURE AT EACH HOUR THROUGHOUT THE DAY (In Fahrenheit)
    temperature = [100, 102, 106, 105, 90, 85, 85, 89, 100, 102, 103, 108, 100, 102,
                   106, 105, 90, 85, 85, 89, 100, 102, 103, 108]
```

We will use twinx to get a second set of axes. This allows us to plot the temperature evolution throughout the day using both C and F.

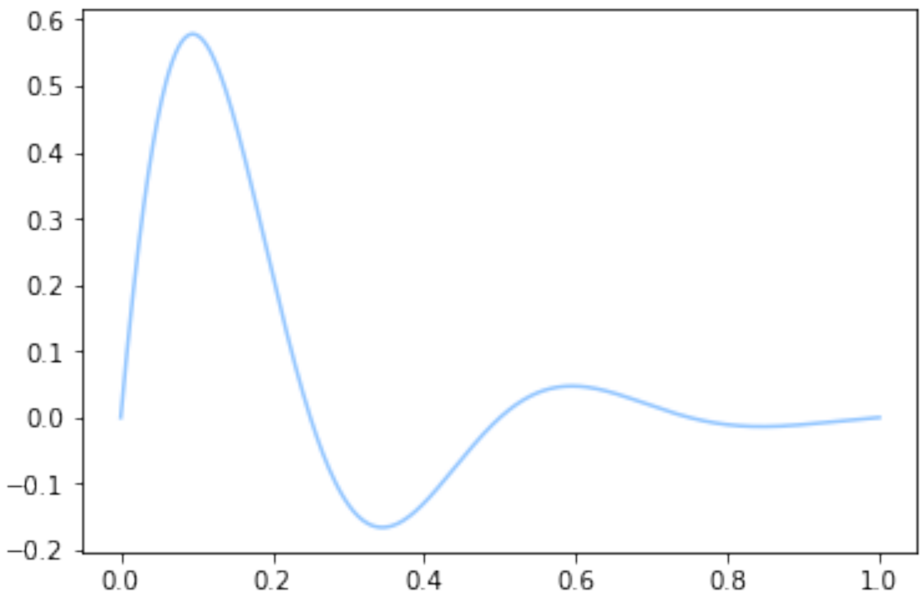
```
In [23]: fig, ax_f = plt.subplots()
         ax_c = ax_f.twinx()

         #plot our data:
         ax_f.plot(temperature)
         ax_f.set_xlim(0, 24) #x-axis shows 24 hours

         # set the axis limits:
         y1, y2 = ax_f.get_ylim()
         ax_c.set_ylim(fahrenheit2celsius(y1), fahrenheit2celsius(y2))
         ax_c.figure.canvas.draw()

         # change some axis labels
         ax_f.set_title('Two scales: Fahrenheit and Celsius')
         ax_f.set_ylabel('Fahrenheit')
         ax_c.set_ylabel('Celsius')
         ax_f.set_xlabel('Time (hour of day)')
```

```
Out[23]: Text(0.5, 15.0, 'Time (hour of day)')
```



Suppose we have a sinusoidal plot (formula line 2 below), and we want to fill it. First let's plot the sinusoid.

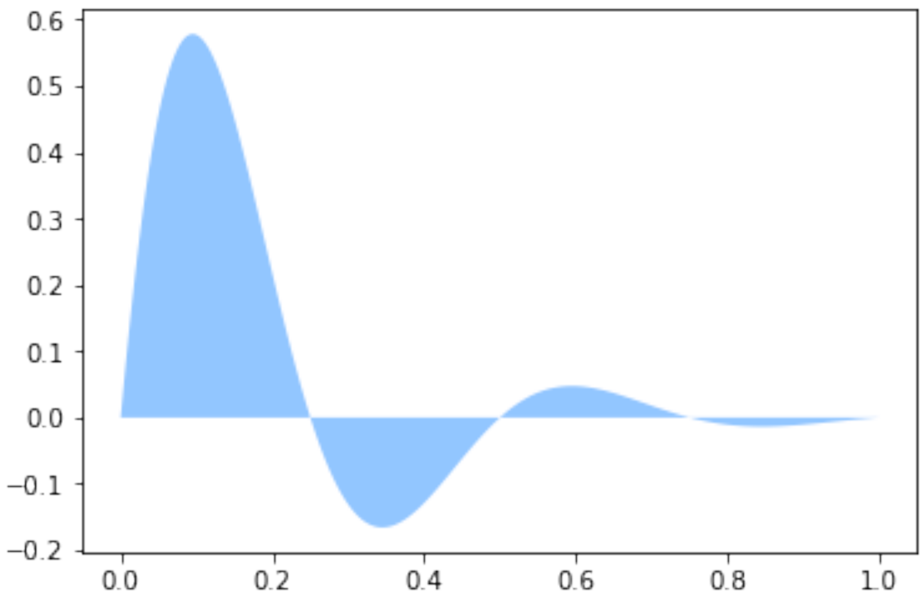
```
In [24]: newx = np.linspace(0, 1, 500) # sample 500 X's between 0 and 1
         newy = np.sin(4 * np.pi * newx) * np.exp(-5 * newx) #formula for our graph

         fig, ax = plt.subplots()  #plt.subplots()  lets us acces the axis
         # and plot seperately.

         ax.plot(newx, newy)

Out[24]: [<matplotlib.lines.Line2D at 0x7f87b8501b70>]
```



Then we can easily use the fill command.

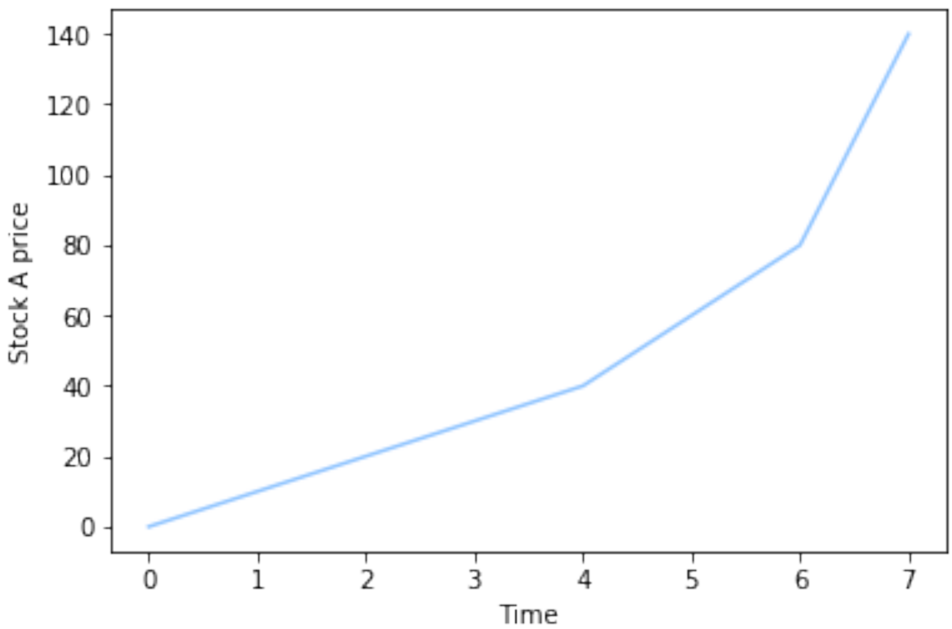
In [25]:
```
fig, ax = plt.subplots()

ax.fill(newx, newy)
```

Out[25]:
```
[<matplotlib.patches.Polygon at 0x7f87b856c4e0>]
```



Axis labels can influence how we perceive the data. Let's have a look at this stock, which has been stagnating recently.

```
In [26]: # growth of stock A
         stockA = [0, 10, 20, 30, 40, 60, 80, 140]

         plt.plot(stockA)
         # plt.ylim(bottom=0, top = 110)
         plt.xlabel('Time')
         plt.ylabel('Stock A price')

Out[26]: Text(0, 0.5, 'Stock A price')
```



Now let's change to a logaritmic axis. Other options here are linear, log, logit, symlog. Give it a try.

fig = plt.figure() ax = fig.add_subplot(1, 1, 1)

line, = ax.plot(stockA) ax.set_yscale('log') #change the scale here

plt.xlabel('Time') plt.ylabel('Stock A price') ax.set_title('Logarithmic')

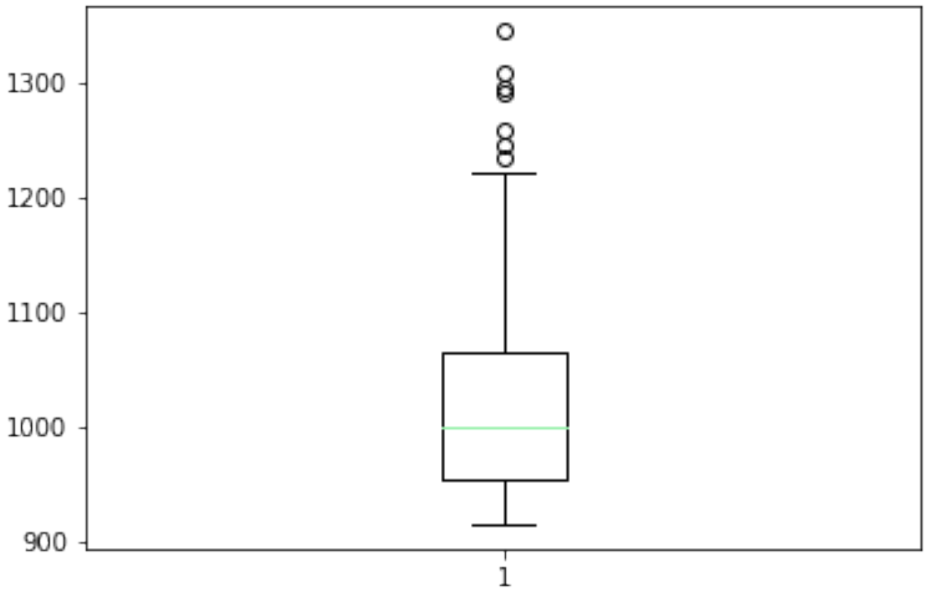
This illustrates how axes can deform the data...

1.4.1 Boxplots

For all the mountains, let's see what their average height is, with standard deviation in a boxplot.

```
In [27]: plt.boxplot(x)
```

```
Out[27]: {'boxes': [<matplotlib.lines.Line2D at 0x7f87b82f76d8>],
          'caps': [<matplotlib.lines.Line2D at 0x7f87b82f7ef0>,
           <matplotlib.lines.Line2D at 0x7f87b8301278>],
          'fliers': [<matplotlib.lines.Line2D at 0x7f87b8301908>],
          'means': [],
          'medians': [<matplotlib.lines.Line2D at 0x7f87b83015c0>],
          'whiskers': [<matplotlib.lines.Line2D at 0x7f87b82f7828>,
           <matplotlib.lines.Line2D at 0x7f87b82f7ba8>]}
```

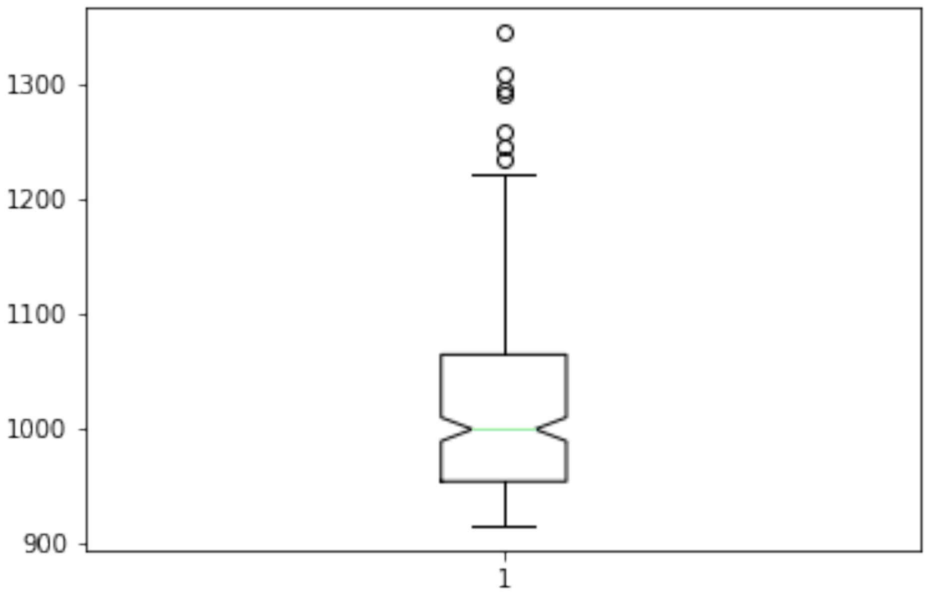


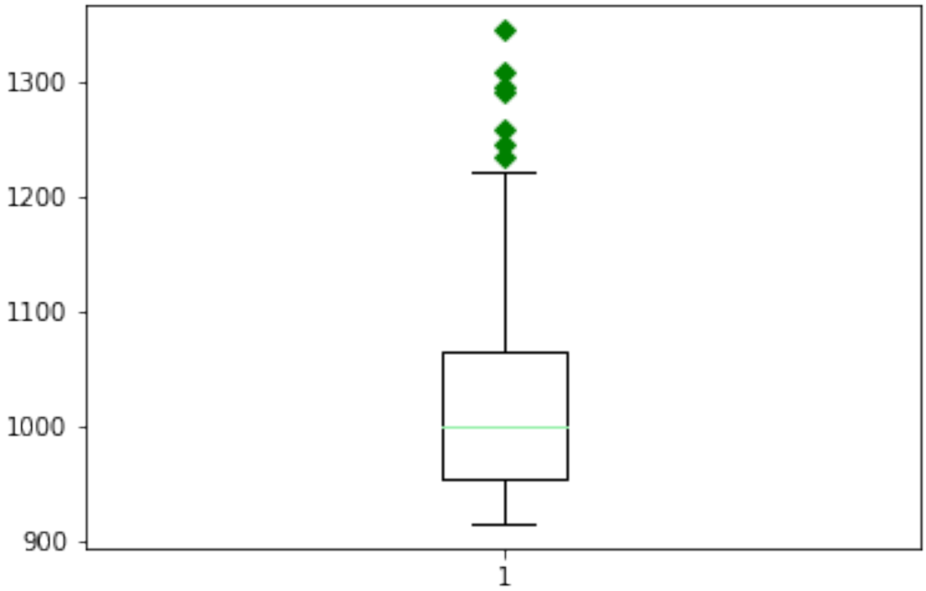
We can make this slightly nicer:

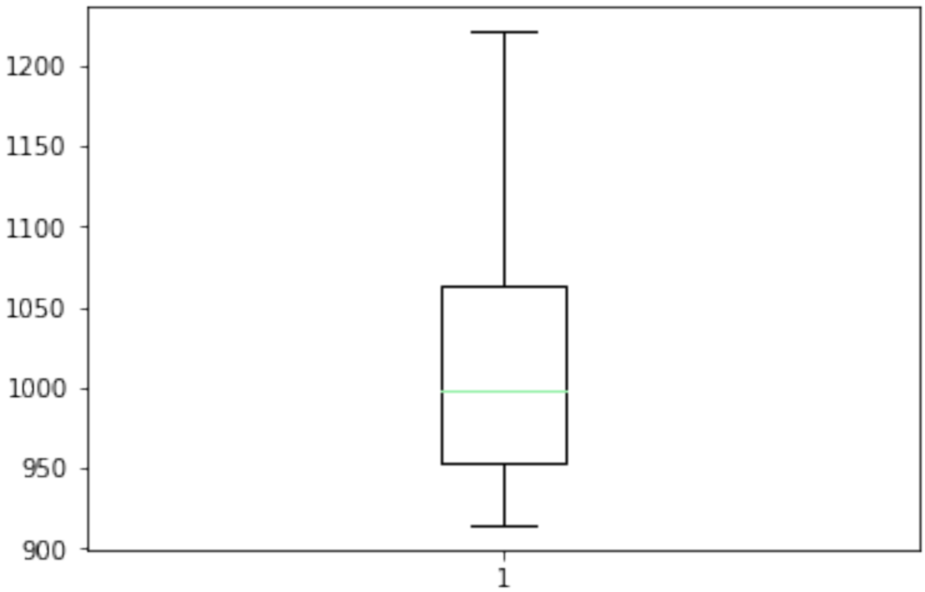
```
In [28]: # notched plot
         plt.figure()
         plt.boxplot(x, 1)

         # change outlier point symbols
         plt.figure()
         plt.boxplot(x, 0, 'gD')

         # don't show outlier points
         plt.figure()
         plt.boxplot(x, 0, '')

         # horizontal boxes
         plt.figure()
```

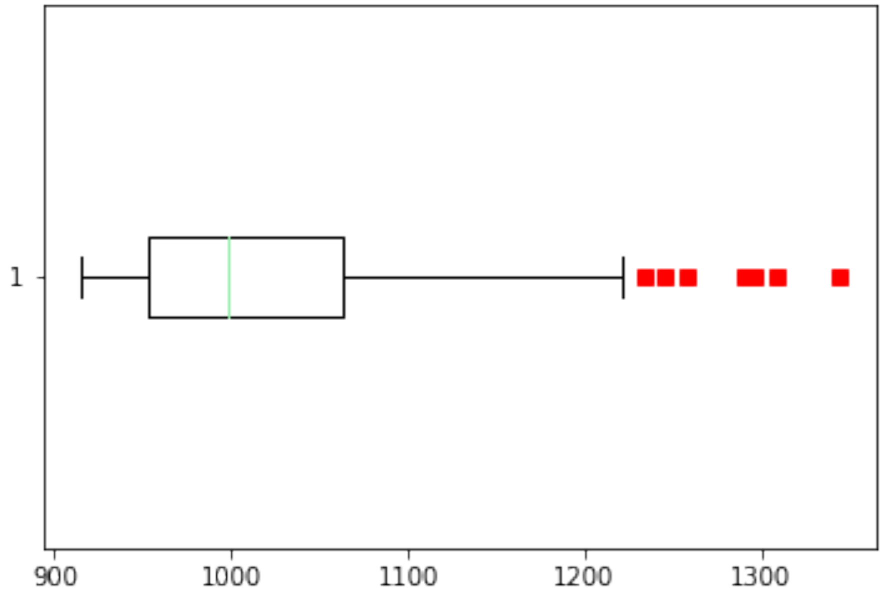
```
plt.boxplot(x, 0, 'rs', 0)

# change whisker length
plt.figure()
plt.boxplot(x, 0, 'rs', 0, 0.75)
```

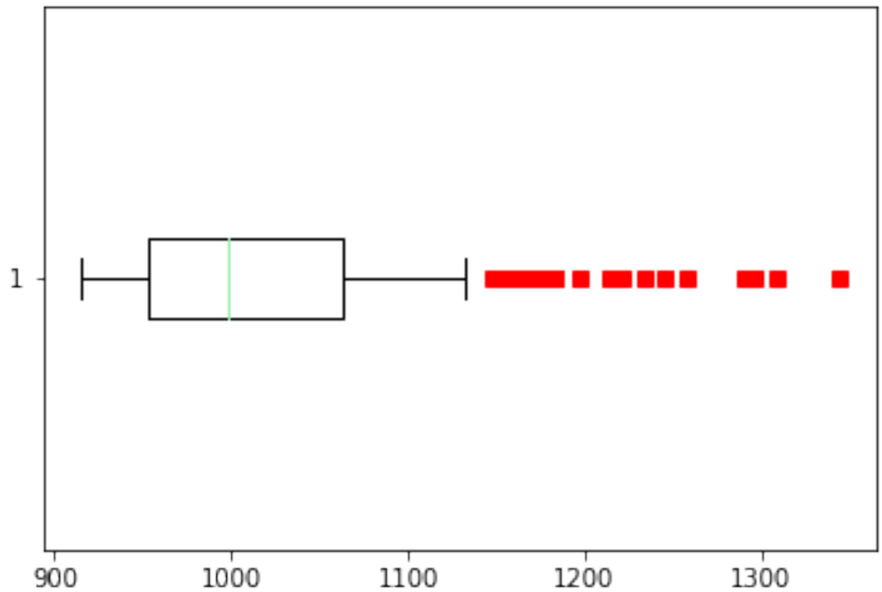
```
Out[28]: {'boxes': [<matplotlib.lines.Line2D at 0x7f87b81bf9b0>],
 'caps': [<matplotlib.lines.Line2D at 0x7f87b81cc208>,
  <matplotlib.lines.Line2D at 0x7f87b81cc550>],
 'fliers': [<matplotlib.lines.Line2D at 0x7f87b81ccbe0>],
 'means': [],
 'medians': [<matplotlib.lines.Line2D at 0x7f87b81cc898>],
 'whiskers': [<matplotlib.lines.Line2D at 0x7f87b81bfb00>,
  <matplotlib.lines.Line2D at 0x7f87b81bfe80>]}
```




1300
1200
1100
1000
900
1


1200
1150
1100
1050
1000
950
900
1


1
900
1000
1100
1200
1300


1
900
1000
1100
1200
1300

2 Now to try yourself:

Load the dataset from `https://raw.githubusercontent.com/plotly/datasets/master/school_earnings.csv`, and have a look at what it contains.

Then create the following:

1. A **histogram** of the salaries for women.
2. Add the men's salaries to this histogram.
3. Give your histogram a dark background and label the axes.
4. Next, please label the colors of the histogram so we know who is what (men vs women).
5. Instead of a histogram, create a **bar chart** that lists the salary for women (y-axis) for each school.
6. Also add men to this bar chart.
7. Make the style nice and add labels.
8. Now create a nice **boxplot** of the data, one for men, one for women (two box's same graph).

2.1 Solution: histogram

In [0]:

In [0]:

2.2 Solution: Bar chart

In [0]:

2.3 Solution: Boxplot

In [0]:

Well done!

In [0]: