In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import math
import random
import seaborn as sns

%matplotlib inline

from IPython.display import Image
```

In [2]:
```
heart_df = pd.read_csv('./DataSet/heart.csv')
```

In [3]:
```
heart_df.head()
```

Out[3]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1

In [4]:
```
heart_df.tail()
```

Out[4]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
298	57	0	0	140	241	0	1	123	1	0.2	1	0	3	0
299	45	1	3	110	264	0	1	132	0	1.2	1	0	3	0
300	68	1	0	144	193	1	1	141	0	3.4	1	2	3	0
301	57	1	0	130	131	0	1	115	1	1.2	1	1	3	0
302	57	0	1	130	236	0	0	174	0	0.0	1	1	2	0

In [5]:
```
heart_df.shape
```

Out[5]:
```
(303, 14)
```

In [6]:
```
heart_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   age       303 non-null    int64
 1   sex       303 non-null    int64
 2   cp        303 non-null    int64
 3   trestbps  303 non-null    int64
 4   chol      303 non-null    int64
```

```
 5   fbs       303 non-null    int64
 6   restecg   303 non-null    int64
 7   thalach   303 non-null    int64
 8   exang     303 non-null    int64
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64
 11  ca        303 non-null    int64
 12  thal      303 non-null    int64
 13  target    303 non-null    int64
dtypes: float64(1), int64(13)
memory usage: 33.3 KB
```

In [7]:
```
heart_df.isnull().sum()
```

Out[7]:
```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          0
thal        0
target      0
dtype: int64
```

In [8]:
```
heart_df.describe()
```

Out[8]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053	149.646865	0.326733
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860	22.905161	0.469794
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	71.000000	0.000000
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	133.500000	0.000000
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	153.000000	0.000000
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000	166.000000	1.000000
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	202.000000	1.000000

In [9]:
```
heart_df.columns
```

Out[9]:
```
Index(['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 'restecg', 'thalach',
       'exang', 'oldpeak', 'slope', 'ca', 'thal', 'target'],
      dtype='object')
```

In [10]:
```
X = heart_df[['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 'restecg', 'thalach',
       'exang', 'oldpeak', 'slope', 'ca', 'thal']]
Y = heart_df['target']
```

In [11]:
```
Y = np.array((Y - Y.mean())/Y.std())
X = X.apply(lambda rec:(rec-rec.mean())/rec.std(),axis=0) #axis=0 -> It is applied to all
```

In [12]:

```python
print(X)
```

```
          age       sex        cp  trestbps      chol       fbs  restecg  \
0    0.950624  0.679881  1.969864  0.762694 -0.255910  2.390484 -1.004171
1   -1.912150  0.679881  1.000921 -0.092585  0.072080 -0.416945  0.897478
2   -1.471723 -1.465992  0.031978 -0.092585 -0.815424 -0.416945 -1.004171
3    0.179877  0.679881  0.031978 -0.662770 -0.198030 -0.416945  0.897478
4    0.289984 -1.465992 -0.936965 -0.662770  2.078611 -0.416945  0.897478
..        ...       ...       ...       ...       ...       ...       ...
298  0.289984 -1.465992 -0.936965  0.477601 -0.101562 -0.416945  0.897478
299 -1.031296  0.679881  1.969864 -1.232956  0.342190 -0.416945  0.897478
300  1.501157  0.679881 -0.936965  0.705675 -1.027653  2.390484  0.897478
301  0.289984  0.679881 -0.936965 -0.092585 -2.223854 -0.416945  0.897478
302  0.289984 -1.465992  0.031978 -0.092585 -0.198030 -0.416945 -1.004171

      thalach    exang   oldpeak     slope        ca      thal
0    0.015417 -0.69548  1.085542 -2.270822 -0.713249 -2.145324
1    1.630774 -0.69548  2.119067 -2.270822 -0.713249 -0.512075
2    0.975900 -0.69548  0.310399  0.974740 -0.713249 -0.512075
3    1.237849 -0.69548 -0.206364  0.974740 -0.713249 -0.512075
4    0.582975  1.43311 -0.378618  0.974740 -0.713249 -0.512075
..        ...      ...       ...       ...       ...       ...
298 -1.163356  1.43311 -0.723126 -0.648041 -0.713249  1.121174
299 -0.770432 -0.69548  0.138144 -0.648041 -0.713249  1.121174
300 -0.377507 -0.69548  2.032940 -0.648041  1.242538  1.121174
301 -1.512623  1.43311  0.138144 -0.648041  0.264644  1.121174
302  1.063216 -0.69548 -0.895381 -0.648041  0.264644 -0.512075

[303 rows x 13 columns]
```

In [13]:

```python
print(Y)
```

```
[ 0.91301882  0.91301882  0.91301882  0.91301882  0.91301882  0.91301882
  0.91301882  0.91301882  0.91301882  0.91301882  0.91301882  0.91301882
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 -1.09165293 -1.09165293 -1.09165293]
```

Working on the Gradient Descent Algorithm

In [14]:

```python
Image(url= "Image/StepsForGradientDescent.png")
```

Out[14]:

In [15]:

```python
def initialize(dim):
    np.random.seed(seed=42)
    random.seed(42)
    b = random.random()        # b -> beta0 (bias or intercept)
    w = np.random.rand(dim)    # w -> beta1 (feature weight)
    return b,w
```

In [16]:

```python
def predict_Y(b,w,x):
    return b + np.matmul(x,w)
```

In [17]:

```python
def get_cost(Y,Y_hat):
    Y_resid = Y - Y_hat
    return np.sum(np.matmul(Y_resid.T, Y_resid))/len(Y_resid)
```

In [18]:

```python
def update_beta(x, y, y_hat, b_0, w_0, learning_rate):
    db = (np.sum(y_hat - y)*2)/len(y)
    dw = (np.dot(y_hat - y, x)*2)/len(y)
    b_1 = b_0 - learning_rate*db
    w_1 = w_0 - learning_rate*dw
    return b_1, w_1
```

In [19]:

```python
def run_gradient_descent(X, Y, alpha=0.01, num_iterations=100):
    b,w = initialize(X.shape[1])

    iter_num = 0
    gd_iteration_df = pd.DataFrame(columns=['Iterations','Cost'])
    result_idx = 0

    for each_iter in range(num_iterations):
        y_hat = predict_Y(b, w, X)
```

```
        this_cost = get_cost(Y, y_hat)
        prev_b = b
        prev_w = w
        b, w = update_beta(X, Y, y_hat, prev_b, prev_w, alpha)

        if iter_num%10==0:
            gd_iteration_df.loc[result_idx] = [iter_num, this_cost]
            result_idx = result_idx + 1
        iter_num = iter_num + 1

    print("\nFinal Estimate of b is {} \n w is {}".format(b,w))
    return gd_iteration_df, b, w
```

In [20]:
```
gid, b , w = run_gradient_descent(X, Y, alpha=0.001, num_iterations=200)
```

```
Final Estimate of b is 0.42844895817391493
 w is [0.17489273 0.49510225 0.70118669 0.27438212 0.06249845 0.00677069
 0.13890371 0.85186318 0.31733192 0.29896375 0.18352353 0.48662455
 0.3574579 ]
```

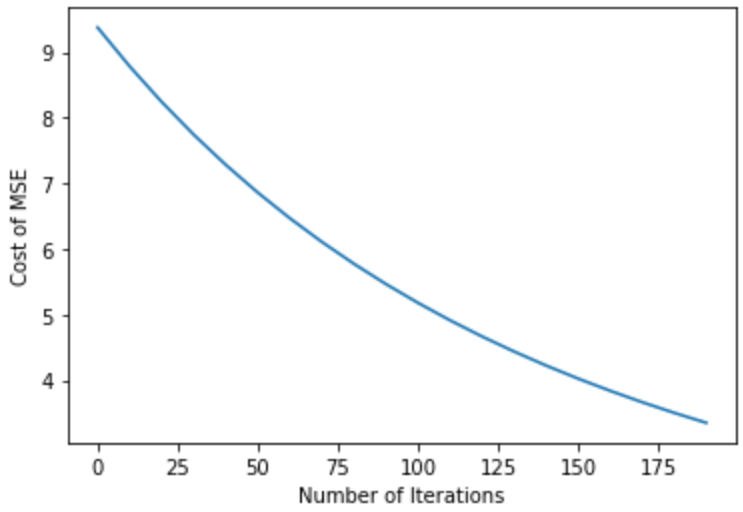
In [21]:
```
gid.head(20)
```

Out[21]:

	Iterations	Cost
0	0.0	9.376909
1	10.0	8.785926
2	20.0	8.243039
3	30.0	7.743802
4	40.0	7.284208
5	50.0	6.860642
6	60.0	6.469848
7	70.0	6.108885
8	80.0	5.775100
9	90.0	5.466095
10	100.0	5.179706
11	110.0	4.913976
12	120.0	4.667134
13	130.0	4.437577
14	140.0	4.223855
15	150.0	4.024652
16	160.0	3.838778
17	170.0	3.665151
18	180.0	3.502789
19	190.0	3.350799

In [22]:
```
plt.plot(gid['Iterations'],gid['Cost'])
plt.xlabel('Number of Iterations')
```

```
plt.ylabel('Cost of MSE')
plt.show()
```

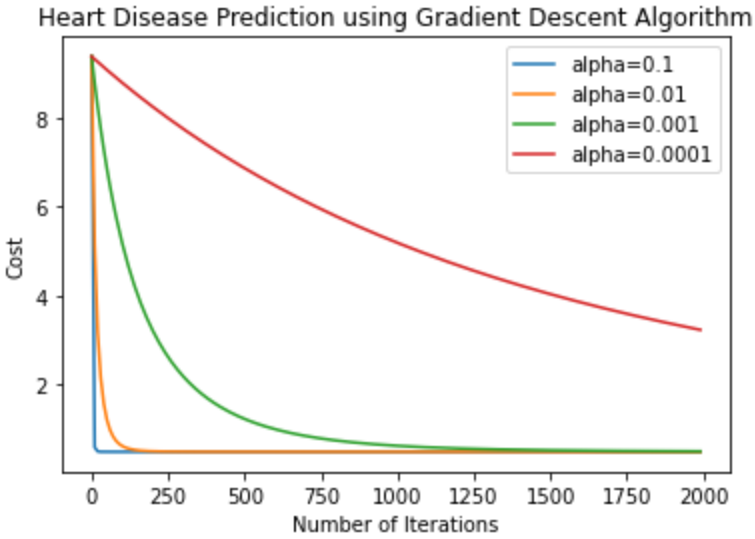


In [23]:
```
alpha_df_1, b, w = run_gradient_descent(X, Y, alpha=0.1, num_iterations=2000)
alpha_df_2, b, w = run_gradient_descent(X, Y, alpha=0.01, num_iterations=2000)
alpha_df_3, b, w = run_gradient_descent(X, Y, alpha=0.001, num_iterations=2000)
alpha_df_4, b, w = run_gradient_descent(X, Y, alpha=0.0001, num_iterations=2000)
```

```
Final Estimate of b is -6.271102523981385e-17
 w is [-0.014937   -0.1830988   0.23317503 -0.0699988  -0.03673396  0.01240582
  0.05254851  0.13863953 -0.13566011 -0.13683504  0.09756498 -0.20623343
 -0.14611027]

Final Estimate of b is -5.998397015702797e-17
 w is [-0.01493697 -0.18309879  0.23317503 -0.06999881 -0.03673397  0.01240581
  0.05254851  0.13863957 -0.13566009 -0.13683508  0.09756494 -0.20623342
 -0.14611027]

Final Estimate of b is 0.011664695556930303
 w is [ 0.03566807 -0.17329831  0.27600757 -0.08635701 -0.04145347 -0.01574182
  0.06678565  0.23549895 -0.05319714 -0.11438976  0.09934815 -0.17545142
 -0.1648434 ]

Final Estimate of b is 0.4286034542113327
 w is [0.17517122 0.49551784 0.70107311 0.27472357 0.06260663 0.00696353
 0.13876063 0.85166111 0.31767097 0.29944636 0.18323055 0.48711162
 0.35795044]
```

In [24]:
```
plt.plot(alpha_df_1['Iterations'],alpha_df_1['Cost'],label='alpha=0.1')
plt.plot(alpha_df_2['Iterations'],alpha_df_2['Cost'],label='alpha=0.01')
plt.plot(alpha_df_3['Iterations'],alpha_df_3['Cost'],label='alpha=0.001')
plt.plot(alpha_df_4['Iterations'],alpha_df_4['Cost'],label='alpha=0.0001')
plt.legend()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Heart Disease Prediction using Gradient Descent Algorithm')
```

Out[24]:
```
Text(0.5, 1.0, 'Heart Disease Prediction using Gradient Descent Algorithm')
```


Heart Disease Prediction using Gradient Descent Algorithm
alpha=0.1
alpha=0.01
alpha=0.001
alpha=0.0001
Cost
Number of Iterations
0
250
500
750
1000
1250
1500
1750
2000
2
4
6
8