In [1]:

```python
%matplotlib inline
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.metrics import r2_score
import statsmodels.api as sm
from sklearn.linear_model import LinearRegression
import time
```

Univariate Linear Regression

In [2]:

```python
data=pd.read_csv("D:/Sem 5/ML/ex1data1.txt", header=None)
data.head()
```

Out[2]:

	0	1
0	6.1101	17.5920
1	5.5277	9.1302
2	8.5186	13.6620
3	7.0032	11.8540
4	5.8598	6.8233

In [3]:

```python
data.describe()
```

Out[3]:

	0	1
count	97.000000	97.000000
mean	8.159800	5.839135
std	3.869884	5.510262
min	5.026900	-2.680700
25%	5.707700	1.986900
50%	6.589400	4.562300
75%	8.578100	7.046700
max	22.203000	24.147000

In [4]:

```python
data.columns = ['Population', 'Profit'] #assigning column names
```

In [5]:

```python
data.isnull().sum()
```

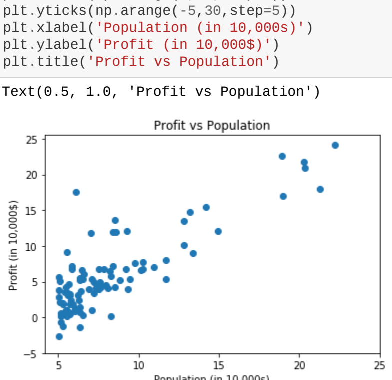
Out[5]:

```
Population    0
Profit        0
dtype: int64
```

In [6]:

```python
plt.scatter(data['Population'], data['Profit'])
plt.xticks(np.arange(5,30,step=5))
plt.yticks(np.arange(-5,30,step=5))
plt.xlabel('Population (in 10,000s)')
plt.ylabel('Profit (in 10,000$)')
plt.title('Profit vs Population')
```

Out[6]: Text(0.5, 1.0, 'Profit vs Population')



Cost Function J(θ)

In [7]:

```python
def computeCost(X,y,theta):
    """
    Take in a numpy arary X,y,theta and get cost function using theta as
parameter in a linear regression model
    """
    m = len(y)
    predictions = X.dot(theta)
    square_err = (predictions - y)**2

    return 1/(m)*np.sum(square_err)
```

In [8]:

```python
data['x0'] = 1
```

In [9]:

```python
data_val = data.values
m =  len(data_val[:-1])
X = data[['x0','Population']].iloc[:-1].values
y = data['Profit'][:-1].values.reshape(m,1)
theta = np.zeros((2,1))

m, X.shape, y.shape, theta.shape
```

Out[9]: (96, (96, 2), (96, 1), (2, 1))

In [10]:

```python
# h(θ) = x0θ0 +x1θ1 ....(x0 = 1)
```

In [11]:

```python
computeCost(X,y,theta)
```

Out[11]: 64.80968355754062

Gradient Descent

In [12]:

```python
def gradientDescent(X,y,theta,alpha,num_iters):
    """
    Take numpy array for X,y,theta and update theta for every iteration
 of gradient steps
    Return theta and the list of cost of theta during each iteration
    """

    m = len(y)
    J_history = []
    for i in range(num_iters):
        predictions = X.dot(theta)
        error = np.dot(X.transpose(), (predictions-y))
        descent = alpha * 1/m * error
        theta-=descent
        J_history.append(computeCost(X,y,theta))

    return theta, J_history
```

In [13]:

```python
theta, J_history = gradientDescent(X,y,theta,0.001, 2000)
```

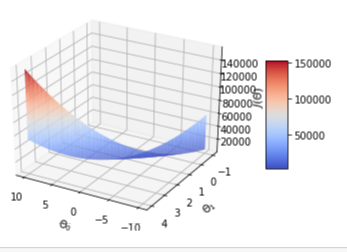
In [14]:

```python
print(f"h(x) = {str(round(theta[0,0],2))} + {str(round(theta[1,0],2))}x
1")
```

```
h(x) = -1.11 + 0.92x1
```

In [15]:

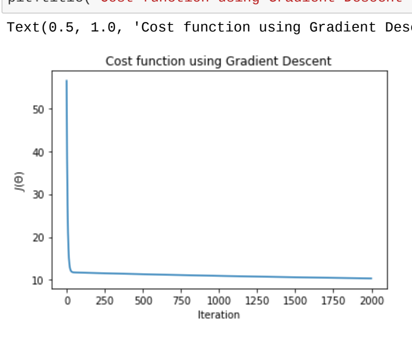
```python
from mpl_toolkits.mplot3d import Axes3D
#Generating values for theta0, theta1 and the resulting cost value
theta0_vals=np.linspace(-10,10,100)
theta1_vals=np.linspace(-1,4,100)
J_vals=np.zeros((len(theta0_vals),len(theta1_vals)))
for i in range(len(theta0_vals)):
    for j in range(len(theta1_vals)):
        t=np.array([theta0_vals[i],theta1_vals[j]])
        J_vals[i,j]=computeCost(X,y,t)
#Generating the surface plot
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
surf=ax.plot_surface(theta0_vals,theta1_vals,J_vals,cmap="coolwarm")
fig.colorbar(surf, shrink=0.5, aspect=5)
ax.set_xlabel("$\Theta_0$")
ax.set_ylabel("$\Theta_1$")
ax.set_zlabel("$J(\Theta)$")
#rotate for better angle
ax.view_init(30,120)
```



In [16]:

```python
plt.plot(J_history)
plt.xlabel("Iteration")
plt.ylabel("$J(\Theta)$")
plt.title("Cost function using Gradient Descent")
```

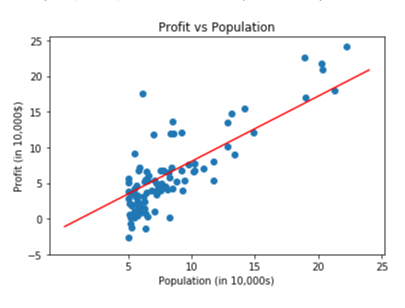
Out[16]: Text(0.5, 1.0, 'Cost function using Gradient Descent')



In [17]:

```python
plt.scatter(data['Population'], data['Profit'])
x_value = [x for x in range(25)]
y_value = [x*theta[1] + theta[0] for x in x_value]
plt.plot(x_value, y_value, color = 'r')
plt.xticks(np.arange(5,30,step=5))
plt.yticks(np.arange(-5,30,step=5))
plt.xlabel('Population (in 10,000s)')
plt.ylabel('Profit (in 10,000$)')
plt.title('Profit vs Population')
```

Out[17]: Text(0.5, 1.0, 'Profit vs Population')



In [18]:

```python
def predict(x,theta):
    """
    Takes in numpy array x and theta and returns predicted value of y
    """
    predictions = np.dot(theta.transpose(),x)
    return predictions[0]
```

In [19]:

```python
data.tail(1)
```

Out[19]:

	Population	Profit	x0
96	5.4369	0.61705	1

In [20]:

```python
predict1 = predict(data[['x0','Population']].iloc[-1].values, theta)*100
00
print(f'For a population of 6170 the predicted profit is ${predict1}')
```

```
For a population of 6170 the predicted profit is $38686.246103378166
```

TODO: Configure code for multivariate linear regression

In [21]:

```python
hw = pd.read_csv("D:/Sem 5/ML/ex1data2.txt", header=None)
hw.head()
```

Out[21]:

	0	1	2
0	2104	3	399900
1	1600	3	329900
2	2400	3	369000
3	1416	2	232000
4	3000	4	539900

In [22]:

```python
hw.columns = ["Size","Num_bedrooms","Price"]
hw.head(1)
```

Out[22]:

	Size	Num_bedrooms	Price
0	2104	3	399900

In [23]:

```python
hw.describe()
```

Out[23]:

	Size	Num_bedrooms	Price
count	47.000000	47.000000	47.000000
mean	2000.680851	3.170213	340412.659574
std	794.702354	0.760982	125039.899586
min	852.000000	1.000000	169900.000000
25%	1432.000000	3.000000	249900.000000
50%	1888.000000	3.000000	299900.000000
75%	2269.000000	4.000000	384450.000000
max	4478.000000	5.000000	699900.000000

In [24]:

```python
hw.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 47 entries, 0 to 46
Data columns (total 3 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Size          47 non-null     int64
 1   Num_bedrooms  47 non-null     int64
 2   Price         47 non-null     int64
dtypes: int64(3)
memory usage: 1.2 KB
```

In [25]:

```python
hw.isnull().sum()
```

Out[25]:

```
Size            0
Num_bedrooms    0
Price           0
dtype: int64
```

Price vs Size of house and Price vs No. of bedrooms

In [26]:

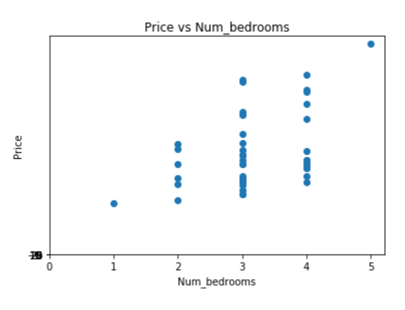
```python
plt.scatter(hw['Size'], hw['Price'])
plt.xticks(np.arange(500,500,step=500))
plt.yticks(np.arange(100000,800000,step=50000))
plt.xlabel('Size')
plt.ylabel('Price')
plt.title('Price vs Size')
```

Out[26]: Text(0.5, 1.0, 'Price vs Size')

In [27]:

```python
plt.scatter(hw['Num_bedrooms'], hw['Price'])
plt.xticks(np.arange(0,6,step=1))
plt.yticks(np.arange(-5,30,step=5))
plt.xlabel('Num_bedrooms')
plt.ylabel('Price')
plt.title('Price vs Num_bedrooms')
```

Out[27]: Text(0.5, 1.0, 'Price vs Num_bedrooms')



Scaling the column "Size"

In [28]:

```python
from sklearn.preprocessing import MinMaxScaler
col = ["Size","Price"]
scaler = MinMaxScaler()

hw[col] = pd.DataFrame(scaler.fit_transform(hw[col]),columns = hw[col].c
olumns)
```

Defining X and y

In [29]:

```python
X = np.array(hw.drop("Price",axis =1)[:-1])
y = np.array(hw["Price"][:-1])
X.shape,y.shape
```

Out[29]: ((46, 2), (46,))

In [30]:

```python
y = y.reshape(y.shape[0],1)
X = np.c_[np.ones(X.shape[0]),X]
X.shape, y.shape
```

Out[30]: ((46, 3), (46, 1))

Defining functions

In [31]:

```python
def computeCost(X,y,theta):
    """
    Take in a numpy arary X,y,theta and get cost function using theta as
parameter in a linear regression model
    """
    m = y.size
    h_theta = np.dot(X,theta) #Predictions
    error = (h_theta - y)
    cost = (1/(2*m))*np.dot(error.T,error)
    return cost
```

In [32]:

```python
def gradientDescent(X,y,theta,alpha,num_iters):
    """
    Take numpy array for X,y,theta and update theta for every iteration
 of gradient steps
    Return theta and the list of cost of theta during each iteration
    """

    m = len(y)
    past_cost = []
    past_theta = [theta]
    for i in range(num_iters):
        h_theta = np.dot(X,theta)
        error =  (h_theta-y)
        past_cost.append(computeCost(X,y,theta))
        descent = alpha * 1/m *np.dot(X.T,error)
        theta-=descent
        past_theta.append(theta)

    return past_theta, past_cost,i
```

In [45]:

```python
def predict(x,theta):
    """
    Takes in numpy array x and theta and returns predicted value of y
    """
    predictions = np.dot(theta.T,x)
    return predictions[0]
```

Declaring θ and α and number of iterations

In [34]:

```python
np.random.seed(1111)
theta = np.random.rand(X.shape[1],1)
alpha = 0.01
num_iters = 5000
```

Performing regression

In [35]:

```python
import time
start = time.time()
past_theta,past_cost,stop = gradientDescent(X,y,theta,alpha,num_iters)
timeTaken = time.time() -start
```

In [36]:

```python
best_theta = past_theta[-1]
best_cost = past_cost[-1]
```

In [37]:

```python
print(f'The model performed {stop} iterations out of {num_iters}.')
print(f'Best Theta: {best_theta}')
print(f'Best cost: {best_cost}')
```

```
The model performed 4999 iterations out of 5000.
Best Theta: [[ 0.06027362]
 [ 0.93572888]
 [-0.01125156]]
Best cost: [[0.00743669]]
```

In [53]:

```python
print(f'h(theta) = {str(round(best_theta[0,0],5))} + {str(round(best_the
ta[0,0],5))}x1 + {str(round(best_theta[0,0],5))}x2')
print(f'Time taken: {timeTaken}')
print(f'Accuracy: {round(r2_score(y,predict(X,best_theta),4))*100}%')
```

```
h(theta) = 0.06027 + 0.06027x1 + 0.06027x2
Time taken: 0.05385303497314453

---------------------------------------------------------------------------
ValueError                                Traceback (most recent call la
st)
<ipython-input-53-fe1c492f4b65> in <module>
      1 print(f'h(theta) = {str(round(best_theta[0,0],5))} + {str(round
(best_theta[0,0],5))}x1 + {str(round(best_theta[0,0],5))}x2')
      2 print(f'Time taken: {timeTaken}')
----> 3 print(f'Accuracy: {round(r2_score(y,predict(X,best_theta),4))*10
0}%')

<ipython-input-45-e8c352d812f8> in predict(x, theta)
      3     Takes in numpy array x and theta and returns predicted value
of y
      4     """
----> 5     predictions = np.dot(theta.T,x)
      6     return predictions[0]

<__array_function__ internals> in dot(*args, **kwargs)

ValueError: shapes (1,3) and (46,3) not aligned: 3 (dim 1) != 46 (dim 0)
```

Plotting cost

In [40]:

```python
cost = np.asarray(past_cost).reshape((len(past_cost),1))
cost.shape
```

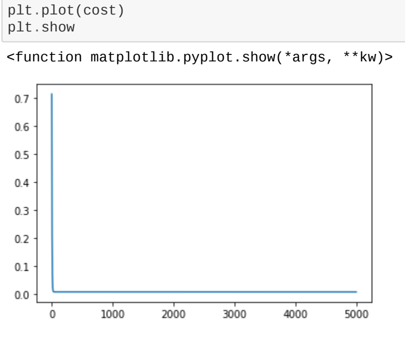
Out[40]: (5000, 1)

In [ ]:

In [41]:

```python
plt.plot(cost)
plt.show
```

Out[41]: <function matplotlib.pyplot.show(*args, **kw)>



Predicting price for test data

In [42]:

```python
hw.tail(1)
```

Out[42]:

	Size	Num_bedrooms	Price
46	0.096801	3	0.131321

In [47]:

```python
from sklearn.metrics import r2_score
prediction = predict(X[-1],best_theta)*1000000
print(f'For house of size 968 sq.ft the predicted price is :${str(predic
tion)}')
```

```
For house of size 968 sq.ft the predicted price is :$273328.3006931557

---------------------------------------------------------------------------
ValueError                                Traceback (most recent call la
st)
<ipython-input-47-1456dc3b3729> in <module>
      2 prediction = predict(X[-1],best_theta)*1000000
      3 print(f'For house of size 968 sq.ft the predicted price is :${st
r(prediction)}')
----> 4 print(f'Accuracy: {round(r2_score(y,predict(X,theta),4))*100}%')

<ipython-input-45-e8c352d812f8> in predict(x, theta)
      3     Takes in numpy array x and theta and returns predicted value
of y
      4     """
----> 5     predictions = np.dot(theta.T,x)
      6     return predictions[0]

<__array_function__ internals> in dot(*args, **kwargs)

ValueError: shapes (1,3) and (46,3) not aligned: 3 (dim 1) != 46 (dim 0)
```

Comparing the parameters

In [44]:

```python
print(f'Parameters from StatsModels: {sm.OLS(y,X).fit().params()}')
print(f'Parameters from ScikitLearn: {LinearRegression().fit(X,y).coef
_}')
print(f'Parameters from GradientDescent: {best_theta.reshape((3,))}')
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call la
st)
<ipython-input-44-d9eb5f790d7c> in <module>
----> 1 print(f'Parameters from StatsModels: {sm.OLS(y,X).fit().params
()}')
      2 print(f'Parameters from ScikitLearn: {LinearRegression().fit(X,
y).coef_}')
      3 print(f'Parameters from GradientDescent: {best_theta.reshape
((3,))}')

TypeError: 'numpy.ndarray' object is not callable
```

In [ ]: