In [71]:
```
'''
Patrick Ballou
ID: 801130521
ECGR 4105
Homework 0
Problem 1
'''
```

Out[71]:
```
'\nPatrick Ballou\nID: 801130521\nECGR 4105\nHomework 0\nProblem 1\n'
```

In [72]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

In [73]:
```
#create pandas dataframe and print first 5 rows
df = pd.read_csv("D3.csv")
df.head(5)
```

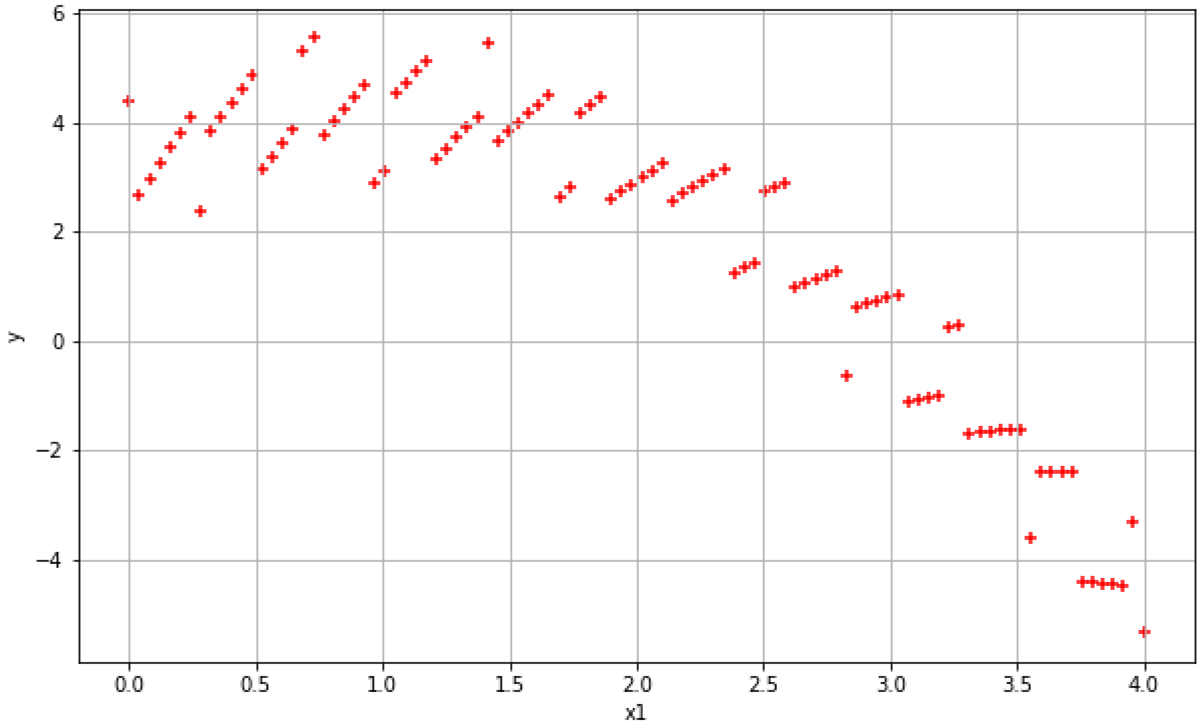
Out[73]:

	X1	X2	X3	Y
0	0.000000	3.440000	0.440000	4.387545
1	0.040404	0.134949	0.888485	2.679650
2	0.080808	0.829899	1.336970	2.968490
3	0.121212	1.524848	1.785455	3.254065
4	0.161616	2.219798	2.233939	3.536375

In [74]:
```
#split columns into 3 explanitory variables as well as output y
x1 = df.values[:,0]
x2 = df.values[:,1]
x3 = df.values[:,2]
y = df.values[:,3]
```

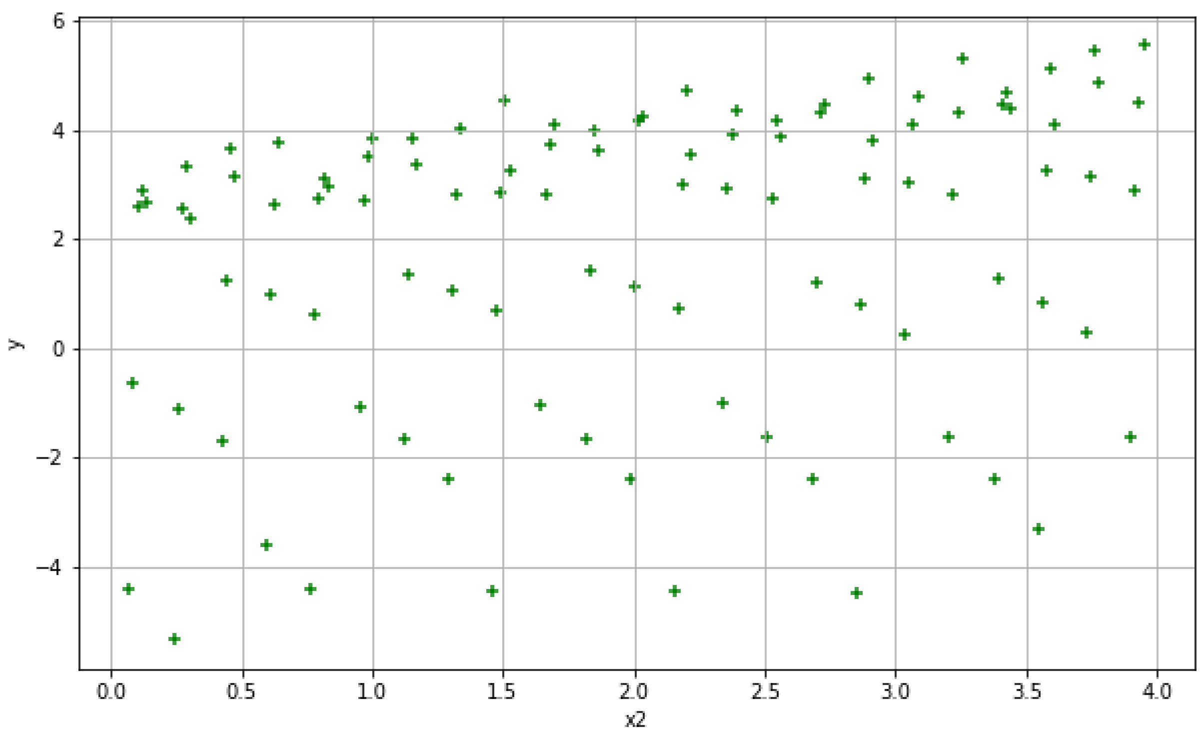
In [75]:
```
#plot x1 vs y
plt.scatter(x1, y, color='red', marker='+')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('x1')
plt.ylabel('y')
```

Out[75]:
```
Text(0, 0.5, 'y')
```



In [76]:
```python
#plot x2 vs y
plt.scatter(x2, y, color='green', marker='+')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('x2')
plt.ylabel('y')
```

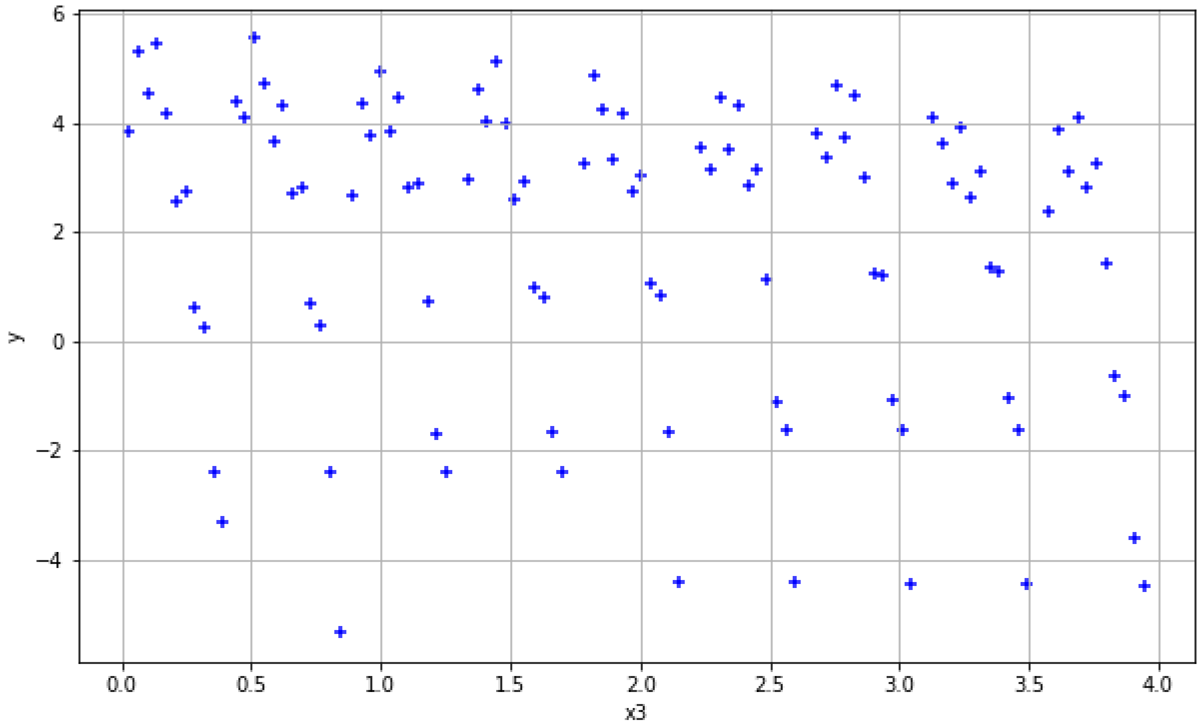
Out[76]: `Text(0, 0.5, 'y')`



In [77]:
```python
#plot x3 vs y
plt.scatter(x3, y, color='blue', marker='+')
plt.rcParams["figure.figsize"] = (10,6)
```

```
plt.grid()
plt.xlabel('x3')
plt.ylabel('y')
```

Out[77]: Text(0, 0.5, 'y')



In [78]:

```
#create x_0 2d array of ones with length m
m = len(x1)
x_0 = np.ones((m,1))
x_0[:5]
```

Out[78]:

```
array([[1.],
       [1.],
       [1.],
       [1.],
       [1.]])
```

In [79]:

```
#prepare x variables so they can be concatenated with x_0
x1 = x1.reshape(m,1)
x2 = x2.reshape(m,1)
x3 = x3.reshape(m,1)
```

In [80]:

```
#horizontally stack x_0 onto each x variable
X1 = np.hstack((x_0, x1))
X2 = np.hstack((x_0, x2))
X3 = np.hstack((x_0, x3))
```

In [81]:

```
#loss function
def compute_cost(X, y, theta):
    predictions = X.dot(theta)
    errors = np.subtract(predictions, y)
    sqrErrors = np.square(errors)
    J = (1/(2*m))*np.sum(sqrErrors)

    return J
```

In [82]:
```
#gradient descent function
def gradient_descent(X, y, theta, alpha, iterations):
    cost_history = np.zeros(iterations)

    for i in range(iterations):
        predictions = X.dot(theta)
        errors = np.subtract(predictions, y)
        sum_delta = (alpha/m) * X.transpose().dot(errors)
        theta -= sum_delta
        cost_history[i] = compute_cost(X, y, theta)

    return theta, cost_history
```

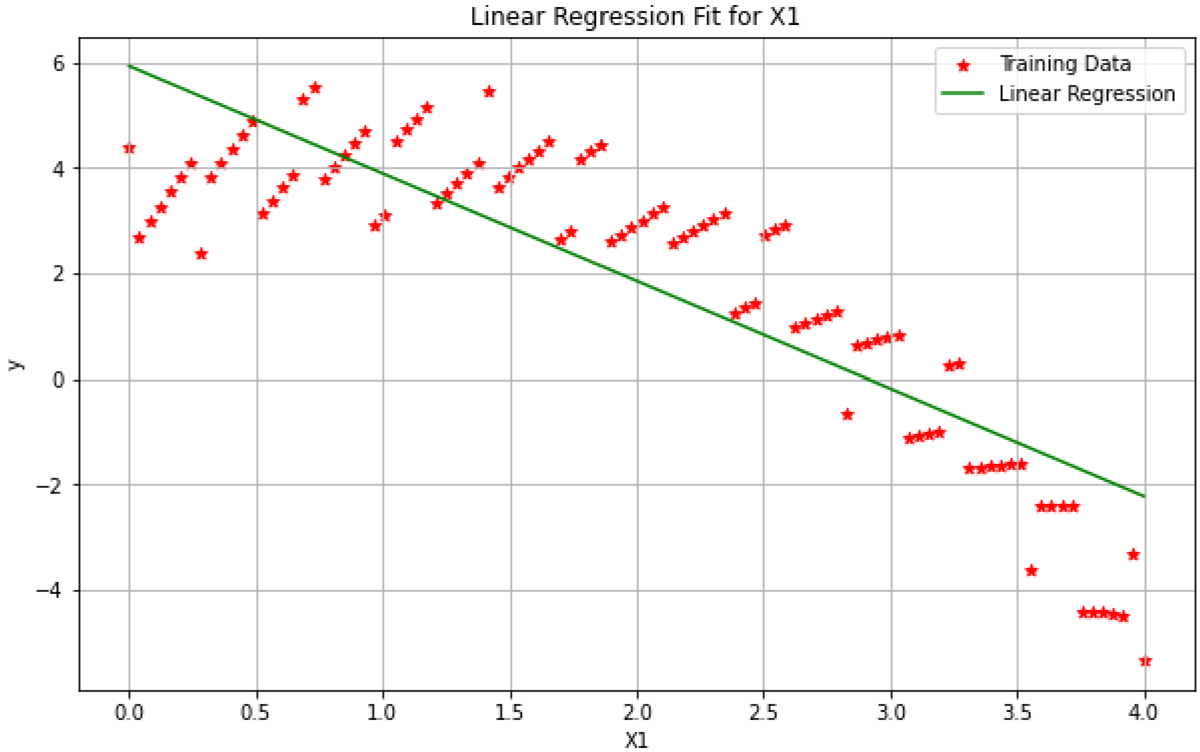
In [83]:
```
#initialize thetas, # of iterations, and learning rate for each model
theta1 = np.zeros(2)
theta2 = np.zeros(2)
theta3 = np.zeros(2)
iterations1 = 5000
iterations2 = 2000
iterations3 = 9500
alpha1 = .06
alpha2 = .08
alpha3 = .011
```

In [84]:
```
#calculate costs for each regression and output last value which should be the lowest
theta1, cost_history1 = gradient_descent(X1, y, theta1, alpha1, iterations1)
print("Final value of theta1 =", theta1)
#print("Cost history1 =", cost_history1)
theta2, cost_history2 = gradient_descent(X2, y, theta2, alpha2, iterations2)
print("Final value of theta2 =", theta2)
#print("Cost history2 =", cost_history2)
theta3, cost_history3 = gradient_descent(X3, y, theta3, alpha3, iterations3)
print("Final value of theta3 =", theta3)
#print("Cost history3 =", cost_history3)
```

```
Final value of theta1 = [ 5.92794892 -2.03833663]
Final value of theta2 = [0.73606043 0.55760761]
Final value of theta3 = [ 2.8714221  -0.52048288]
```

In [85]:
```
#plot X1 regression
plt.scatter(X1[:,1], y, color='red', marker='*', label='Training Data')
plt.plot(X1[:,1],X1.dot(theta1), color='green', label='Linear Regression')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('X1')
plt.ylabel('y')
plt.title('Linear Regression Fit for X1')
plt.legend()
```

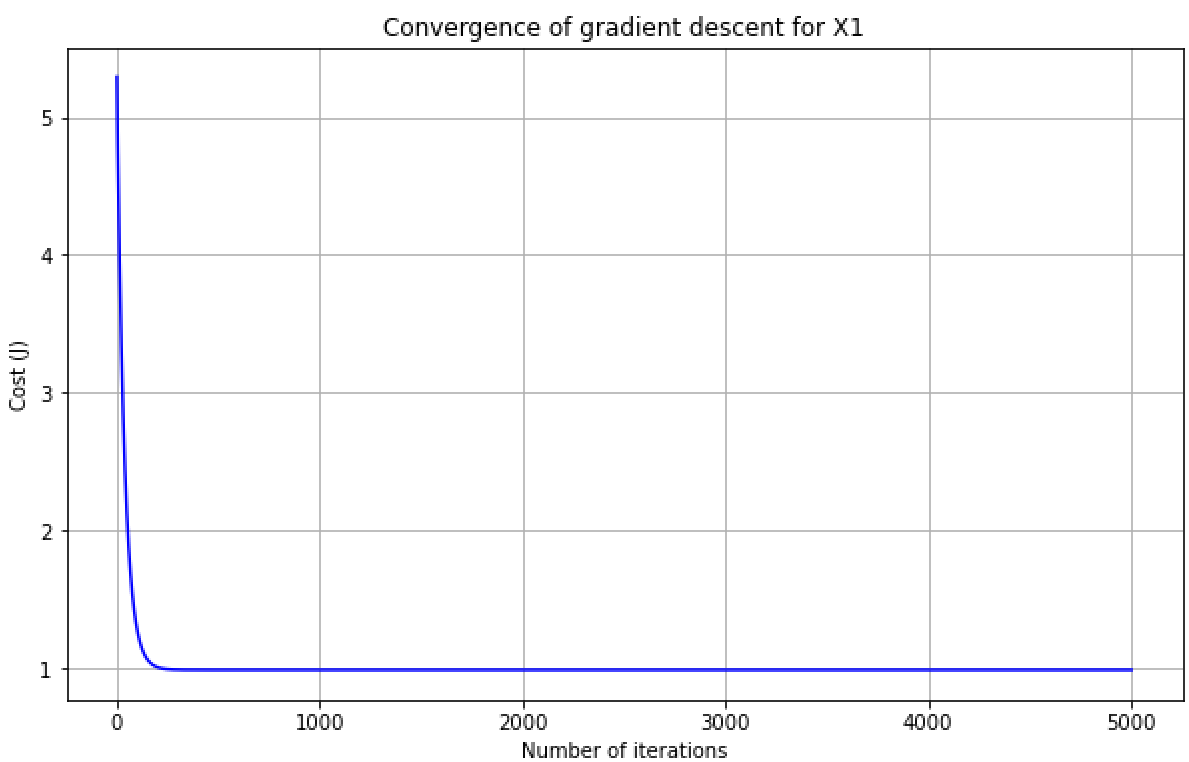
Out[85]:
```
<matplotlib.legend.Legend at 0x1743c75fe20>
```



In [86]:

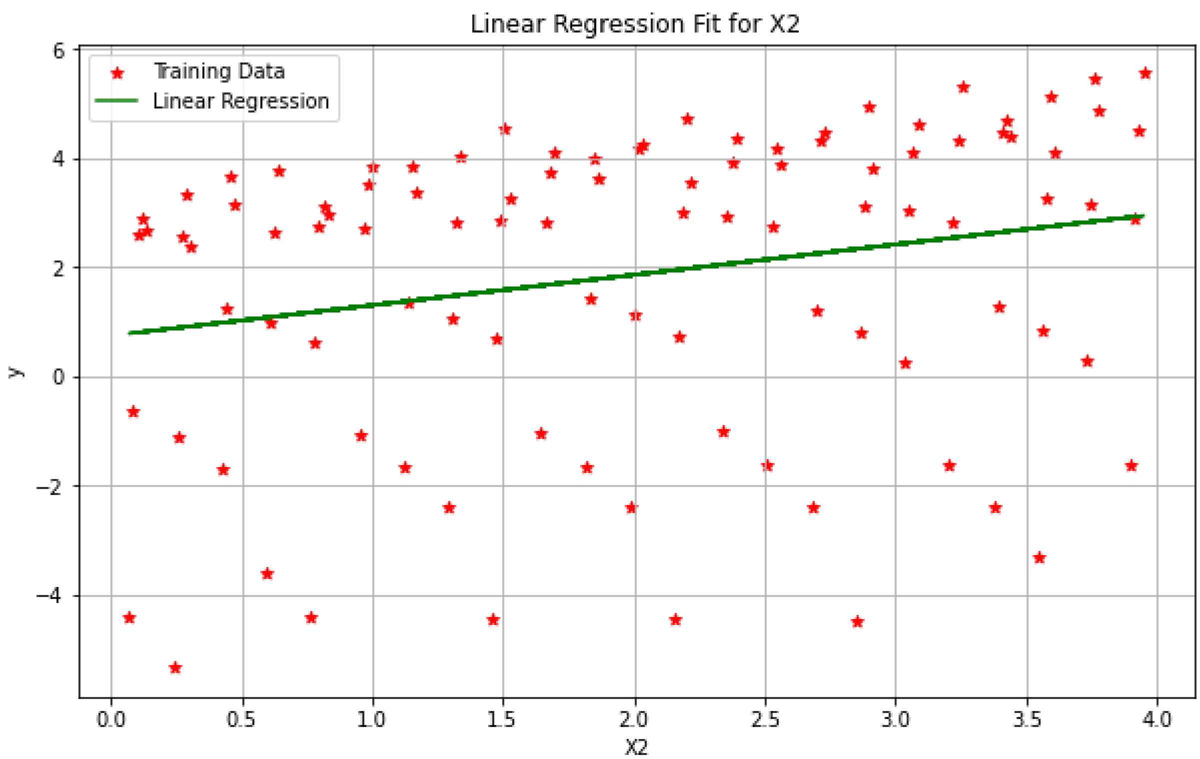
```
#plot X1 loss vs iterations
plt.plot(range(1, iterations1 + 1), cost_history1, color='blue')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Convergence of gradient descent for X1')
print("Cost1:", cost_history1[-1])
```

```
Cost1: 0.9849930825405945
```



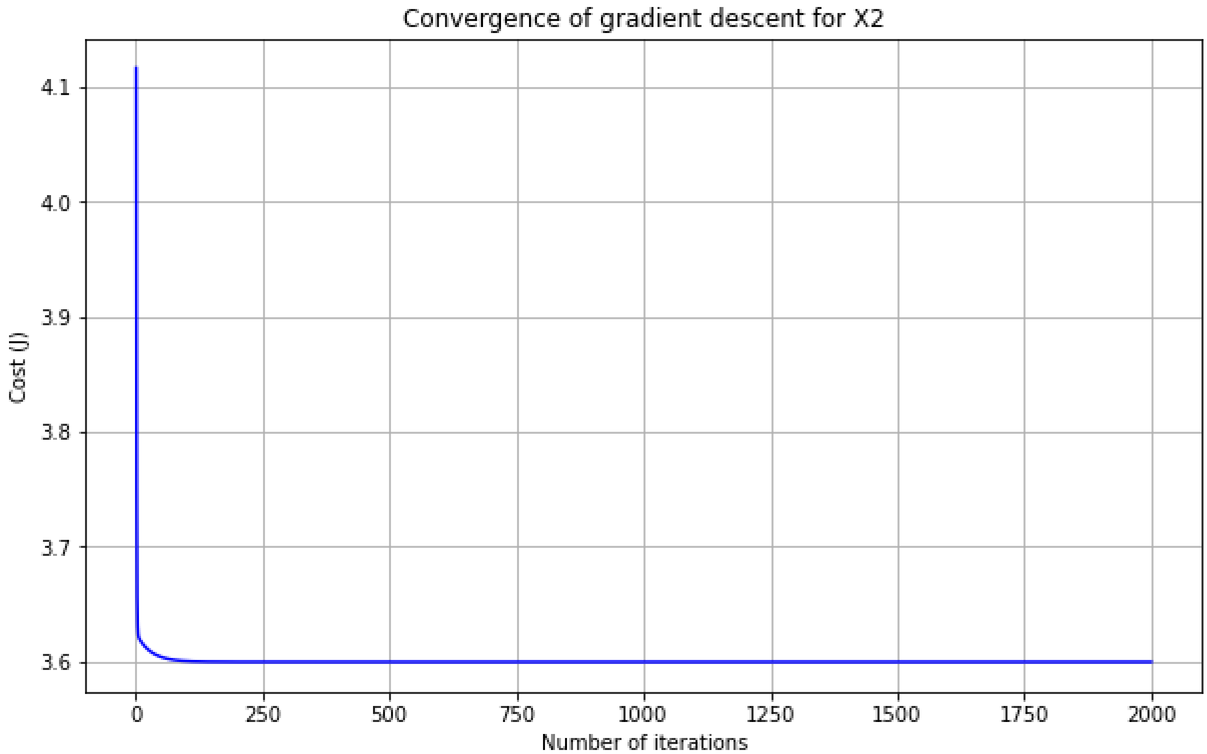
In [87]:
```
#plot X2 regression
plt.scatter(X2[:,1], y, color='red', marker='*', label='Training Data')
plt.plot(X2[:,1],X2.dot(theta2), color='green', label='Linear Regression')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('X2')
plt.ylabel('y')
plt.title('Linear Regression Fit for X2')
plt.legend()
```

Out[87]: <matplotlib.legend.Legend at 0x1743db92550>



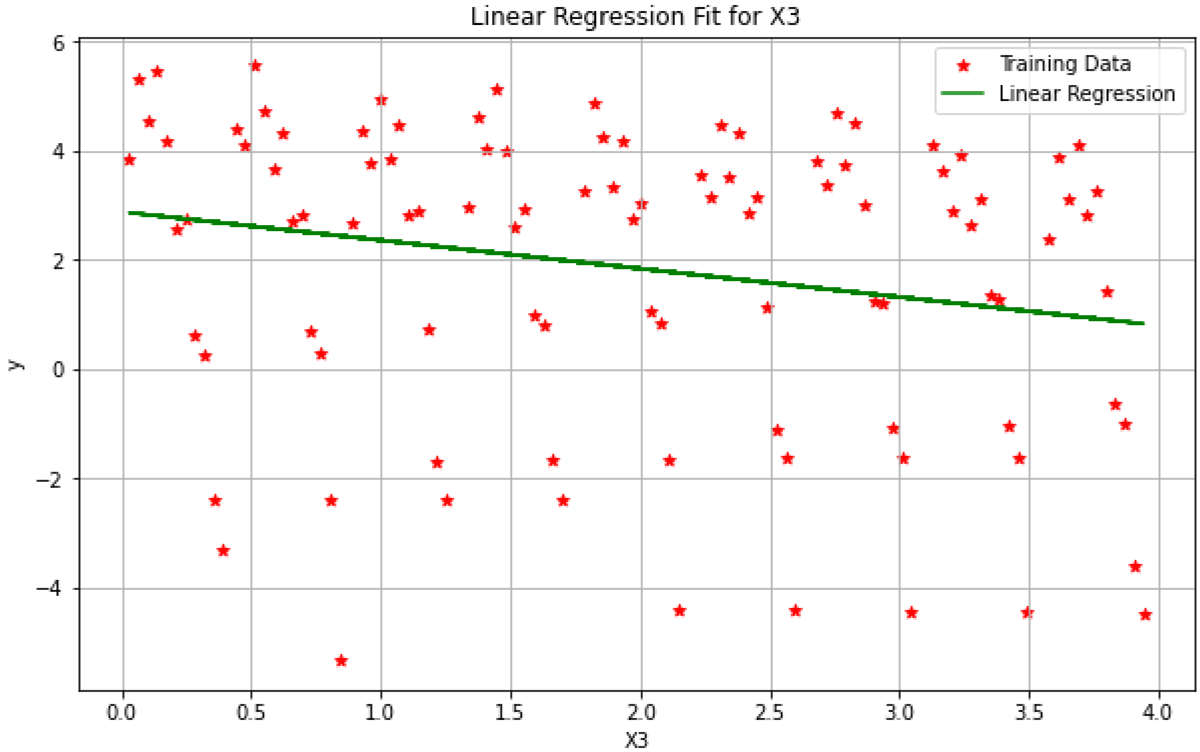
In [88]:
```
#plot X2 loss vs iterations
plt.plot(range(1, iterations2 + 1), cost_history2, color='blue')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Convergence of gradient descent for X2')
print("Cost2:", cost_history2[-1])
```

```
Cost2: 3.599366018168041
```



In [89]:
```
#plot X3 regression
plt.scatter(X3[:,1], y, color='red', marker='*', label='Training Data')
plt.plot(X3[:,1],X3.dot(theta3), color='green', label='Linear Regression')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('X3')
plt.ylabel('y')
plt.title('Linear Regression Fit for X3')
plt.legend()
```

Out[89]:
```
<matplotlib.legend.Legend at 0x1743f0c6e50>
```



In [90]:
```
#plot X3 loss vs iterations
plt.plot(range(1, iterations3 + 1), cost_history3, color='blue')
plt.rcParams["figure.figsize"] = (10,6)
plt.grid()
plt.xlabel('Number of iterations')
plt.ylabel('Cost (J)')
plt.title('Convergence of gradient descent for X3')
print("Cost3:", cost_history3[-1])
```

```
Cost3: 3.629451124607915
```