3. a) Without missing data

In [1]:

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

%matplotlib inline
```

In [2]:

```
filepath = "input.csv"

df = pd.read_csv(filepath, index_col = 0)
df = df.dropna(thresh=8) # drop rows with NaN values in any column
df = df.sample(frac=1) # shuffle the rows
df.head()
```

Out[2]:

Sl.No	Regressor	Var1	Var2	Var3	Var4	Var5	Var6	Var7
115	20.0	4	97.0	88.0	2279	19.0	73	3
317	38.1	4	89.0	60.0	1968	18.8	80	3
174	29.0	4	97.0	75.0	2171	16.0	75	3
9	15.0	8	390.0	190.0	3850	8.5	70	1
263	20.5	6	225.0	100.0	3430	17.2	78	1

In [3]:

```
# assuming Y is always the column next to index

Y = df.iloc[:,0].copy().values
X = df.iloc[:,1:].copy().values

no_x = X.shape[1] # no of independent variables

limit = 70*df.shape[0]//100 # for selecting 70% of data

Y_train = np.array(Y[:limit])
Y_test = np.array(Y[limit:])

X = np.transpose(X)
X = np.array([(i - np.mean(i))/(np.max(i)-np.min(i)) for i in X]) # normalising

X = np.transpose(X)
X_train = np.transpose(X[:limit])
X_test = np.transpose(X[limit:])
```

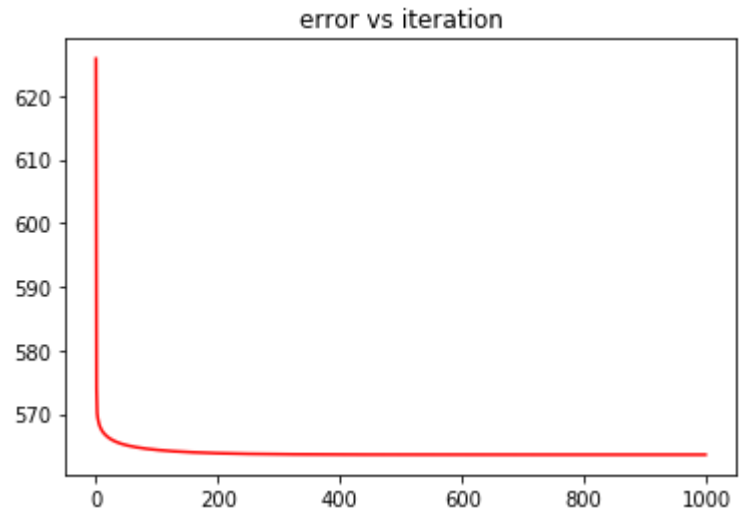
In [4]:

```
learning_rate = 1
error = []
W = np.zeros(no_x)

for _ in range(1000):

    Y_ = np.matmul(W, X_train)

    mse = np.mean((Y_train - Y_)**2)
    error.append(mse) # for plotting

    ct = 2*(Y_train - Y_) # common term in derivative

    dL_dw = np.array([ np.mean(ct*x_js) for x_js in X_train])

    W =  W + learning_rate*dL_dw

print("train_error : "+str(mse))
print("weights : "+str(W))
```

```
train_error : 563.575743107
weights : [ -4.25831657  10.48247245   4.19569573 -30.32223647   1.273
67308
  10.27200828   4.17551559]
```

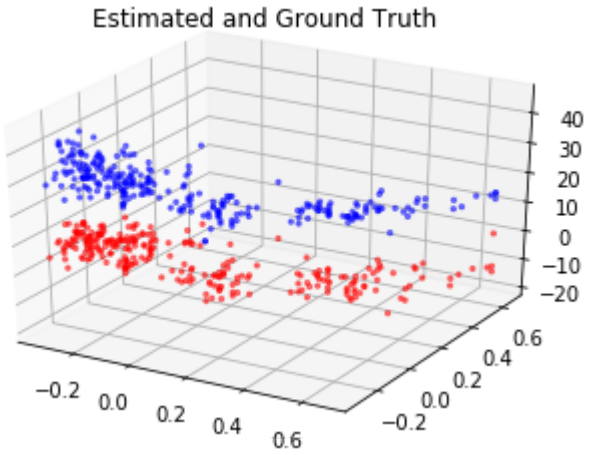
In [5]:

```
plt.plot(range(len(error[:])),error[:], color="red")
plt.title("error vs iteration")
plt.show()
```



In [6]:

```
from mpl_toolkits.mplot3d import Axes3D

fig = plt.figure()
ax = fig.add_subplot(111, projection="3d")

x1 = np.linspace(-1,1,100)
x2 = np.linspace(-1,1,100)
x1, x2 = np.meshgrid(x1,x2)

ax.scatter(X_train[1], X_train[2], Y_train, color= 'b', marker=".",alpha= 0.5)
ax.scatter(X_train[1], X_train[2], Y_, color= 'r',marker=".", alpha= 0.5)

plt.title("Estimated and Ground Truth")
plt.show()
```



In [7]:

```
Y_ = np.matmul(W, X_test)
test_error = np.mean((Y_test - Y_)**2)
print("test_error : "+str(test_error))
```

```
test_error : 558.468406851
```

Using Normal Equation

In [8]:

```
step_one = np.matmul(np.transpose(X),X)
step_two = np.linalg.inv(step_one)
step_three = np.matmul(step_two,np.transpose(X))
weights = np.matmul(step_three,Y)
```

In [10]:

```
Y_ = np.matmul(weights, X_test)
test_error = np.mean((Y_test - Y_)**2)
print("test_error : "+str(test_error))
```

```
test_error : 550.043537172
```

3. b) With missing data

Discuss briefly, the different ways in which you can think of estimating the missing values.

- Using measures of central tendencies i.e mean, median, mode. Something that would be more representative than median is respective quartile median
- The better and complex version is a predictive model. We first train the model with complete data and use the model to predict the missing data fields.
- Another version suggested was to use a nearest neighbours method, which looks for points which are similar in other fields and use its value to impute the missing field.

Evaluate two different methods of replacing missing data and report your results like in Task 1 for both.

Not using method 2 because model performed poorly on test data. And don't know how to implement third So using mean and median as two types of imputation techniques

In [26]:

```
filepath = "input.csv"

df = pd.read_csv(filepath, index_col = 0)
df = df.fillna(value={"Regressor":np.median(Y), "Var3":np.median(np.transpose(X[2]))
# df = df.fillna(value={"Regressor":np.mean(Y), "Var3":np.mean(np.transpose(X[2]))}
df = df.sample(frac=1) # shuffle the rows
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 406 entries, 327 to 272
Data columns (total 8 columns):
Regressor    406 non-null float64
Var1         406 non-null int64
Var2         406 non-null float64
Var3         406 non-null float64
Var4         406 non-null int64
Var5         406 non-null float64
Var6         406 non-null int64
Var7         406 non-null int64
dtypes: float64(4), int64(4)
memory usage: 28.5 KB
```

In [27]:

```
Y = df.iloc[:,0].copy().values
X = df.iloc[:,1:].copy().values

no_x = X.shape[1] # no of independent variables

limit = 70*df.shape[0]//100 # for selecting 70% of data

Y_train = np.array(Y[:limit])
Y_test = np.array(Y[limit:])

X = np.transpose(X)
X = np.array([(i - np.mean(i))/(np.max(i)-np.min(i)) for i in X]) # normalising

X = np.transpose(X)
X_train = np.transpose(X[:limit])
X_test = np.transpose(X[limit:])
```

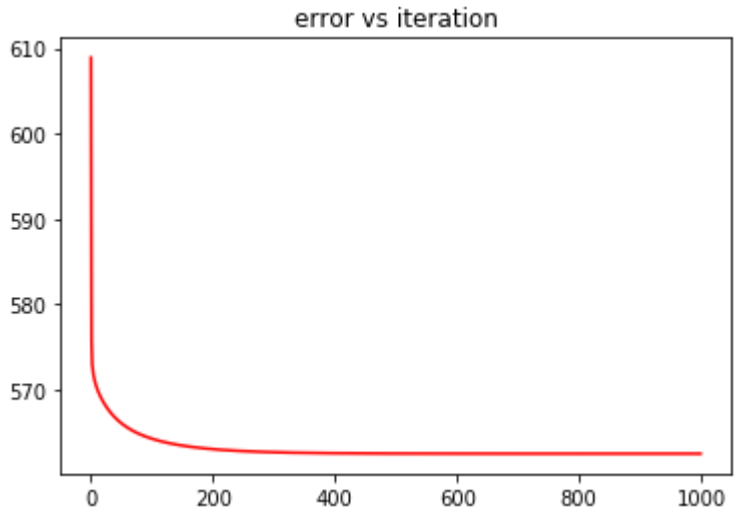
In [28]:

```
learning_rate = 1
error = []
W = np.zeros(no_x)

for _ in range(1000):

    Y_ = np.matmul(W, X_train)

    mse = np.mean((Y_train - Y_)**2)
    error.append(mse) # for plotting

    ct = 2*(Y_train - Y_) # common term in derivative

    dL_dw = np.array([ np.mean(ct*x_js) for x_js in X_train])

    W =  W + learning_rate*dL_dw

print("train_error : "+str(mse))
print("weights : "+str(W))
```

```
train_error : 562.473404906
weights : [ -2.10030835  25.78474414   1.24227927 -39.59896909   6.236
72806
   9.49771442   4.09734145]
```

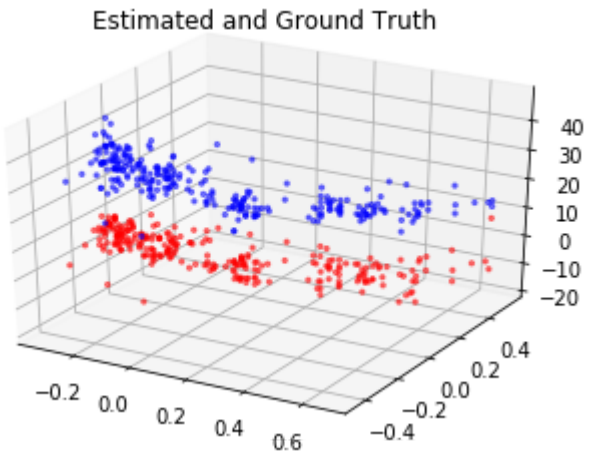
In [29]:

```
plt.plot(range(len(error[:])),error[:], color="red")
plt.title("error vs iteration")
plt.show()
```



In [30]:

```
from mpl_toolkits.mplot3d import Axes3D

fig = plt.figure()
ax = fig.add_subplot(111, projection="3d")

x1 = np.linspace(-1,1,100)
x2 = np.linspace(-1,1,100)
x1, x2 = np.meshgrid(x1,x2)

ax.scatter(X_train[1], X_train[2], Y_train, color= 'b', marker=".",alpha= 0.5)
ax.scatter(X_train[1], X_train[2], Y_, color= 'r',marker=".", alpha= 0.5)

plt.title("Estimated and Ground Truth")
plt.show()
```



In [31]:

```
Y_ = np.matmul(W, X_test)
test_error = np.mean((Y_test - Y_)**2)
print("test_error with median : "+str(test_error))
```

```
test_error with median : 578.729802512
```

In [25]:

```
Y_ = np.matmul(W, X_test)
test_error = np.mean((Y_test - Y_)**2)
print("test_error with mean fill : "+str(test_error))
```

```
test_error with mean fill : 584.324799834
```