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

In [2]:
```
housing = pd.DataFrame(pd.read_csv("Housing.csv"))
housing.head()
```

Out[2]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating
0	13300000	7420	4	2	3	yes	no	no	no
1	12250000	8960	4	4	4	yes	no	no	no
2	12250000	9960	3	2	2	yes	no	yes	no
3	12215000	7500	4	2	2	yes	no	yes	no
4	11410000	7420	4	1	2	yes	yes	yes	no

In [3]:
```
m = len(housing)
m
```

Out[3]:
```
545
```

In [4]:
```
housing.shape
```

Out[4]:
```
(545, 13)
```

In [5]:
```
housing.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 545 entries, 0 to 544
Data columns (total 13 columns):
 #   Column            Non-Null Count  Dtype 
---  ------            --------------  ----- 
 0   price             545 non-null    int64 
 1   area              545 non-null    int64 
 2   bedrooms          545 non-null    int64 
 3   bathrooms         545 non-null    int64 
 4   stories           545 non-null    int64 
 5   mainroad          545 non-null    object
 6   guestroom         545 non-null    object
 7   basement          545 non-null    object
 8   hotwaterheating   545 non-null    object
 9   airconditioning   545 non-null    object
 10  parking           545 non-null    int64 
 11  prefarea          545 non-null    object
 12  furnishingstatus  545 non-null    object
dtypes: int64(6), object(7)
memory usage: 55.5+ KB
```

In [6]:
```
housing.describe()
```

Out[6]:

	price	area	bedrooms	bathrooms	stories	parking
count	5.450000e+02	545.000000	545.000000	545.000000	545.000000	545.000000
mean	4.766729e+06	5150.541284	2.965138	1.286239	1.805505	0.693578
std	1.870440e+06	2170.141023	0.738064	0.502470	0.867492	0.861586
min	1.750000e+06	1650.000000	1.000000	1.000000	1.000000	0.000000
25%	3.430000e+06	3600.000000	2.000000	1.000000	1.000000	0.000000
50%	4.340000e+06	4600.000000	3.000000	1.000000	2.000000	0.000000
75%	5.740000e+06	6360.000000	3.000000	2.000000	2.000000	1.000000
max	1.330000e+07	16200.000000	6.000000	4.000000	4.000000	3.000000

In [7]:

```
varlist = ['mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning', '
def binary_map(x):
    return x.map({'yes' : 1, "no" : 0})
housing[varlist] = housing[varlist].apply(binary_map)
housing.head()
```

Out[7]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating
0	13300000	7420	4	2	3	1	0	0	0
1	12250000	8960	4	4	4	1	0	0	0
2	12250000	9960	3	2	2	1	0	1	0
3	12215000	7500	4	2	2	1	0	1	0
4	11410000	7420	4	1	2	1	1	1	0

In [8]:

```
from sklearn.model_selection import train_test_split
np.random.seed(0)
df_train, df_test = train_test_split(housing, train_size = 0.7, test_size = 0.3, random
df_train.shape
```

Out[8]: (381, 13)

In [9]:

```
df_test.shape
```

Out[9]: (164, 13)

In [10]:

```
num_vars = ['area', 'bedrooms', 'bathrooms', 'stories', 'parking', 'price']
df_Newtrain = df_train[num_vars]
df_Newtest = df_test[num_vars]
df_Newtrain.head()
```

Out[10]:

	area	bedrooms	bathrooms	stories	parking	price

	area	bedrooms	bathrooms	stories	parking	price
454	4500	3	1	2	0	3143000
392	3990	3	1	2	0	3500000
231	4320	3	1	1	0	4690000
271	1905	5	1	2	0	4340000
250	3510	3	1	3	0	4515000

In [11]:
```
df_Newtest.head()
```

Out[11]:

	area	bedrooms	bathrooms	stories	parking	price
239	4000	3	1	2	1	4585000
113	9620	3	1	1	2	6083000
325	3460	4	1	2	0	4007500
66	13200	2	1	1	1	6930000
479	3660	4	1	2	0	2940000

In [12]:
```
def hypothesis(theta, X, n):
    h = np.ones((X.shape[0],1))
    theta = theta.reshape(1,n+1)
    for i in range(0,X.shape[0]):
        h[i] = float(np.matmul(theta, X[i]))
    h = h.reshape(X.shape[0])
    return h
```

In [13]:
```
def GD(theta, alpha, num_iter, h, X, y, n):
    cost = np.ones(num_iter)
    for i in range(0,num_iter):
        theta[0] = theta[0] - (alpha/X.shape[0]) * sum(h - y)
        for j in range(1,n+1):
            theta[j] = theta[j] - (alpha/X.shape[0]) * sum((h-y) * X.transpose()[j])
        h = hypothesis(theta, X, n)
        cost[i] = (1/X.shape[0]) * 0.5 * sum(np.square(h - y))
    theta = theta.reshape(1,n+1)
    return theta, cost
```

In [14]:
```
def linear_regression(X, y, alpha, num_iter):
    n = X.shape[1]
    column = np.ones((X.shape[0],1))
    X = np.concatenate((column, X), axis = 1)
    theta = np.zeros(n+1)
    h = hypothesis(theta, X, n)
    theta, cost = GD(theta,alpha,num_iter,h,X,y,n)
    return theta, cost
```

In [15]:
```
X_t = df_Newtrain.values[:,[0,1,2,3,4]]
```

```
Y_t = df_Newtrain.values[:,5]
X_v = df_Newtest.values[:,[0,1,2,3,4]]
Y_v = df_Newtest.values[:,5]
```

In [16]:

```
mean = np.ones(X_t.shape[1])
std = np.ones(X_t.shape[1])
for i in range(0, X_t.shape[1]):
    mean[i] = np.mean(X_t.transpose()[i])
    std[i] = np.std(X_t.transpose()[i])
    for j in range(0, X_t.shape[0]):
        X_t[j][i] = (X_t[j][i] - mean[i])/std[i]
mean = np.ones(X_v.shape[1])
std = np.ones(X_v.shape[1])
for i in range(0, X_v.shape[1]):
    mean[i] = np.mean(X_v.transpose()[i])
    std[i] = np.std(X_v.transpose()[i])
    for j in range(0, X_v.shape[0]):
        X_v[j][i] = (X_v[j][i] - mean[i])/std[i]
```

In [17]:

```
df_Newtrain.shape
```

Out[17]: (381, 6)

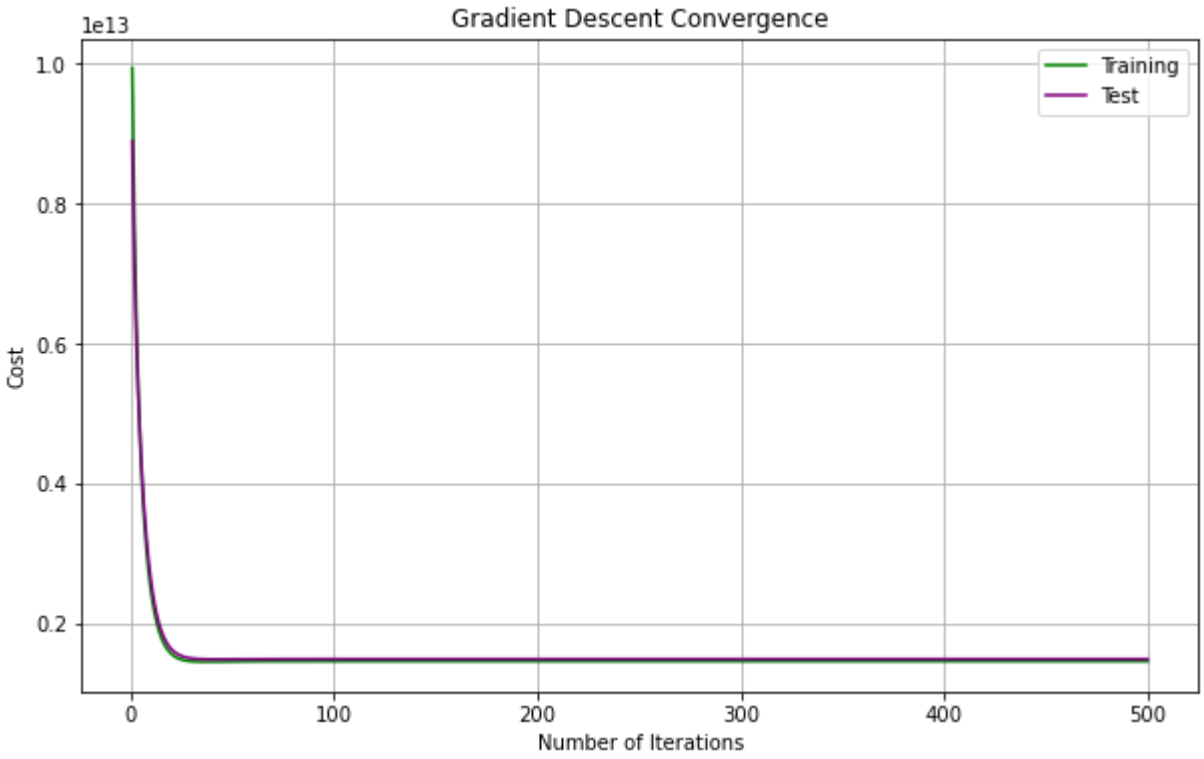
In [90]:

```
theta, cost = linear_regression(X_t, Y_t, 0.1, 500)
cost = list(cost)
theta2, cost2 = linear_regression(X_v, Y_v, 0.1, 500)
cost2 = list(cost2)

n_iterations = [x for x in range(1,501)]
n_iterations2 = [x for x in range(1,501)]

plt.plot(n_iterations, cost, color = 'green', label = 'Training')
plt.plot(n_iterations2, cost2, color = 'purple', label = 'Test')
plt.legend()
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Gradient Descent Convergence')
```

Out[90]: Text(0.5, 1.0, 'Gradient Descent Convergence')



In [19]:
```
num_vars = ['area', 'bedrooms', 'bathrooms', 'mainroad', 'guestroom', 'basement', 'hotw
df_Newtrain = df_train[num_vars]
df_Newtest = df_test[num_vars]
df_Newtrain.head()
```

Out[19]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditioning
454	4500	3	1	1	0	0	0	1
392	3990	3	1	1	0	0	0	0
231	4320	3	1	1	0	0	0	0
271	1905	5	1	0	0	1	0	0
250	3510	3	1	1	0	0	0	0

In [20]:
```
df_Newtest.head()
```

Out[20]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditioning
239	4000	3	1	1	0	0	0	0
113	9620	3	1	1	0	1	0	0
325	3460	4	1	1	0	0	0	1
66	13200	2	1	1	0	1	1	0
479	3660	4	1	0	0	0	0	0

In [21]:
```
X_v = df_Newtest.values[:,0:10]
Y_v = df_Newtest.values[:,10]
```

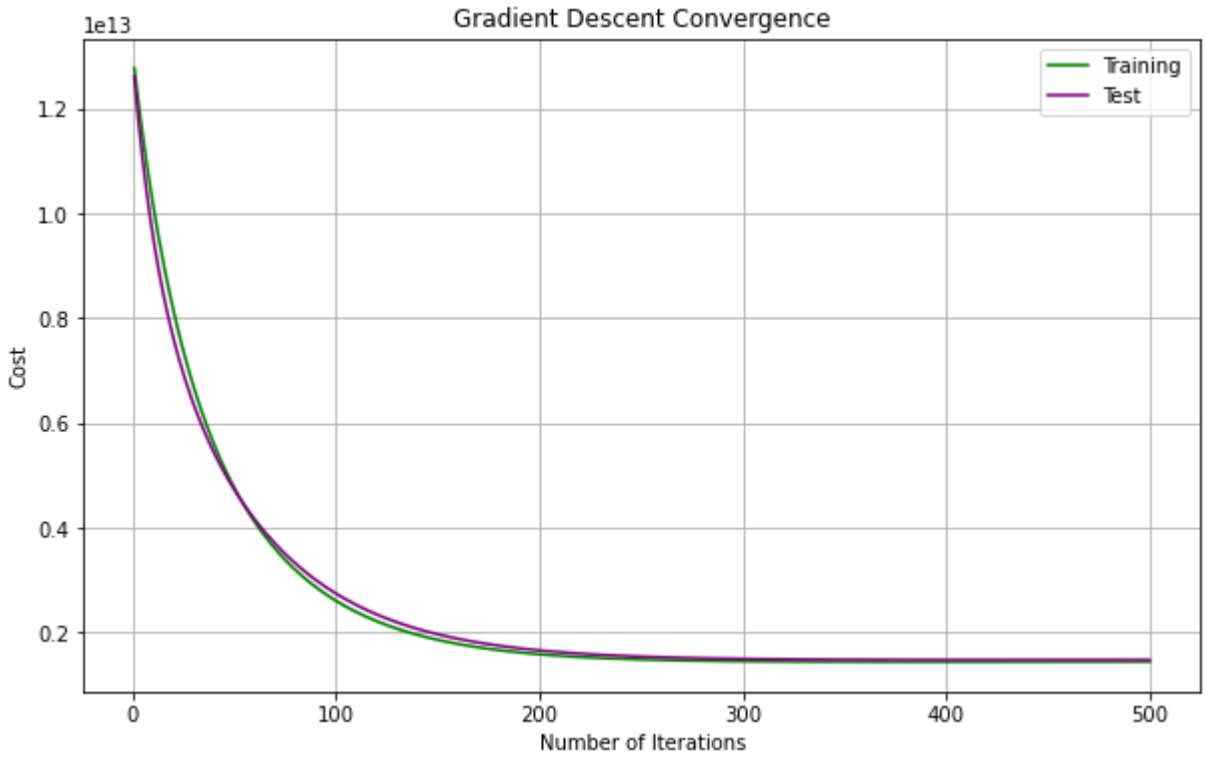
In [22]:
```
mean = np.ones(X_t.shape[1])
std = np.ones(X_t.shape[1])
for i in range(0, X_t.shape[1]):
    mean[i] = np.mean(X_t.transpose()[i])
    std[i] = np.std(X_t.transpose()[i])
    for j in range(0, X_t.shape[0]):
        X_t[j][i] = (X_t[j][i] - mean[i])/std[i]
mean = np.ones(X_v.shape[1])
std = np.ones(X_v.shape[1])
for i in range(0, X_v.shape[1]):
    mean[i] = np.mean(X_v.transpose()[i])
    std[i] = np.std(X_v.transpose()[i])
    for j in range(0, X_v.shape[0]):
        X_v[j][i] = (X_v[j][i] - mean[i])/std[i]
```

In [92]:
```
theta, cost = linear_regression(X_t, Y_t, 0.01, 500)
cost = list(cost)
theta2, cost2 = linear_regression(X_v, Y_v, 0.01, 500)
cost2 = list(cost2)

n_iterations = [x for x in range(1,501)]
n_iterations2 = [x for x in range(1,501)]

plt.plot(n_iterations, cost, color = 'green', label = 'Training')
plt.plot(n_iterations2, cost2, color = 'purple', label = 'Test')
plt.legend()
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Gradient Descent Convergence')
```

Out[92]:
```
Text(0.5, 1.0, 'Gradient Descent Convergence')
```



In [24]:
```
## Problem 2 ##
```

In [25]:
```
from sklearn.model_selection import train_test_split
np.random.seed(0)
df_train, df_test = train_test_split(housing, train_size = 0.7, test_size = 0.3, random
df_train.shape
```

Out[25]: (381, 13)

In [26]:
```
num_vars = ['area', 'bedrooms', 'bathrooms', 'stories', 'parking','price']
df_Newtrain = df_train[num_vars]
df_Newtest = df_test[num_vars]
df_Normal = df_Newtrain
df_Standard = df_Newtrain
df_Newtrain.head()
```

Out[26]:

	area	bedrooms	bathrooms	stories	parking	price
454	4500	3	1	2	0	3143000
392	3990	3	1	2	0	3500000
231	4320	3	1	1	0	4690000
271	1905	5	1	2	0	4340000
250	3510	3	1	3	0	4515000

In [27]:
```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
```

```
scaler = MinMaxScaler()
df_Normal[num_vars] = scaler.fit_transform(df_Normal[num_vars])
df_Normal.head(20)
```

Out[27]:

	area	bedrooms	bathrooms	stories	parking	price
454	0.193548	0.50	0.0	0.333333	0.000000	0.120606
392	0.156495	0.50	0.0	0.333333	0.000000	0.151515
231	0.180471	0.50	0.0	0.000000	0.000000	0.254545
271	0.005013	1.00	0.0	0.333333	0.000000	0.224242
250	0.121622	0.50	0.0	0.666667	0.000000	0.239394
541	0.040976	0.50	0.0	0.000000	0.000000	0.001485
461	0.226969	0.25	0.0	0.000000	0.000000	0.115152
124	0.340671	0.50	0.5	1.000000	0.333333	0.363636
154	0.131793	0.50	0.5	0.333333	0.666667	0.327273
451	0.357018	0.25	0.0	0.000000	0.000000	0.121212
59	0.302528	0.50	0.5	1.000000	0.333333	0.472727
493	0.154316	0.50	0.0	0.000000	0.000000	0.090909
465	0.142691	0.25	0.0	0.000000	0.000000	0.112121
490	0.182650	0.50	0.0	0.333333	0.333333	0.093939
540	0.084568	0.25	0.0	0.000000	0.666667	0.006061
406	0.253124	0.25	0.0	0.000000	0.333333	0.148485
289	0.291630	0.25	0.0	0.000000	0.666667	0.212121
190	0.418774	0.75	0.0	0.333333	0.666667	0.284848
55	0.302528	0.50	0.0	0.333333	0.333333	0.484848
171	0.612685	0.50	0.0	0.000000	0.333333	0.303030

In [28]:

```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
scaler = StandardScaler()
df_Standard[num_vars] = scaler.fit_transform(df_Standard[num_vars])
df_Standard.head(20)
```

Out[28]:

	area	bedrooms	bathrooms	stories	parking	price
454	-0.286366	0.073764	-0.581230	0.207401	-0.822960	-0.868394
392	-0.544762	0.073764	-0.581230	0.207401	-0.822960	-0.677628
231	-0.377564	0.073764	-0.581230	-0.937813	-0.822960	-0.041744
271	-1.601145	2.884176	-0.581230	0.207401	-0.822960	-0.228768
250	-0.787958	0.073764	-0.581230	1.352614	-0.822960	-0.135256

	area	bedrooms	bathrooms	stories	parking	price
541	-1.350349	0.073764	-0.581230	-0.937813	-0.822960	-1.603589
461	-0.053303	-1.331442	-0.581230	-0.937813	-0.822960	-0.902058
124	0.739618	0.073764	1.488383	2.497828	0.321375	0.631546
154	-0.717026	0.073764	1.488383	0.207401	1.465710	0.407116
451	0.853616	-1.331442	-0.581230	-0.937813	-0.822960	-0.864653
59	0.473622	0.073764	1.488383	2.497828	0.321375	1.304836
493	-0.559962	0.073764	-0.581230	-0.937813	-0.822960	-1.051678
465	-0.641027	-1.331442	-0.581230	-0.937813	-0.822960	-0.920761
490	-0.362365	0.073764	-0.581230	0.207401	0.321375	-1.032976
540	-1.046354	-1.331442	-0.581230	-0.937813	1.465710	-1.575348
406	0.129094	-1.331442	-0.581230	-0.937813	0.321375	-0.696331
289	0.397623	-1.331442	-0.581230	-0.937813	1.465710	-0.303578
190	1.284276	1.478970	-0.581230	0.207401	1.465710	0.145281
55	0.473622	0.073764	-0.581230	0.207401	0.321375	1.379646
171	2.636548	0.073764	-0.581230	-0.937813	0.321375	0.257496

In [29]:
```
Xn = df_Normal.values[:,[0,1,2,3,4]]
Yn = df_Normal.values[:,5]
Xtest = df_Newtest.values[:,[0,1,2,3,4]]
Ytest = df_Newtest.values[:,5]
Xs = df_Standard.values[:,[0,1,2,3,4]]
Ys = df_Standard.values[:,5]
```

In [30]:
```
mean = np.ones(Xn.shape[1])
std = np.ones(Xn.shape[1])
for i in range(0, Xn.shape[1]):
    mean[i] = np.mean(Xn.transpose()[i])
    std[i] = np.std(Xn.transpose()[i])
    for j in range(0, Xn.shape[0]):
        Xn[j][i] = (Xn[j][i] - mean[i])/std[i]
```

In [31]:
```
mean = np.ones(Xs.shape[1])
std = np.ones(Xs.shape[1])
for i in range(0, Xs.shape[1]):
    mean[i] = np.mean(Xs.transpose()[i])
    std[i] = np.std(Xs.transpose()[i])
    for j in range(0, Xs.shape[0]):
        Xs[j][i] = (Xs[j][i] - mean[i])/std[i]
```

In [32]:
```
mean = np.ones(Xtest.shape[1])
std = np.ones(Xtest.shape[1])
for i in range(0, Xtest.shape[1]):
```

```
    mean[i] = np.mean(Xtest.transpose()[i])
    std[i] = np.std(Xtest.transpose()[i])
    for j in range(0, Xtest.shape[0]):
        Xtest[j][i] = (Xtest[j][i] - mean[i])/std[i]
```

In [33]:

```
def compute_cost(X, n, theta):
    h = np.ones((X.shape[0],1))
    theta = theta.reshape(1,n+1)
    for i in range(0,X.shape[0]):
        h[i] = float(np.matmul(theta, X[i]))
    h = h.reshape(X.shape[0])
    return h
```

In [34]:

```
def gradient_descent(X, Y, theta, alpha, iterations, n, h):
    cost = np.ones(iterations)
    for i in range(0,iterations):
        theta[0] = theta[0] - (alpha/X.shape[0]) * sum(h - Y)
        for j in range(1,n+1):
            theta[j] = theta[j] - (alpha/X.shape[0]) * sum((h-Y) * X.transpose()[j])
        h = compute_cost(X, n, theta)
        cost[i] = (1/X.shape[0]) * 0.5 * sum(np.square(h - Y))
    theta = theta.reshape(1,n+1)
    return theta, cost
```

In [35]:

```
def linear_regression(X, Y, alpha, iterations):
    n = X.shape[1]
    one_column = np.ones((X.shape[0],1))
    X = np.concatenate((one_column, X), axis = 1)
    theta = np.zeros(n+1)
    h = compute_cost(X, n, theta)
    theta, cost = gradient_descent(X, Y, theta, alpha, iterations, n, h)
    return theta, cost
```

In [36]:

```
iterations = 500;
```

In [37]:

```
theta, cost = linear_regression(Xn, Yn, 0.1, iterations)
print('Final Theta Value with Normalization =', theta)
cost = list(cost)
n_iterations = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value with Normalization = [[1.24535844e-16 3.83653304e-01 1.04343457e-01 2.
98541735e-01
  2.34542828e-01 1.49757135e-01]]
```

In [38]:

```
theta2, cost2 = linear_regression(Xs, Ys, 0.1, iterations)
print('Final Theta Value with Standardization =', theta2)
cost2 = list(cost2)
n_iterations2 = [x for x in range(1,(iterations + 1))]
```

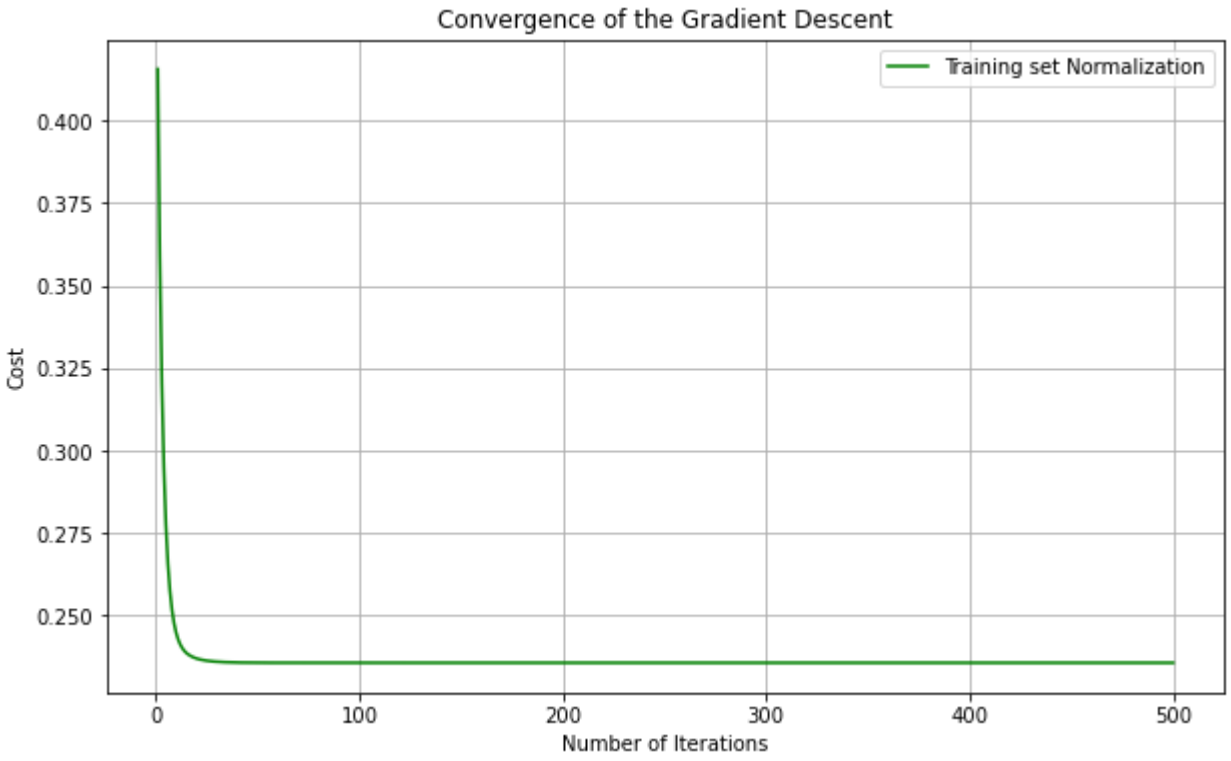
```
Final Theta Value with Standardization = [[1.24535844e-16 3.83653304e-01 1.04343457e-01
2.98541735e-01
  2.34542828e-01 1.49757135e-01]]
```

In [39]:
```
theta_t, cost_t = linear_regression(Xtest, Ytest, 0.1, iterations)
print('Final Theta Value of the Test Set =', theta_t)
cost_t = list(cost_t)
n_iterations_t = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value of the Test Set = [[4009323.46427773  844638.61768703  225437.77741561
911745.77297157
   885446.81234427  751101.29064712]]
```

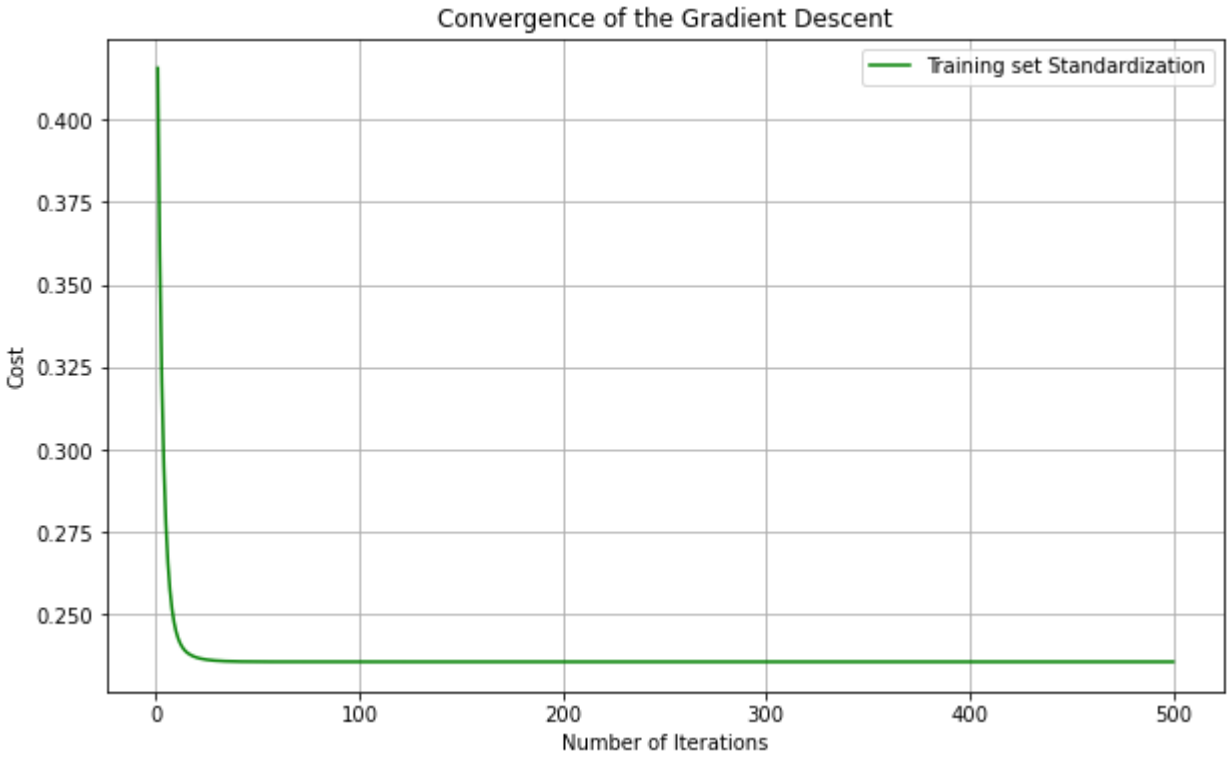
In [40]:
```
plt.plot(n_iterations, cost, color = 'green', label='Training set Normalization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[40]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [41]:
```
plt.plot(n_iterations2, cost2, color = 'green', label='Training set Standardization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

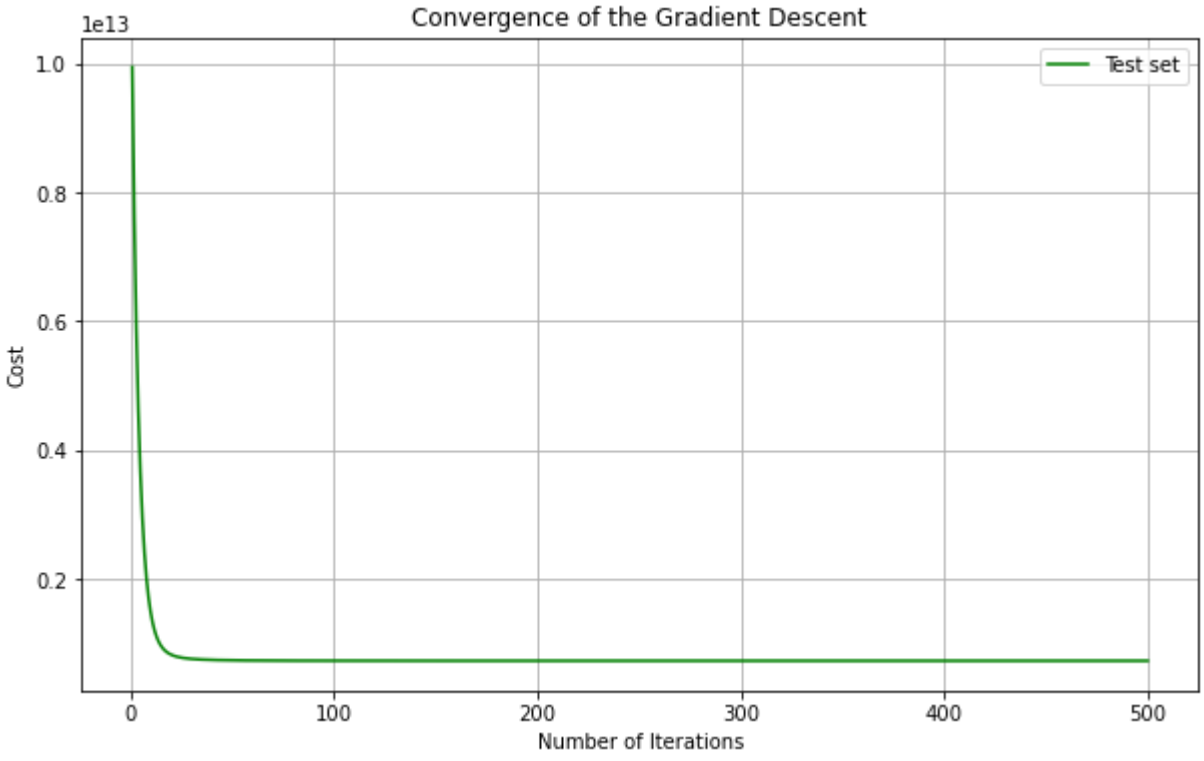
Out[41]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [42]:

```
plt.plot(n_iterations_t, cost_t, color = 'green', label='Test set')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[42]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [43]:
```
num_vars = ['area', 'bedrooms', 'bathrooms', 'mainroad', 'guestroom', 'basement', 'hotw
df_Newtrain = df_train[num_vars]
df_Newtest = df_test[num_vars]
df_Normal = df_Newtrain
df_Standard = df_Newtrain
df_Newtrain.head()
```

Out[43]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditioning
454	4500	3	1	1	0	0	0	1
392	3990	3	1	1	0	0	0	0
231	4320	3	1	1	0	0	0	0
271	1905	5	1	0	0	1	0	0
250	3510	3	1	1	0	0	0	0

In [44]:
```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
scaler = MinMaxScaler()
df_Normal[num_vars] = scaler.fit_transform(df_Normal[num_vars])
df_Normal.head(20)
```

Out[44]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditionin
454	0.193548	0.50	0.0	1.0	0.0	0.0	0.0	1
392	0.156495	0.50	0.0	1.0	0.0	0.0	0.0	0
231	0.180471	0.50	0.0	1.0	0.0	0.0	0.0	0
271	0.005013	1.00	0.0	0.0	0.0	1.0	0.0	0
250	0.121622	0.50	0.0	1.0	0.0	0.0	0.0	0
541	0.040976	0.50	0.0	0.0	0.0	0.0	0.0	0
461	0.226969	0.25	0.0	1.0	0.0	1.0	0.0	1
124	0.340671	0.50	0.5	1.0	0.0	0.0	0.0	0
154	0.131793	0.50	0.5	1.0	0.0	0.0	0.0	0
451	0.357018	0.25	0.0	1.0	0.0	0.0	0.0	0
59	0.302528	0.50	0.5	1.0	1.0	0.0	0.0	1
493	0.154316	0.50	0.0	1.0	0.0	0.0	0.0	0
465	0.142691	0.25	0.0	1.0	0.0	0.0	0.0	0
490	0.182650	0.50	0.0	0.0	0.0	0.0	1.0	0
540	0.084568	0.25	0.0	1.0	0.0	1.0	0.0	0
406	0.253124	0.25	0.0	1.0	0.0	0.0	0.0	0
289	0.291630	0.25	0.0	1.0	1.0	1.0	0.0	0

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditionin
190	0.418774	0.75	0.0	1.0	0.0	0.0	0.0	1
55	0.302528	0.50	0.0	1.0	0.0	0.0	0.0	1
171	0.612685	0.50	0.0	1.0	0.0	0.0	0.0	0

In [45]:

```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
scaler = StandardScaler()
df_Standard[num_vars] = scaler.fit_transform(df_Standard[num_vars])
df_Standard.head(20)
```

Out[45]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditioni
454	-0.286366	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	1.4226
392	-0.544762	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
231	-0.377564	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
271	-1.601145	2.884176	-0.581230	-2.543735	-0.457738	1.405903	-0.216109	-0.7029
250	-0.787958	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
541	-1.350349	0.073764	-0.581230	-2.543735	-0.457738	-0.711287	-0.216109	-0.7029
461	-0.053303	-1.331442	-0.581230	0.393123	-0.457738	1.405903	-0.216109	1.4226
124	0.739618	0.073764	1.488383	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
154	-0.717026	0.073764	1.488383	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
451	0.853616	-1.331442	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
59	0.473622	0.073764	1.488383	0.393123	2.184657	-0.711287	-0.216109	1.4226
493	-0.559962	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
465	-0.641027	-1.331442	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
490	-0.362365	0.073764	-0.581230	-2.543735	-0.457738	-0.711287	4.627285	-0.7029
540	-1.046354	-1.331442	-0.581230	0.393123	-0.457738	1.405903	-0.216109	-0.7029
406	0.129094	-1.331442	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
289	0.397623	-1.331442	-0.581230	0.393123	2.184657	1.405903	-0.216109	-0.7029
190	1.284276	1.478970	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	1.4226
55	0.473622	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	1.4226
171	2.636548	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029

In [46]:

```
Xn = df_Normal.values[:,0:10]
Yn = df_Normal.values[:,10]
```

```
Xtest = df_Newtest.values[:,0:10]
Ytest = df_Newtest.values[:,10]
Xs = df_Standard.values[:,0:10]
Ys = df_Standard.values[:,10]
```

In [47]:
```
mean = np.ones(Xn.shape[1])
std = np.ones(Xn.shape[1])
for i in range(0, Xn.shape[1]):
    mean[i] = np.mean(Xn.transpose()[i])
    std[i] = np.std(Xn.transpose()[i])
    for j in range(0, Xn.shape[0]):
        Xn[j][i] = (Xn[j][i] - mean[i])/std[i]
```

In [48]:
```
mean = np.ones(Xs.shape[1])
std = np.ones(Xs.shape[1])
for i in range(0, Xs.shape[1]):
    mean[i] = np.mean(Xs.transpose()[i])
    std[i] = np.std(Xs.transpose()[i])
    for j in range(0, Xs.shape[0]):
        Xs[j][i] = (Xs[j][i] - mean[i])/std[i]
```

In [49]:
```
mean = np.ones(Xtest.shape[1])
std = np.ones(Xtest.shape[1])
for i in range(0, Xtest.shape[1]):
    mean[i] = np.mean(Xtest.transpose()[i])
    std[i] = np.std(Xtest.transpose()[i])
    for j in range(0, Xtest.shape[0]):
        Xtest[j][i] = (Xtest[j][i] - mean[i])/std[i]
```

In [50]:
```
theta, cost = linear_regression(Xn, Yn, 0.1, iterations)
print('Final Theta Value with Normalization =', theta)
cost = list(cost)
n_iterations = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value with Normalization = [[1.24885520e-16 2.64108625e-01 1.27168543e-01 2.
88652311e-01
  1.21315783e-01 9.99334571e-02 3.90689188e-02 1.43965719e-01
  2.70513007e-01 9.08846334e-02 1.67876986e-01]]
```

In [51]:
```
theta2, cost2 = linear_regression(Xs, Ys, 0.1, iterations)
print('Final Theta Value with Standardization =', theta2)
cost2 = list(cost2)
n_iterations2 = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value with Standardization = [[1.24885520e-16 2.64108625e-01 1.27168543e-01
2.88652311e-01
  1.21315783e-01 9.99334571e-02 3.90689188e-02 1.43965719e-01
  2.70513007e-01 9.08846334e-02 1.67876986e-01]]
```

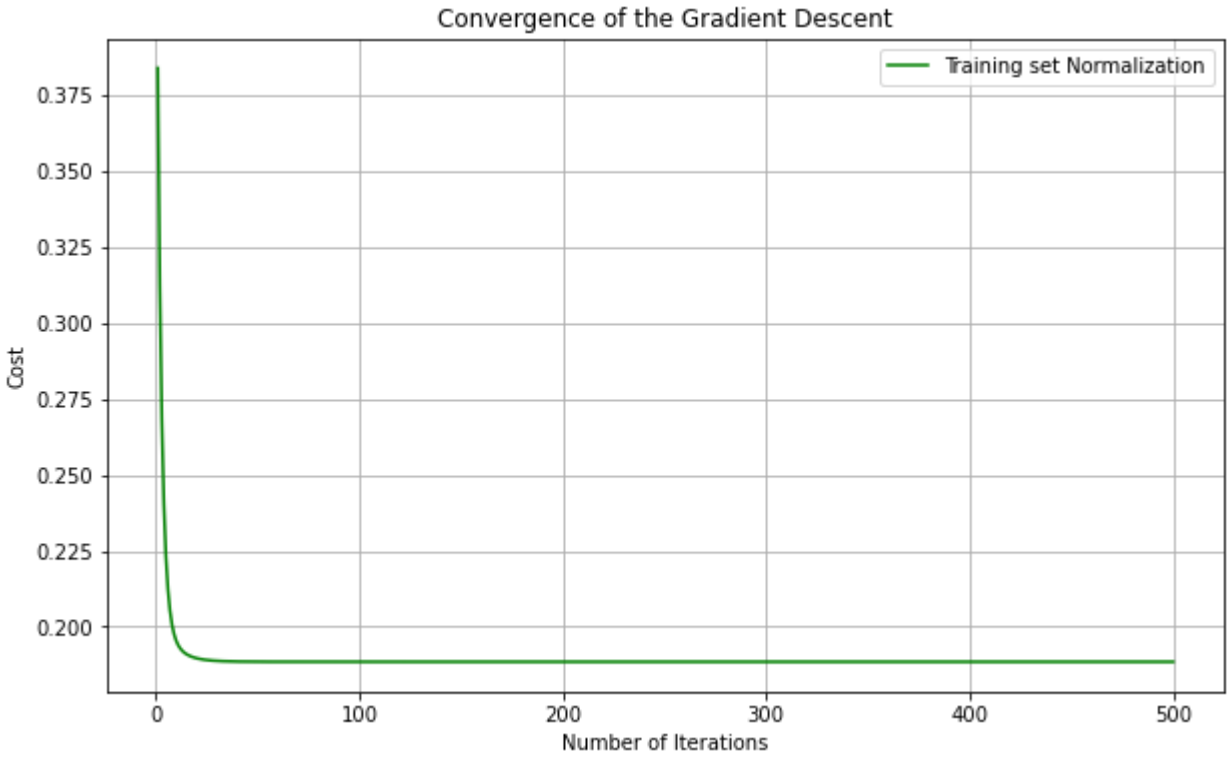
In [52]:
```
theta_t, cost_t = linear_regression(Xtest, Ytest, 0.1, iterations)
print('Final Theta Value of the Test Set =', theta_t)
cost_t = list(cost_t)
n_iterations_t = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value of the Test Set = [[3665283.80998753  741402.85068115  264657.01674763
992948.00356364
   305680.32344454  126509.594599    265573.12956302   96887.61766261
  1318395.63714537  574221.3020385   498783.75949985]]
```

In [53]:

```
plt.plot(n_iterations, cost, color = 'green', label='Training set Normalization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

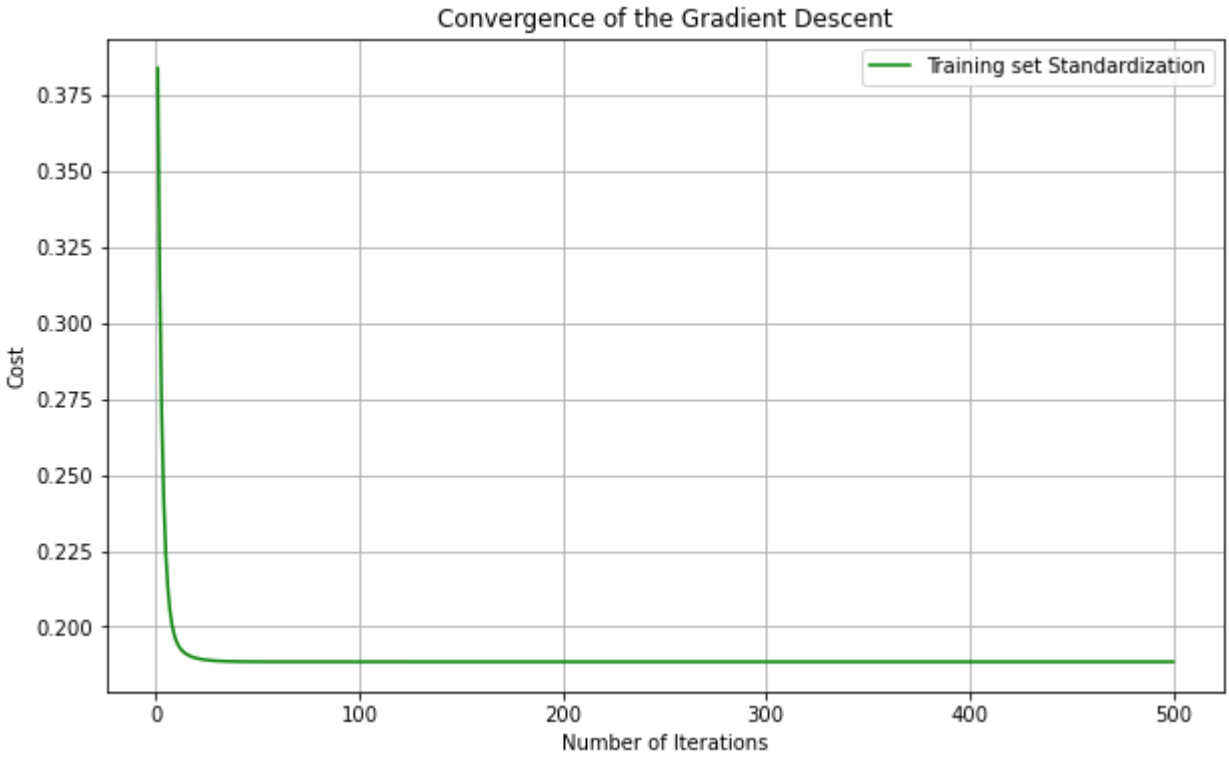
Out[53]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [54]:

```
plt.plot(n_iterations2, cost2, color = 'green', label='Training set Standardization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

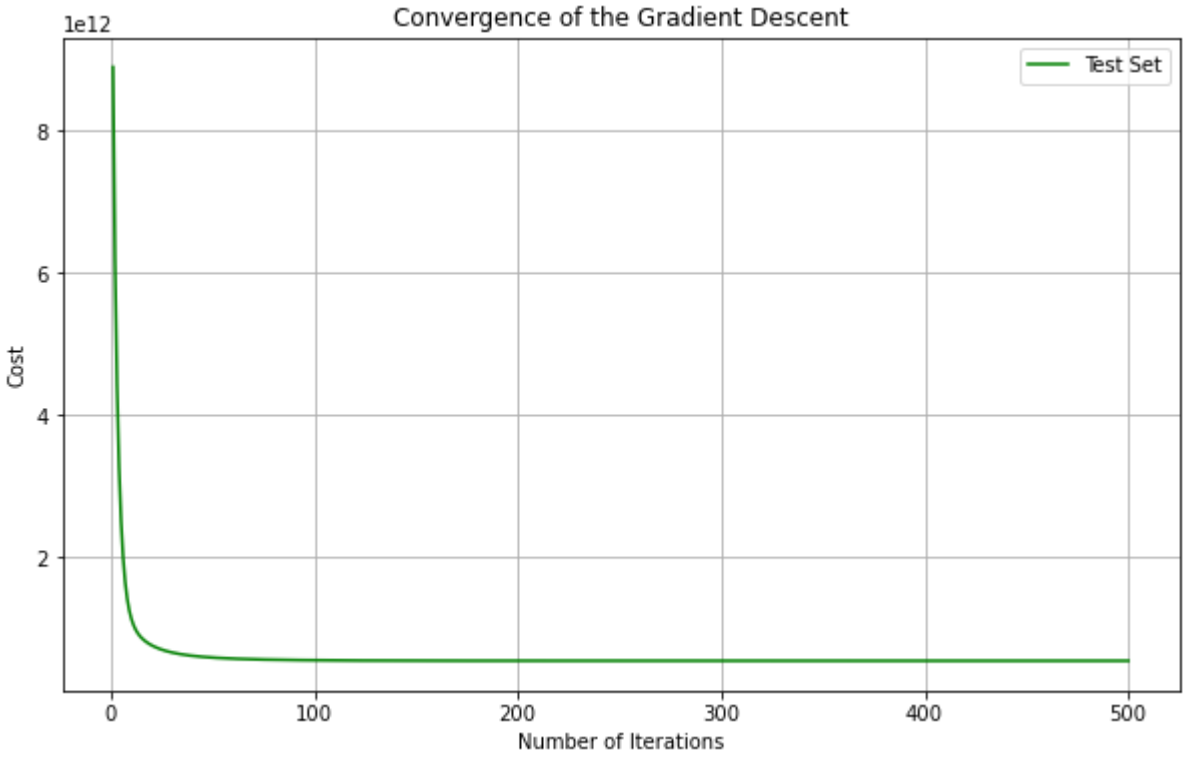
Out[54]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [55]:

```
plt.plot(n_iterations_t, cost_t, color = 'green', label='Test Set')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[55]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [56]:
```
## Problem 3 ##
```

In [57]:
```
from sklearn.model_selection import train_test_split
np.random.seed(0)
df_train, df_test = train_test_split(housing, train_size = 0.7, test_size = 0.3, random
df_train.shape
```

Out[57]:
```
(381, 13)
```

In [58]:
```
num_vars = ['area', 'bedrooms', 'bathrooms', 'stories', 'parking','price']
df_Newtrain = df_train[num_vars]
df_Newtest = df_test[num_vars]
df_Normal = df_Newtrain
df_Standard = df_Newtrain
df_Newtrain.head()
```

Out[58]:

	area	bedrooms	bathrooms	stories	parking	price
454	4500	3	1	2	0	3143000
392	3990	3	1	2	0	3500000
231	4320	3	1	1	0	4690000
271	1905	5	1	2	0	4340000
250	3510	3	1	3	0	4515000

In [59]:
```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
scaler = MinMaxScaler()
df_Normal[num_vars] = scaler.fit_transform(df_Normal[num_vars])
df_Normal.head(20)
```

Out[59]:

	area	bedrooms	bathrooms	stories	parking	price
454	0.193548	0.50	0.0	0.333333	0.000000	0.120606
392	0.156495	0.50	0.0	0.333333	0.000000	0.151515
231	0.180471	0.50	0.0	0.000000	0.000000	0.254545
271	0.005013	1.00	0.0	0.333333	0.000000	0.224242
250	0.121622	0.50	0.0	0.666667	0.000000	0.239394
541	0.040976	0.50	0.0	0.000000	0.000000	0.001485
461	0.226969	0.25	0.0	0.000000	0.000000	0.115152
124	0.340671	0.50	0.5	1.000000	0.333333	0.363636
154	0.131793	0.50	0.5	0.333333	0.666667	0.327273
451	0.357018	0.25	0.0	0.000000	0.000000	0.121212
59	0.302528	0.50	0.5	1.000000	0.333333	0.472727

	area	bedrooms	bathrooms	stories	parking	price
493	0.154316	0.50	0.0	0.000000	0.000000	0.090909
465	0.142691	0.25	0.0	0.000000	0.000000	0.112121
490	0.182650	0.50	0.0	0.333333	0.333333	0.093939
540	0.084568	0.25	0.0	0.000000	0.666667	0.006061
406	0.253124	0.25	0.0	0.000000	0.333333	0.148485
289	0.291630	0.25	0.0	0.000000	0.666667	0.212121
190	0.418774	0.75	0.0	0.333333	0.666667	0.284848
55	0.302528	0.50	0.0	0.333333	0.333333	0.484848
171	0.612685	0.50	0.0	0.000000	0.333333	0.303030

In [60]:

```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
scaler = StandardScaler()
df_Standard[num_vars] = scaler.fit_transform(df_Standard[num_vars])
df_Standard.head(20)
```

Out[60]:

	area	bedrooms	bathrooms	stories	parking	price
454	-0.286366	0.073764	-0.581230	0.207401	-0.822960	-0.868394
392	-0.544762	0.073764	-0.581230	0.207401	-0.822960	-0.677628
231	-0.377564	0.073764	-0.581230	-0.937813	-0.822960	-0.041744
271	-1.601145	2.884176	-0.581230	0.207401	-0.822960	-0.228768
250	-0.787958	0.073764	-0.581230	1.352614	-0.822960	-0.135256
541	-1.350349	0.073764	-0.581230	-0.937813	-0.822960	-1.603589
461	-0.053303	-1.331442	-0.581230	-0.937813	-0.822960	-0.902058
124	0.739618	0.073764	1.488383	2.497828	0.321375	0.631546
154	-0.717026	0.073764	1.488383	0.207401	1.465710	0.407116
451	0.853616	-1.331442	-0.581230	-0.937813	-0.822960	-0.864653
59	0.473622	0.073764	1.488383	2.497828	0.321375	1.304836
493	-0.559962	0.073764	-0.581230	-0.937813	-0.822960	-1.051678
465	-0.641027	-1.331442	-0.581230	-0.937813	-0.822960	-0.920761
490	-0.362365	0.073764	-0.581230	0.207401	0.321375	-1.032976
540	-1.046354	-1.331442	-0.581230	-0.937813	1.465710	-1.575348
406	0.129094	-1.331442	-0.581230	-0.937813	0.321375	-0.696331
289	0.397623	-1.331442	-0.581230	-0.937813	1.465710	-0.303578
190	1.284276	1.478970	-0.581230	0.207401	1.465710	0.145281

	area	bedrooms	bathrooms	stories	parking	price
55	0.473622	0.073764	-0.581230	0.207401	0.321375	1.379646
171	2.636548	0.073764	-0.581230	-0.937813	0.321375	0.257496

In [61]:
```
Xn = df_Normal.values[:,[0,1,2,3,4]]
Yn = df_Normal.values[:,5]
Xtest = df_Newtest.values[:,[0,1,2,3,4]]
Ytest = df_Newtest.values[:,5]
Xs = df_Standard.values[:,[0,1,2,3,4]]
Ys = df_Standard.values[:,5]
```

In [62]:
```
mean = np.ones(Xn.shape[1])
std = np.ones(Xn.shape[1])
for i in range(0, Xn.shape[1]):
    mean[i] = np.mean(Xn.transpose()[i])
    std[i] = np.std(Xn.transpose()[i])
    for j in range(0, Xn.shape[0]):
        Xn[j][i] = (Xn[j][i] - mean[i])/std[i]
```

In [63]:
```
mean = np.ones(Xs.shape[1])
std = np.ones(Xs.shape[1])
for i in range(0, Xs.shape[1]):
    mean[i] = np.mean(Xs.transpose()[i])
    std[i] = np.std(Xs.transpose()[i])
    for j in range(0, Xs.shape[0]):
        Xs[j][i] = (Xs[j][i] - mean[i])/std[i]
```

In [64]:
```
mean = np.ones(Xtest.shape[1])
std = np.ones(Xtest.shape[1])
for i in range(0, Xtest.shape[1]):
    mean[i] = np.mean(Xtest.transpose()[i])
    std[i] = np.std(Xtest.transpose()[i])
    for j in range(0, Xtest.shape[0]):
        Xtest[j][i] = (Xtest[j][i] - mean[i])/std[i]
```

In [65]:
```
def compute_cost(X, n, theta):
    h = np.ones((X.shape[0],1))
    theta = theta.reshape(1,n+1)
    for i in range(0,X.shape[0]):
        h[i] = float(np.matmul(theta, X[i]))
    h = h.reshape(X.shape[0])
    return h
```

In [66]:
```
def gradient_descent(X, Y, theta, alpha, iterations, n, h):
    lam = 1000
    cost = np.ones(iterations)
    for i in range(0,iterations):
        theta[0] = theta[0] - (alpha/X.shape[0]) * sum(h - Y)
        for j in range(1,n+1):
            theta[j] = (theta[j]*(1-(alpha*(lam/X.shape[0])))) - (alpha/X.shape[0]) * s
```

```
        h = compute_cost(X, n, theta)
        cost[i] = (1/X.shape[0]) * 0.5 * sum(np.square(h - Y))
    theta = theta.reshape(1,n+1)
    return theta, cost
```

In [67]:
```
def linear_regression(X, Y, alpha, iterations):
    n = X.shape[1]
    one_column = np.ones((X.shape[0],1))
    X = np.concatenate((one_column, X), axis = 1)
    theta = np.zeros(n+1)
    h = compute_cost(X, n, theta)
    theta, cost = gradient_descent(X, Y, theta, alpha, iterations, n, h)
    return theta, cost
```

In [68]:
```
iterations = 500;
```

In [69]:
```
theta, cost = linear_regression(Xn, Yn, 0.1, iterations)
print('Final Theta Value with Normalization =', theta)
cost = list(cost)
n_iterations = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value with Normalization = [[1.42056096e-16 1.24270894e-01 7.53179957e-02 1.
10985844e-01
  9.01203112e-02 7.75127501e-02]]
```

In [70]:
```
theta2, cost2 = linear_regression(Xs, Ys, 0.1, iterations)
print('Final Theta Value with Standardization =', theta2)
cost = list(cost2)
n_iterations2 = [x for x in range(1,(iterations + 1))]
```

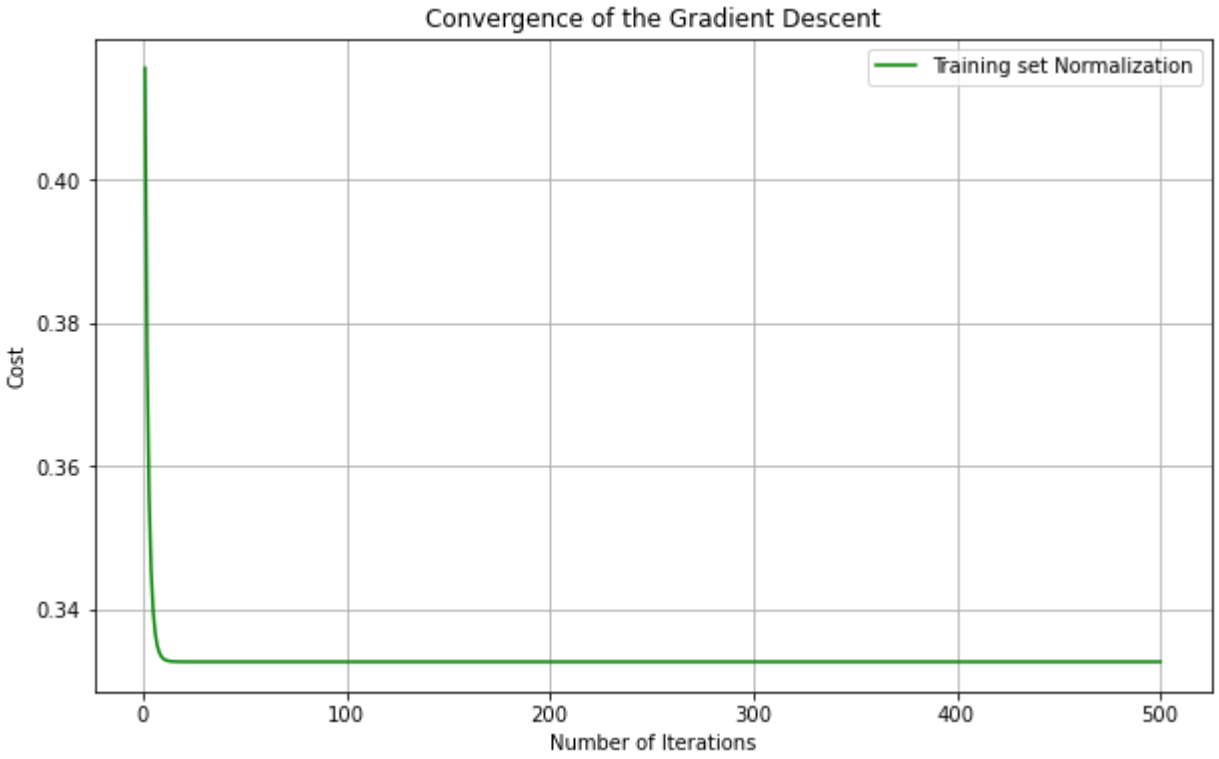
```
Final Theta Value with Standardization = [[1.42056096e-16 1.24270894e-01 7.53179957e-02
1.10985844e-01
  9.01203112e-02 7.75127501e-02]]
```

In [71]:
```
theta_t, cost_t = linear_regression(Xtest, Ytest, 0.1, iterations)
print('Final Theta Value of the Test Set =', theta)
cost_t = list(cost_t)
n_iterations_t = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value of the Test Set = [[1.42056096e-16 1.24270894e-01 7.53179957e-02 1.109
85844e-01
  9.01203112e-02 7.75127501e-02]]
```

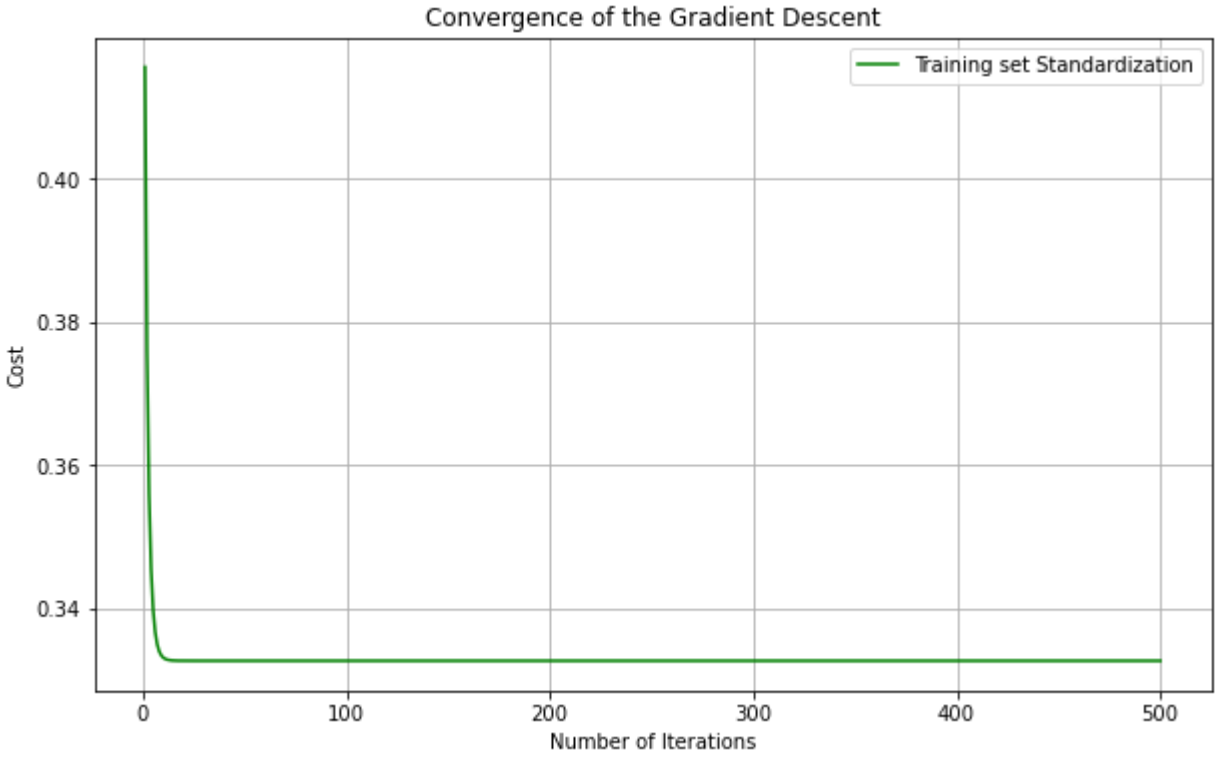
In [72]:
```
plt.plot(n_iterations, cost, color = 'green', label='Training set Normalization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[72]:
```
Text(0.5, 1.0, 'Convergence of the Gradient Descent')
```



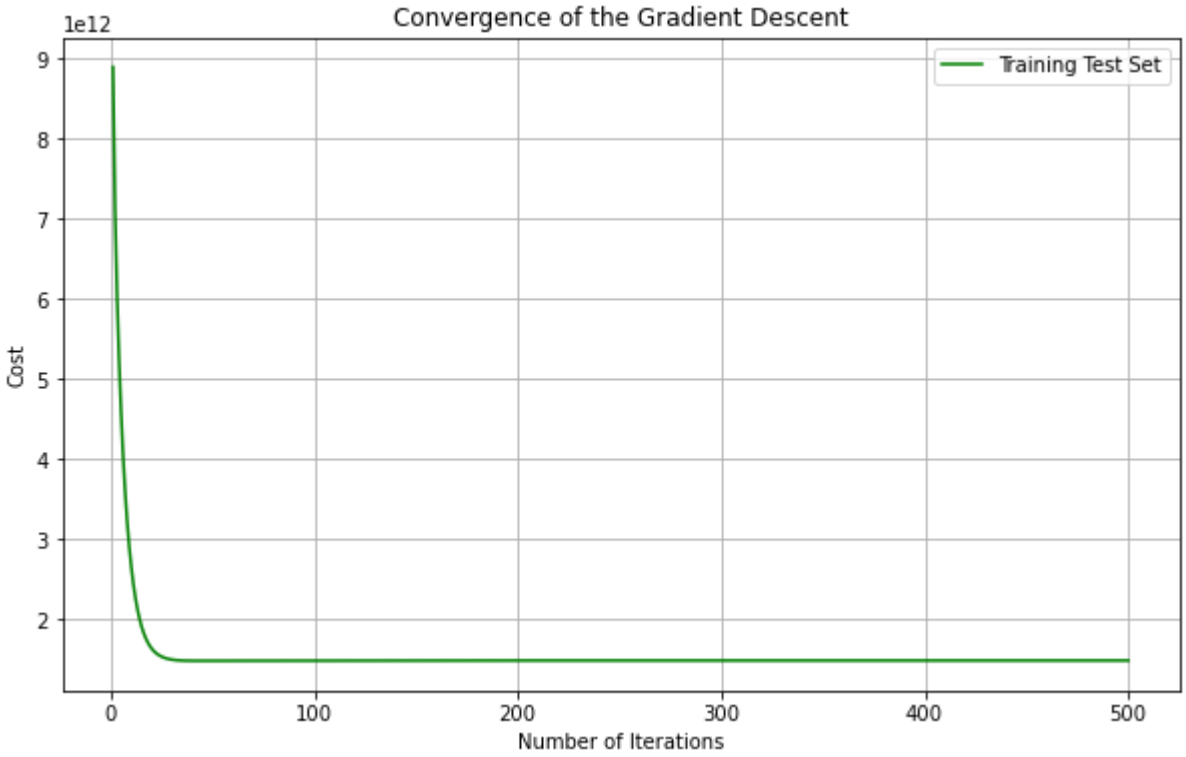
In [73]:
```
plt.plot(n_iterations2, cost2, color = 'green', label='Training set Standardization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[73]:
```
Text(0.5, 1.0, 'Convergence of the Gradient Descent')
```



In [94]:
```
plt.plot(n_iterations_t, cost_t, color = 'green', label='Training Test Set')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[94]:
```
Text(0.5, 1.0, 'Convergence of the Gradient Descent')
```



In [75]:
```
num_vars = ['area', 'bedrooms', 'bathrooms', 'mainroad', 'guestroom', 'basement', 'hotw
df_Newtrain = df_train[num_vars]
df_Newtest = df_test[num_vars]
df_Normal = df_Newtrain
df_Standard = df_Newtrain
df_Newtrain.head()
```

Out[75]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditioning
454	4500	3	1	1	0	0	0	1
392	3990	3	1	1	0	0	0	0
231	4320	3	1	1	0	0	0	0
271	1905	5	1	0	0	1	0	0
250	3510	3	1	1	0	0	0	0

In [76]:
```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
```

```
scaler = MinMaxScaler()
df_Normal[num_vars] = scaler.fit_transform(df_Normal[num_vars])
df_Normal.head(20)
```

Out[76]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditionin
454	0.193548	0.50	0.0	1.0	0.0	0.0	0.0	1
392	0.156495	0.50	0.0	1.0	0.0	0.0	0.0	0
231	0.180471	0.50	0.0	1.0	0.0	0.0	0.0	0
271	0.005013	1.00	0.0	0.0	0.0	1.0	0.0	0
250	0.121622	0.50	0.0	1.0	0.0	0.0	0.0	0
541	0.040976	0.50	0.0	0.0	0.0	0.0	0.0	0
461	0.226969	0.25	0.0	1.0	0.0	1.0	0.0	1
124	0.340671	0.50	0.5	1.0	0.0	0.0	0.0	0
154	0.131793	0.50	0.5	1.0	0.0	0.0	0.0	0
451	0.357018	0.25	0.0	1.0	0.0	0.0	0.0	0
59	0.302528	0.50	0.5	1.0	1.0	0.0	0.0	1
493	0.154316	0.50	0.0	1.0	0.0	0.0	0.0	0
465	0.142691	0.25	0.0	1.0	0.0	0.0	0.0	0
490	0.182650	0.50	0.0	0.0	0.0	0.0	1.0	0
540	0.084568	0.25	0.0	1.0	0.0	1.0	0.0	0
406	0.253124	0.25	0.0	1.0	0.0	0.0	0.0	0
289	0.291630	0.25	0.0	1.0	1.0	1.0	0.0	0
190	0.418774	0.75	0.0	1.0	0.0	0.0	0.0	1
55	0.302528	0.50	0.0	1.0	0.0	0.0	0.0	1
171	0.612685	0.50	0.0	1.0	0.0	0.0	0.0	0

In [77]:

```
import warnings
warnings.filterwarnings('ignore')
from sklearn.preprocessing import MinMaxScaler, StandardScaler
scaler = StandardScaler()
df_Standard[num_vars] = scaler.fit_transform(df_Standard[num_vars])
df_Standard.head(20)
```

Out[77]:

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditioni
454	-0.286366	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	1.4226
392	-0.544762	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
231	-0.377564	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
271	-1.601145	2.884176	-0.581230	-2.543735	-0.457738	1.405903	-0.216109	-0.7029

	area	bedrooms	bathrooms	mainroad	guestroom	basement	hotwaterheating	airconditioni
250	-0.787958	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
541	-1.350349	0.073764	-0.581230	-2.543735	-0.457738	-0.711287	-0.216109	-0.7029
461	-0.053303	-1.331442	-0.581230	0.393123	-0.457738	1.405903	-0.216109	1.4226
124	0.739618	0.073764	1.488383	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
154	-0.717026	0.073764	1.488383	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
451	0.853616	-1.331442	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
59	0.473622	0.073764	1.488383	0.393123	2.184657	-0.711287	-0.216109	1.4226
493	-0.559962	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
465	-0.641027	-1.331442	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
490	-0.362365	0.073764	-0.581230	-2.543735	-0.457738	-0.711287	4.627285	-0.7029
540	-1.046354	-1.331442	-0.581230	0.393123	-0.457738	1.405903	-0.216109	-0.7029
406	0.129094	-1.331442	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029
289	0.397623	-1.331442	-0.581230	0.393123	2.184657	1.405903	-0.216109	-0.7029
190	1.284276	1.478970	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	1.4226
55	0.473622	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	1.4226
171	2.636548	0.073764	-0.581230	0.393123	-0.457738	-0.711287	-0.216109	-0.7029

In [78]:
```
Xn = df_Normal.values[:,0:10]
Yn = df_Normal.values[:,10]
Xtest = df_Newtest.values[:,0:10]
Ytest = df_Newtest.values[:,10]
Xs = df_Standard.values[:,0:10]
Ys = df_Standard.values[:,10]
```

In [79]:
```
mean = np.ones(Xn.shape[1])
std = np.ones(Xn.shape[1])
for i in range(0, Xn.shape[1]):
    mean[i] = np.mean(Xn.transpose()[i])
    std[i] = np.std(Xn.transpose()[i])
    for j in range(0, Xn.shape[0]):
        Xn[j][i] = (Xn[j][i] - mean[i])/std[i]
```

In [80]:
```
mean = np.ones(Xs.shape[1])
std = np.ones(Xs.shape[1])
for i in range(0, Xs.shape[1]):
    mean[i] = np.mean(Xs.transpose()[i])
    std[i] = np.std(Xs.transpose()[i])
    for j in range(0, Xs.shape[0]):
        Xs[j][i] = (Xs[j][i] - mean[i])/std[i]
```

In [81]:

```
mean = np.ones(Xtest.shape[1])
std = np.ones(Xtest.shape[1])
for i in range(0, Xtest.shape[1]):
    mean[i] = np.mean(Xtest.transpose()[i])
    std[i] = np.std(Xtest.transpose()[i])
    for j in range(0, Xtest.shape[0]):
        Xtest[j][i] = (Xtest[j][i] - mean[i])/std[i]
```

In [82]:

```
theta, cost = linear_regression(Xn, Yn, 0.1, iterations)
print('Final Theta Value with Normalization =', theta)
cost = list(cost)
n_iterations = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value with Normalization = [[1.38369922e-16 1.08337017e-01 7.58521283e-02 1.
08013107e-01
  5.54076634e-02 5.32500668e-02 3.66508358e-02 3.65154719e-02
  9.68953820e-02 6.81505402e-02 7.57869446e-02]]
```

In [83]:

```
theta2, cost2 = linear_regression(Xs, Ys, 0.1, iterations)
print('Final Theta Value with Standardization =', theta2)
cost2 = list(cost2)
n_iterations2 = [x for x in range(1,(iterations + 1))]
```

```
Final Theta Value with Standardization = [[1.38369922e-16 1.08337017e-01 7.58521283e-02
1.08013107e-01
  5.54076634e-02 5.32500668e-02 3.66508358e-02 3.65154719e-02
  9.68953820e-02 6.81505402e-02 7.57869446e-02]]
```

In [84]:

```
theta_t, cost_t = linear_regression(Xtest, Ytest, 0.1, iterations)
print('Final Theta Value of the Test Set =', theta_t)
cost_t = list(cost_t)
n_iterations_t = [x for x in range(1,(iterations + 1))]
```

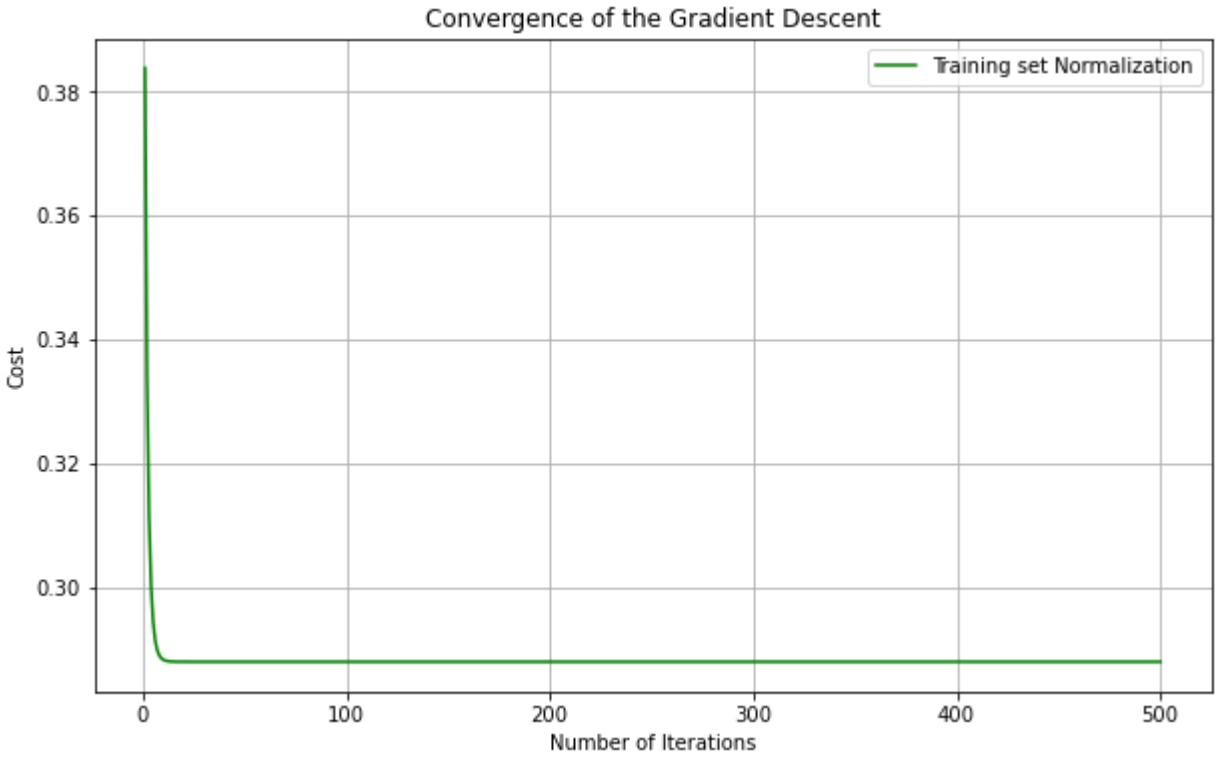
```
Final Theta Value of the Test Set = [[4.68135283e+06 9.14174376e+04 7.10541172e+04 1.030
91554e+05
  6.81362933e+04 4.24713613e+04 1.63927974e+04 8.78780977e+02
  6.38058529e+04 5.14196389e+04 2.74614616e+04]]
```

In [85]:

```
plt.plot(n_iterations, cost, color = 'green', label='Training set Normalization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[85]:

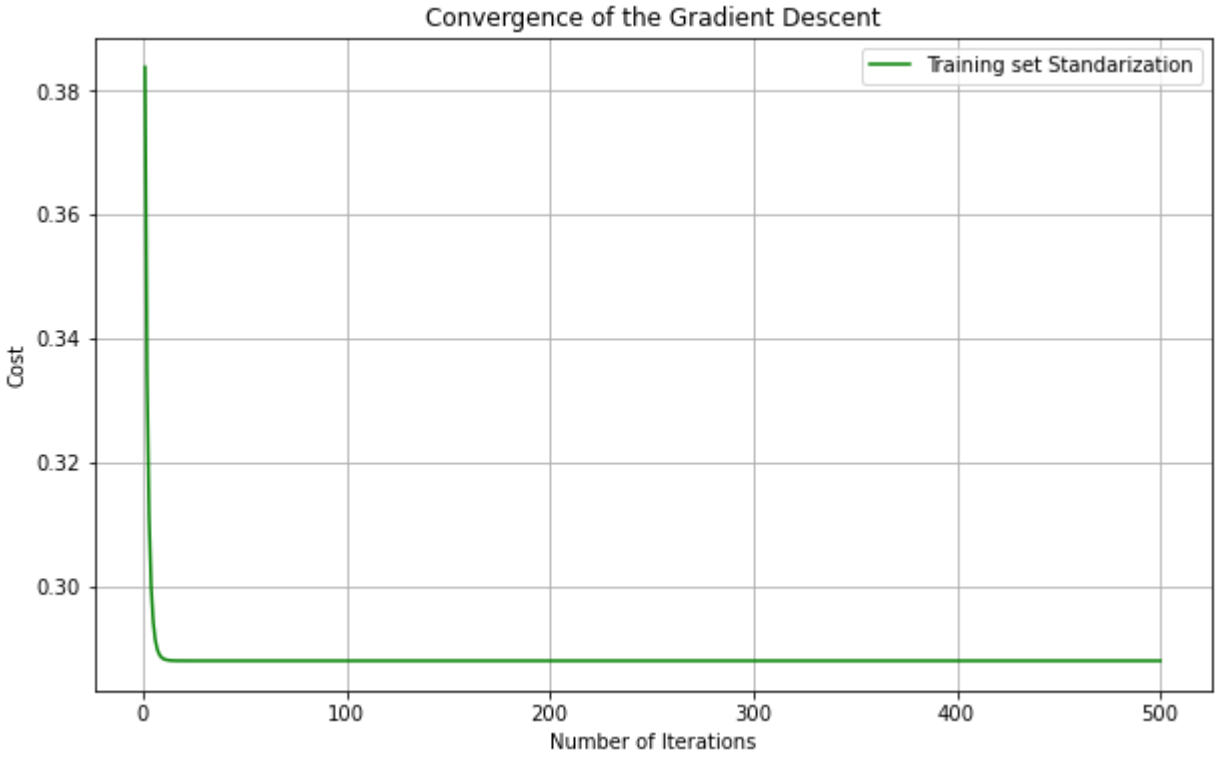
```
Text(0.5, 1.0, 'Convergence of the Gradient Descent')
```



In [86]:

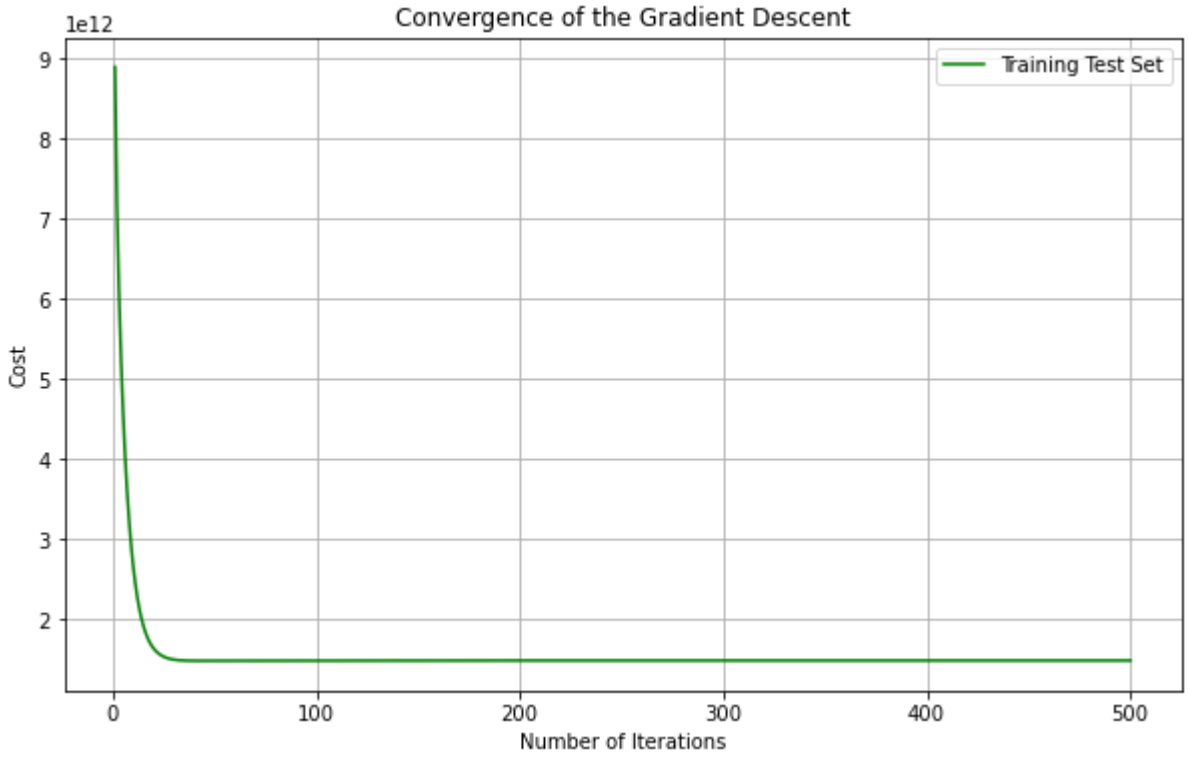
```
plt.plot(n_iterations2, cost2, color = 'green', label='Training set Standarization')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[86]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [93]:
```
plt.plot(n_iterations_t, cost_t, color = 'green', label='Training Test Set')
plt.legend()
plt.rcParams["figure.figsize"]=(10,6)
plt.grid()
plt.xlabel('Number of Iterations')
plt.ylabel('Cost')
plt.title('Convergence of the Gradient Descent')
```

Out[93]: Text(0.5, 1.0, 'Convergence of the Gradient Descent')



In [ ]: