Assignment 3

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In [1]:

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [2]:

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

Univariate Linear Regression

In [3]:

```
data = pd.read_csv('/content/drive/MyDrive/Semester-V/ML_Experiment3/ex1data1.tx
t', header=None)
```

In [4]:

```
data.head(10)
```

Out[4]:

	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
5	8.3829	11.8860
6	7.4764	4.3483
7	8.5781	12.0000
8	6.4862	6.5987
9	5.0546	3.8166

In [5]:

```
data.describe()
```

Out[5]:

	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 [6]:

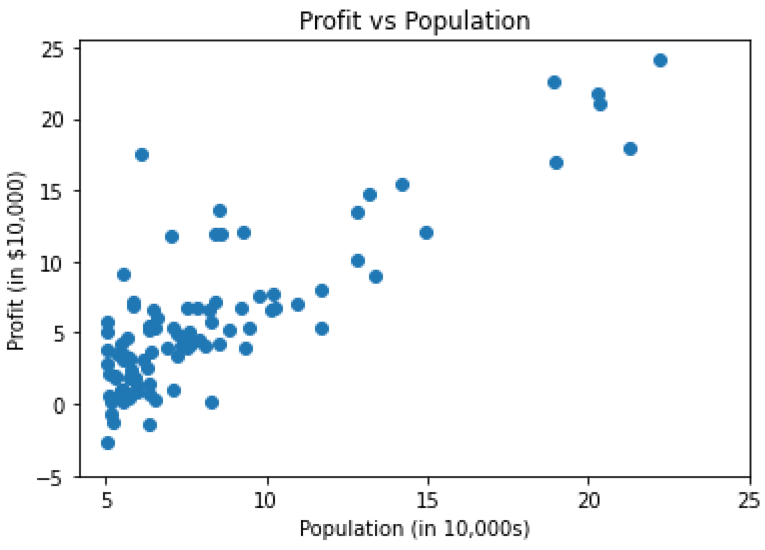
```
# Assigning column names
data.columns = ['Population', 'Profit']
```

In [7]:

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

Out[7]:

```
Text(0.5, 1.0, 'Profit vs Population')
```



Cost Function J(θ)

In [8]:

```
def computeCost(X,y,theta):
    """
    Take in a numpy array X, y, theta and get cost function using theta as param
eter 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 [9]:

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

In [10]:

```
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))
```

In [11]:

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

Out[11]:

```
(96, (96, 2), (96, 1), (2, 1))
```

In [12]:

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

Out[12]:

```
64.80968355754062
```

Gradient Descent

In [13]:

```python
def gradientDescent(X,y,theta,alpha,num_iters):
    """
    Take numpy array for X, y, theta and update theta for every iteration of gra
dient 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 [14]:

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

In [15]:

```python
print(f'h(x) = {str(round(theta[0, 0], 2))} + {str(round(theta[1, 0], 2))}X1')
```

```
h(x) = -1.11 + 0.92X1
```

In [16]:

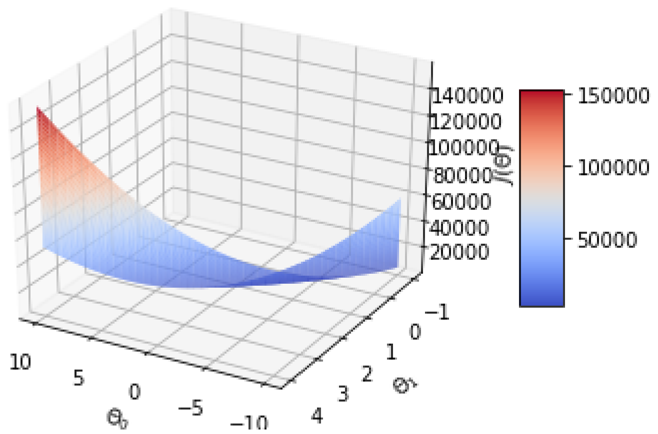
```python
from mpl_toolkits.mplot3d import Axes3D

# 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)
```

In [17]:

```
# 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("$J(\Theta)$")
ax.view_init(30, 120) # rotate for better angle
```

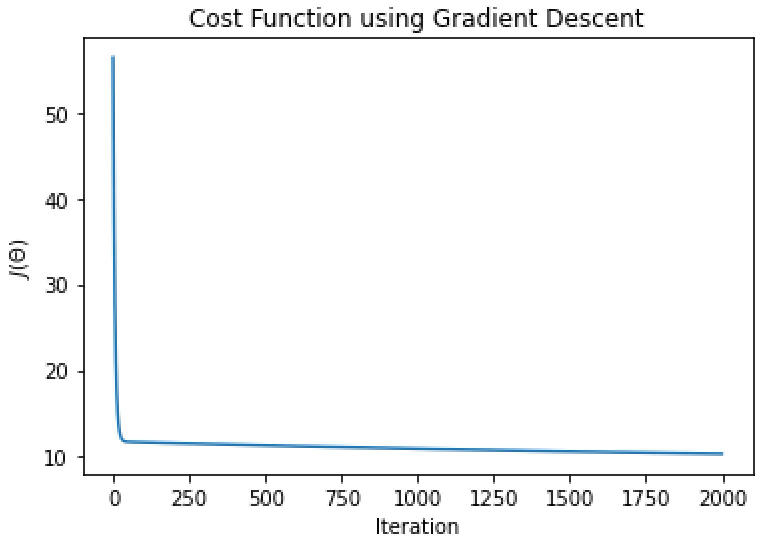


In [18]:

```
plt.plot(J_history)
plt.xlabel('Iteration')
plt.ylabel('$J(\Theta)$')
plt.title('Cost Function using Gradient Descent')
```

Out[18]:

```
Text(0.5, 1.0, 'Cost Function using Gradient Descent')
```



In [19]:

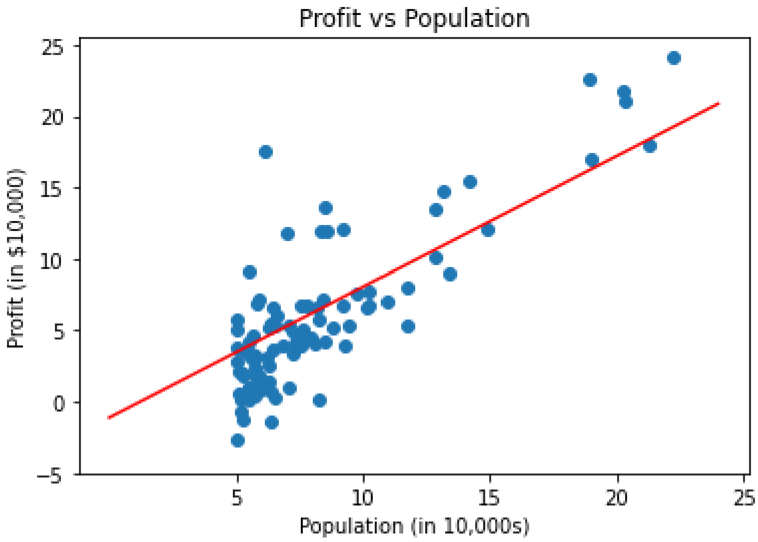
```
plt.scatter(data['Population'], data['Profit'])

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, 5))
plt.yticks(np.arange(-5, 30, 5))
plt.xlabel('Population (in 10,000s)')
plt.ylabel('Profit (in $10,000)')
plt.title('Profit vs Population')
```

Out[19]:

```
Text(0.5, 1.0, 'Profit vs Population')
```



In [20]:

```
def predict(X, theta):
    """
    Takes in numpy array x and theta and returns predicted value of y
    """
    predictions = np.dot(X, theta)

    return predictions
```

In [21]:

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

Out[21]:

	Population	Profit	x0
96	5.4369	0.61705	1

In [22]:

```
predict1 = predict(data[['x0', 'Population']].iloc[-1].values, theta) * 10000
print(f'For a population of 6170, the predicted profit is: ${predict1}')
```

```
For a population of 6170, the predicted profit is: $[38686.24610338]
```

Multivariate Linear Regression

In [23]:

```
data2 = pd.read_csv('/content/drive/MyDrive/Semester-V/ML_Experiment3/ex1data2.t
xt', header=None)

data = data2.copy()
```

In [24]:

```
data.columns = ['Size of the house', 'Number of bedrooms', 'Price of the house']
```

In [25]:

```
data.head(10)
```

Out[25]:

	Size of the house	Number of bedrooms	Price of the house
0	2104	3	399900
1	1600	3	329900
2	2400	3	369000
3	1416	2	232000
4	3000	4	539900
5	1985	4	299900
6	1534	3	314900
7	1427	3	198999
8	1380	3	212000
9	1494	3	242500

In [26]:

```
data.describe()
```

Out[26]:

	Size of the house	Number of bedrooms	Price of the house
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 [27]:

```
# Log normalizing the data
data.iloc[:, [0, 2]] = np.log(data.iloc[:, [0, 2]])
```

In [28]:

```
data.head(10)
```

Out[28]:

	Size of the house	Number of bedrooms	Price of the house
0	7.651596	3	12.898970
1	7.377759	3	12.706545
2	7.783224	3	12.818552
3	7.255591	2	12.354493
4	8.006368	4	13.199139
5	7.593374	4	12.611204
6	7.335634	3	12.660010
7	7.263330	3	12.201055
8	7.229839	3	12.264342
9	7.309212	3	12.398757

In [29]:

```
data.shape
```

Out[29]:

```
(47, 3)
```

In [30]:

```
# Splitting the data to X and y
X = data.iloc[:, :-1]
y = data.iloc[:, -1]
```

In [31]:

```
alpha = 0.01

# Generating random theta values
X_n = X.shape[1]
np.random.seed(123)
theta = np.random.rand(X_n + 1)
```

In [32]:

```
# initial theta values
theta
```

Out[32]:

```
array([0.69646919, 0.28613933, 0.22685145])
```

In [33]:

```
def GD(X, y, alpha, theta):
  X_n = X.shape[1]

  X = (np.array(X)).reshape(X.shape[0], X_n)
  y = (np.array(y)).reshape(y.shape[0], 1)

  X = np.c_[np.ones(X.shape[0]), X]

  m = y.size

  theta = theta.reshape(-1, 1)

  flag = True

  old_cost = None

  cost = []

  theta_history = []

  while flag:
    h_theta = np.dot(X, theta)

    error = h_theta - y

    cost_val = (1 / (2 * m)) * np.dot(error.T, error)

    cost_val = cost_val.tolist()

    if old_cost == cost_val or cost_val == 0:
      flag = False

    else:
      old_cost = cost_val

      cost.append(cost_val)

      theta = theta - alpha * ((1 / m) * np.dot(X.T, error))
      theta_history.append(theta)

  return cost, theta_history
```

In [34]:

```
def predict(X, theta):
    """
    Takes in numpy array X and theta and returns predicted value of y
    """
    X_n = X.shape[1]

    X = np.array(X)
    X = X.reshape(X.shape[0], X_n)
    X = np.c_[np.ones(X.shape[0]), X]

    theta = theta.reshape(-1, 1)

    predictions = np.dot(X, theta)

    return predictions
```

In [35]:

```
%%time
cost, best_theta = GD(X, y, alpha, theta)
```

```
CPU times: user 7.99 s, sys: 107 ms, total: 8.1 s
Wall time: 8.13 s
```

In [36]:

```
print(f'h(x) = {str(round(best_theta[-1][0][0], 2))} + {str(round(best_theta[-1]
[1][0], 2))}X1  {str(round(best_theta[-1][2][0], 2))}X2')
```

```
h(x) = 6.62 + 0.82X1  -0.03X2
```

In [37]:

```
y_pred = predict(X, theta)
```

In [42]:

```
cost = (np.asarray(cost)).reshape(-1, 1)
```

In [45]:

```
import matplotlib.pyplot as plt

plt.plot(cost)
plt.title('Cost Function')
plt.xlabel('Iteration')
plt.ylabel('Cost Function')
plt.xlim(0, 5)
plt.show()
```