In [180]:

```
#Importing libraries
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import random
import math
```

In [181]:

```
#Reading data from CSV file
Dataset = pd.read_csv('Fish.csv')
print(Dataset)
```

```
    Species  Weight  Length1  Length2  Length3   Height   Width
0     Bream   242.0     23.2     25.4     30.0  11.5200  4.0200
1     Bream   290.0     24.0     26.3     31.2  12.4800  4.3056
2     Bream   340.0     23.9     26.5     31.1  12.3778  4.6961
3     Bream   363.0     26.3     29.0     33.5  12.7300  4.4555
4     Bream   430.0     26.5     29.0     34.0  12.4440  5.1340
..      ...     ...      ...      ...      ...      ...     ...
154   Smelt    12.2     11.5     12.2     13.4   2.0904  1.3936
155   Smelt    13.4     11.7     12.4     13.5   2.4300  1.2690
156   Smelt    12.2     12.1     13.0     13.8   2.2770  1.2558
157   Smelt    19.7     13.2     14.3     15.2   2.8728  2.0672
158   Smelt    19.9     13.8     15.0     16.2   2.9322  1.8792

[159 rows x 7 columns]
```

In [273]:

```
# Select model from the Scikitlearn and then divided the data into 80% Training and
20% Testing
from sklearn.model_selection import train_test_split
```

In [481]:

```
# Create variable input_features and Output for the Simple linear regression
features = ['Length1']
print(features)
output = ['Weight']
print(output)
```

```
['Length1']
['Weight']
```

In [482]:

```
#Taking Lenght1 as an input features and Weight as ouput feature.
x = Dataset[['Length1']]
print(x)
y = Dataset[['Weight']]
print(y)
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.2)
```

```
     Length1
0       23.2
1       24.0
2       23.9
3       26.3
4       26.5
..       ...
154     11.5
155     11.7
156     12.1
157     13.2
158     13.8

[159 rows x 1 columns]
     Weight
0     242.0
1     290.0
2     340.0
3     363.0
4     430.0
..      ...
154    12.2
155    13.4
156    12.2
157    19.7
158    19.9

[159 rows x 1 columns]
```

Question1. Implement the gradient descent algorithm (regression_gradient_descent) from scratch to compute coefficients for multiple regression. [Make sure you add a ‘constant’ column in the feature matrix. Implement functions for output prediction, feature derivative and RSS calculations.]

In [483]:

```
#Adding constant column into Feature list.
Dataset['constant'] = 1
print(Dataset)
print(len(Dataset))
```

```
    Species  Weight  Length1  Length2  Length3   Height   Width  consta
nt
0     Bream   242.0     23.2     25.4     30.0  11.5200  4.0200
1
1     Bream   290.0     24.0     26.3     31.2  12.4800  4.3056
1
2     Bream   340.0     23.9     26.5     31.1  12.3778  4.6961
1
3     Bream   363.0     26.3     29.0     33.5  12.7300  4.4555
1
4     Bream   430.0     26.5     29.0     34.0  12.4440  5.1340
1
..      ...     ...      ...      ...      ...      ...     ...
...
154   Smelt    12.2     11.5     12.2     13.4   2.0904  1.3936
1
155   Smelt    13.4     11.7     12.4     13.5   2.4300  1.2690
1
156   Smelt    12.2     12.1     13.0     13.8   2.2770  1.2558
1
157   Smelt    19.7     13.2     14.3     15.2   2.8728  2.0672
1
158   Smelt    19.9     13.8     15.0     16.2   2.9322  1.8792
1

[159 rows x 8 columns]
159
```

In [484]:

```
#Feature_matrix with one extra column name constant
feature_matrix = ['constant'] + features
print(feature_matrix)
print(len(feature_matrix))
output = ['Weight']
print(output)
```

```
['constant', 'Length1']
2
['Weight']
```

In [573]:

```
#Feature_matrix with the constant column name using numpy
def getdata_numpy(Dataset, features, output):

    features_matrix = np.array([np.ones(len(Dataset))] + [Dataset[feature] for feat
ure in features])

    output_array = np.array(Dataset[output])

    return features_matrix, output_array
```

In [520]:

```
#Below code just the output for our data
(ex_features, ex_output) = getdata_numpy(Dataset, ['Length1'], 'Weight')
print(example_features[0,:])
print(example_output[0])
```

```
[1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
1.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
242.0
```

In [521]:

```
#Below function predict the output values for the feature matrix and and weights.
def output_prediction(feature_matrix, weights):
    return feature_matrix.T.dot(weights)
```

In [522]:

```
#Below function predict the prediction 'errors' (predictions - output) then the der
ivative of
#the regression cost function with respect to the weight of 'feature' is just twice
the dot product between
#'feature' and 'errors'. IT gives the derivtion of errors and features.
def feature_derivation(errors, feature):
    return 2 * feature.dot(errors)
```

In [523]:

```
#importing math library
from math import sqrt
```

In [524]:

```
# Below Function Accepts a numpy feature_matrix 2D array, a 1D output array, an arr
ay of initial weights,step size and a tolerance.
# At each step computes the magnitude/length of the gradient (square root of the su
m of squared components)
# input tolerance returns the final weight vector When the magnitude of the gradien
t is smaller than the
# Below code return the weights for gradient decent.
def regression_gradient_descent(feature_matrix, output, initial_weights, step_size,
tolerance):
    converged = False
    weights = np.array(initial_weights)

    while not converged:

        predictions = output_prediction(feature_matrix, weights) # Calculate predic
tions based on feature_matrix and weights:

        errors = predictions - output # calculate the error:

        gradient_sum_squares = 0

        for i in range(len(weights)):

            derivative = feature_derivation(errors, feature_matrix.T[:,i]) # calcul
ate the derivative for weight[i]:

            gradient_sum_squares = derivative ** 2 #Gradient Magnitude

            weights[i] = weights[i] - step_size * derivative # update the weight ba
sed on step size and derivative

        gradient_magnitude = np.sqrt(gradient_sum_squares)
        if gradient_magnitude < tolerance:
            converged = True
    return(weights)
```

Question2. Use the regression_gradient_descent function implemented in Q1 to compute the model coefficients and test error (RSS) for each of the following cases. Calculate training and test RSS for each step of the gradient descent and then plot it for each of the cases given below.

In [559]:

```
features = ['Length1']
output= 'Weight'
S_feature_matrix, output = getdata_numpy(Train_data, features, output)
initial_weights = np.array([-7.5, 1.])
step_size = 7e-10
tolerance = 1.4e4
```

In [560]:

```
#calculate the model coefficent for length1.
Model_coefficient_Length1 = regression_gradient_descent(S_feature_matrix, output,in
itial_weights, step_size,tolerance)
print(Model_coefficient_Length1)
```

```
[-7.30922984 17.19865988]
```

In [561]:

```
#predicted output values for test data first case
test_simple_feature_matrix, train_output = getdata_numpy(Test_data, features, my_ou
tput)
test_predictions = output_prediction(test_simple_feature_matrix, Model_coefficient_
Length1)
print(test_predictions)
```

```
[336.66396773 677.19743332 345.26329766 336.66396773 594.6438659
 539.60815429 190.47535876 955.81572335 176.71643086 682.35703128
 336.66396773 281.62825611 551.64721621 319.46530785 371.06128748
 336.66396773 515.53003046 532.72869034 577.44520602 955.81572335
 312.5858439  324.62490581 319.46530785 305.70637994 453.6148549
 453.6148549  224.87267852 405.45860724 319.46530785 353.8626276
 273.02892618 486.29230867]
```

In [562]:

```
#Calculated RSS value for test data first case
test_rss = np.sum((test_predictions - test_output) ** 2)
print(test_rss)
```

```
1986971.9239113512
```

In [613]:

```
#predicted output for train data first case
train_simple_feature_matrix, train_output = getdata_numpy(Train_data, features, my_
output)
train_predictions = output_prediction(train_simple_feature_matrix, Model_coefficien
t_Length1)
print(train_predictions)
```

```
[ 541.32802028  405.45860724  171.55683289  603.24319584  188.75549277
  515.53003046  305.70637994  219.71308055  635.92064961  293.66731803
  498.33137058  429.53673107  238.63160642  498.33137058  321.18517384
  121.68071925  372.78115347  543.04788627  467.3737828   525.84922639
  493.17177262  481.1327107   353.8626276   276.46865815  187.03562678
  594.6438659   271.30906019  345.26329766  467.3737828   823.38604229
  699.55569116  405.45860724  178.43629684  371.06128748  429.53673107
 1007.41170299  591.20413393  422.65726712  482.85257669  348.70302964
  187.03562678  630.76105165  537.8882883   735.67287691  164.67736894
  381.38048341  432.97646305  438.13606101  298.82691599  362.46195754
  629.04118566  391.69967934  426.09699909  586.04453596  646.23984554
  577.44520602  524.1293604   345.26329766  615.28225776  343.54343168
  398.57914329  357.30235958  568.84587608  531.00882435  763.19073271
  398.57914329  500.05123657  388.25994736  319.46530785  572.28560806
  482.85257669  166.39723493  556.80681417  403.73874125  319.46530785
  470.81351478  388.25994736  326.3447718   684.07689727  634.20078362
  355.58249359  680.63716529  620.44185572  629.04118566  422.65726712
  682.35703128  587.76440195  152.63830703  230.03227648  293.66731803
  345.26329766  455.33472089  309.14611192  333.22423575  715.03448505
  448.45525694  407.17847323  539.60815429  288.50772007  555.08694818
  543.04788627  207.67401864  517.24989645  663.43850542  200.79455469
  371.06128748  627.32131967  396.8592773   214.55348259  336.66396773
  319.46530785  500.05123657  429.53673107  620.44185572  508.65056651
  230.03227648  622.16172171  887.02108384  611.84252578  371.06128748
  534.44855633  262.70973025  445.01552496  555.08694818  680.63716529
  193.91509073  250.67066833]
```

In [614]:

```
#Calculated RSS value for the train data
train_rss = np.sum((train_predictions - train_output) ** 2)
print(train_rss)
```

```
5454820.09853312
```

In [615]:

```
model_features = ['Length1', 'Width']
my_output = 'Weight'
(feature_matrix, output) = getdata_numpy(Train_data, model_features, my_output)
initial_weights = np.array([-8.5, 1., 1.])
step_size = 4e-10
tolerance = 1.4e4

my_weights = regression_gradient_descent(feature_matrix, output,initial_weights, st
ep_size, tolerance)
my_weights
```

Out[615]:

```
array([-8.32453822, 16.59406427,  3.92527246])
```

In [616]:

```
test_feature_matrix, test_output = get_numpy_data(Test_data, model_features, my_out
put)
test_predictions2 = predict_outcome(test_feature_matrix, my_weights)
test_predictions2
```

Out[616]:

```
array([337.3933326 , 680.68421247, 346.84949769, 339.23821066,
       597.16552555, 543.43098091, 187.97746058, 945.05993488,
       174.24530745, 677.23251661, 337.3933326 , 282.71593752,
       561.58279708, 320.11862609, 371.75904288, 336.93211309,
       516.88165065, 533.80936308, 582.81671713, 945.05993488,
       314.35476603, 325.81281506, 319.8941005 , 306.14860144,
       455.73777174, 457.1159349 , 224.8274758 , 406.83365736,
       319.94552157, 354.38384939, 272.65096266, 486.82372311])
```

In [617]:

```
test2ss = np.sum((test_predictions2 - test_output) ** 2)
test2_rss, test_rss
```

Out[617]:

```
(2003456.176977193, 1986971.9239113512)
```

In [611]:

```
train_feature_matrix, test_output = get_numpy_data(Train_data, model_features, my_o
utput)
train_predictions2 = predict_outcome(train_feature_matrix, my_weights)
train_predictions2
```

Out[611]:

```
array([ 542.96445977,  406.55260785,  169.67060618,  598.72875277,
        185.35557735,  516.5366192 ,  304.56828675,  218.83143337,
        638.77845635,  293.52592407,  501.44397165,  430.18075035,
        238.05444637,  499.83775015,  321.95113703,  121.65772743,
        374.60466664,  546.5904277 ,  468.68487037,  528.57384469,
        491.70832214,  482.98226274,  353.20234238,  276.55346353,
        184.22765281,  597.22165695,  273.53748796,  346.07896671,
        468.08116347,  817.39240742,  703.50708783,  407.58416946,
        175.93611606,  371.79908066,  431.08827334, 1000.0862917 ,
        584.9277086 ,  422.7933976 ,  484.07328971,  349.4213312 ,
        183.76486319,  633.33980261,  534.02858202,  727.65511511,
        162.16942053,  383.0532143 ,  434.86006264,  437.96435685,
        298.97007319,  363.0694835 ,  634.94779298,  392.43734813,
        430.0111836 ,  588.76094095,  647.25585225,  582.33312356,
        524.58361148,  346.07896671,  618.87499988,  344.93141581,
        398.62749278,  357.85025249,  573.49518888,  532.9314784 ,
        756.19180581,  399.96836585,  502.22019177,  387.79768109,
        321.35861966,  576.69859872,  490.36393136,  163.7832938 ,
        560.29117865,  406.70706983,  320.34943211,  471.72027856,
        389.60526906,  326.53133368,  690.71641381,  636.24646185,
        356.72625322,  672.94082247,  626.77244429,  634.0159333 ,
        425.26474915,  686.20922221,  590.82072517,  150.11237492,
        228.04992071,  293.47214784,  345.77986095,  456.2509986 ,
        309.9313815 ,  332.63041201,  707.84429507,  451.57051375,
        408.26893073,  543.12716482,  289.06623328,  557.27009521,
        547.75819626,  206.94866985,  521.41671168,  665.80430967,
        197.3929966 ,  371.35866509,  631.89098956,  398.27520208,
        214.6414088 ,  337.3933326 ,  320.9170265 ,  501.11247988,
        430.18075035,  620.92221821,  502.74753959,  230.21981133,
        627.87446203,  881.98443942,  604.67258406,  370.99832507,
        535.1143174 ,  263.74845976,  445.58840353,  551.51132798,
        672.40502278,  190.80718449,  250.91617283])
```

In [618]:

```
train2_rss = np.sum((train_predictions2 - train_output) ** 2)
train2_rss, train_rss
```

Out[618]:

```
(5392552.831522416, 5454820.09853312)
```

In [625]:

```
#case3
model_features = ['Length1', 'Width','Height']
my_output = 'Weight'
(feature_matrix, output) = get_numpy_data(Train_data, model_features, my_output)
initial_weights = np.array([-10, 1., 1.,1.])
step_size = 4e-10
tolerance = 1.4e4

my_weights1 = regression_gradient_descent(feature_matrix, output,initial_weights, s
tep_size, tolerance)
my_weights1
```

Out[625]:

```
array([-13.05796564,  12.94243719,   5.16870649,  11.03515654])
```

In [626]:

```
test_feature_matrix, test_output = get_numpy_data(Test_data, model_features, my_out
put)
test_predictions3 = predict_outcome(test_feature_matrix, my_weights1)
print(test_predictions3)
```

```
[331.4352749  671.34506115 349.62267606 327.38141248 672.00860791
 600.89723128 166.05106259 849.4125522  155.01602228 618.36689112
 326.24875132 277.8929028  574.64122044 321.62662317 361.7950777
 330.82795188 571.69764629 597.58446291 582.53643831 849.4125522
 314.73988979 325.44572012 344.08988    300.88302697 509.37224857
 517.55537026 249.2531664  457.53366306 315.24437642 335.06190939
 293.43725412 541.86588451]
```

In [638]:

```
test3_rss = np.sum((test_predictions3 - test_output) ** 2)
print(test3_rss, test2_rss,test_rss)
```

```
2156293.070428636 2003456.176977193 1986971.9239113512
```

In [624]:

```
train_feature_matrix, train_output = get_numpy_data(Train_data, model_features, my_
output)
train_predictions3 = predict_outcome(train_feature_matrix, my_weights1)
train_predictions3
```

Out[624]:

```
array([607.9101409 , 444.89248961, 152.90939981, 550.49943087,
       164.74745988, 572.09964514, 292.90271105, 200.16875297,
       711.50855453, 321.12672821, 566.65181645, 417.17745545,
       256.56073825, 559.20018005, 319.75549621, 114.5941026 ,
       375.92702747, 613.13247105, 523.73574497, 577.4825191 ,
       537.97879224, 538.28159276, 348.19943966, 273.54435691,
       164.25789301, 671.56276454, 271.40789375, 345.94417219,
       508.20996745, 742.46088621, 695.95252642, 418.76004371,
       155.19292421, 374.64195899, 419.64812448, 908.51986535,
       527.50949315, 411.02208576, 538.42793511, 339.30738256,
       163.64850252, 624.25144602, 481.69524122, 657.21286113,
       144.12343444, 375.27703528, 439.3328467 , 430.18077148,
       289.70796436, 353.7034728 , 641.0072316 , 435.10978046,
       431.49025515, 585.40191703, 706.15997334, 578.8991946 ,
       585.91105092, 335.61526567, 697.3010114 , 334.42671072,
       390.77425981, 394.42529829, 663.8361115 , 587.77279474,
       679.30018858, 406.81717548, 501.09081435, 374.71791051,
       314.62220053, 586.86585957, 508.28026798, 142.66955703,
       629.87106421, 457.13000623, 354.16202832, 455.44412614,
       428.39502501, 322.52815372, 688.39873047, 639.7490751 ,
       350.29354548, 603.0017274 , 620.96630115, 632.59850081,
       429.72552252, 682.34487337, 584.31781209, 131.9093673 ,
       207.61798676, 289.97429503, 343.80565851, 442.75648609,
       340.23583536, 366.963112  , 632.63507264, 493.77424685,
       410.69978412, 610.33391194, 287.5094777 , 622.67209688,
       547.29722003, 197.98780946, 523.47426425, 668.45003897,
       175.16343736, 371.39814334, 632.88283059, 385.40111708,
       211.38710157, 328.84201311, 314.04072105, 548.494775  ,
       415.90179135, 613.26286099, 454.10638716, 220.31640031,
       635.81380571, 813.97665929, 544.00657997, 366.75567746,
       593.21551722, 255.97134651, 490.83484683, 498.33051034,
       607.31719519, 171.74306836, 245.35841303])
```

In [637]:

```
train3_rss = np.sum((train_predictions3 - train_output) ** 2)
print(train3_rss, train2_rss, train_rss)
```

```
4971406.468135323 5392552.831522416 5454820.09853312
```

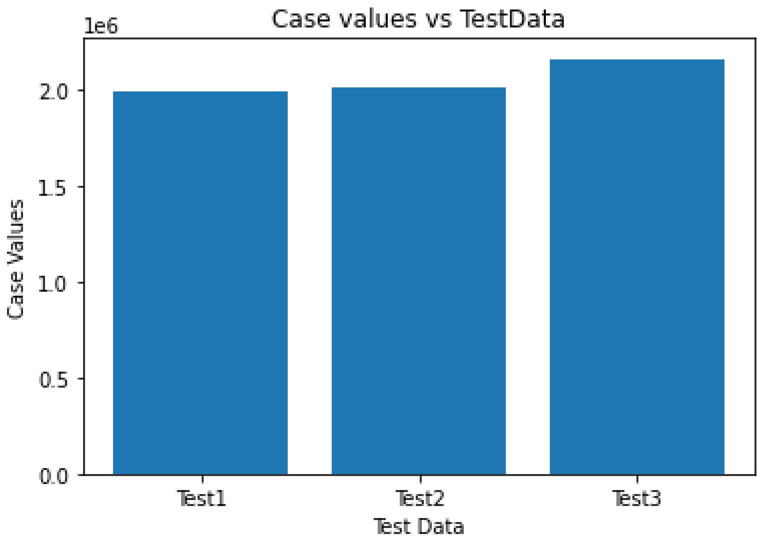
In [656]:

```
TestDataG = [test_rss, test2_rss,test3_rss]
print(TestDataG)
TEST = ['Test1', 'Test2', 'Test3']
```

```
[1986971.9239113512, 2003456.176977193, 2156293.070428636]
```

In [657]:

```
plt.figure()
plt.bar(TEST,TestDataG)
plt.title("Case values vs TestData")
plt.xlabel("Test Data")
plt.ylabel("Case Values")
plt.show()
```



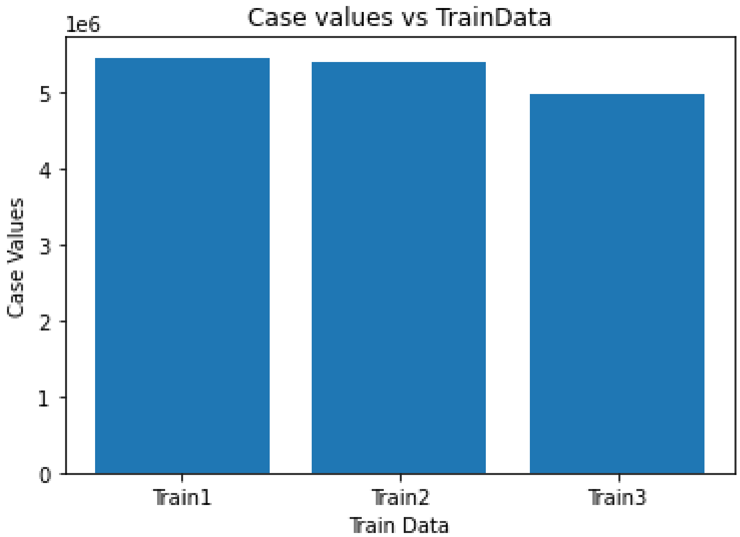
In [659]:

```
TrainDataG = [train_rss, train2_rss,train3_rss]
print(TestDataG)
Train = ['Train1', 'Train2', 'Train3']
```

```
[1986971.9239113512, 2003456.176977193, 2156293.070428636]
```

In [661]:

```
plt.figure()
plt.bar(Train,TrainDataG)
plt.title("Case values vs TrainData")
plt.xlabel("Train Data")
plt.ylabel("Case Values")
plt.show()
```



3. Use in-built linear regression functions of Scikit Learn library to compute higher polynomial regression models for degrees 2, 3, 4, 5 and 6. Use 'Lenght1' as the input feature and 'Weight' as output. For each of the model, compute the RSS (on the train and test dataset), and plot the model through the training data.

In [510]:

```
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
```

In [629]:

```
Test_RSS={}
Train_RSS={}

def perform_polynomial_structure(features, poly_degree):
    polynomial_features = PolynomialFeatures(poly_degree)
    features_poly = polynomial_features.fit_transform(features.reshape(-1,1))
    return features_poly
```

In [630]:

```
def calculate_rss_value(output_train_poly_prediction, output_test_poly_prediction,
output_train, output_test, poly_degree):
    Train_RSS[poly_degree] = np.sum((output_train-output_train_poly_prediction)**2)
    Test_RSS[poly_degree] = np.sum((output_test-output_test_poly_prediction)**2)
```

In [632]:

```
def predict_output_values(train_features, test_features, model, poly_degree, output
_train, output_test):
    train_features_poly = perform_polynomial_structure(train_features, poly_degree)
    test_features_poly = perform_polynomial_structure(test_features, poly_degree)
    output_train_poly_prediction = model.predict(train_features_poly)
    output_test_poly_prediction = model.predict(test_features_poly)
    calculate_rss_value(output_train_poly_prediction, output_test_poly_prediction,
output_train, output_test, poly_degree)
```

In [633]:

```
def perform_polynomial_regression(train_features,test_features, output_train, outpu
t_test, poly_degree):
    features_poly = perform_polynomial_structure(train_features, poly_degree)
    model = LinearRegression()
    model.fit(features_poly, output_train)
    predict_output_values(train_features, test_features, model, poly_degree, output
_train,output_test)
```

In [634]:

```
polys_degree = [2,3,4,5,6]
for i in polys_degree:
    perform_polynomial_regression(np.array(x_train['Length1'].values.tolist()),
                                  np.array(x_test['Length1'].values.tolist()),
                                  np.array(y_train['Weight'].values.tolist()),
                                  np.array(y_test['Weight'].values.tolist()),i )
print('Test RSS Values:' ,Test_RSS )
print('Train RSS Values:', Train_RSS)
```

```
Test RSS Values: {2: 501842.6164169266, 3: 478360.54172428884, 4: 46629
6.3603803235, 5: 483525.79786606657, 6: 513625.86408585403}
Train RSS Values: {2: 2594721.0120108463, 3: 2512449.547397242, 4: 2195
668.242920056, 5: 2115348.7110960935, 6: 1949574.419389849}
```

In [597]:

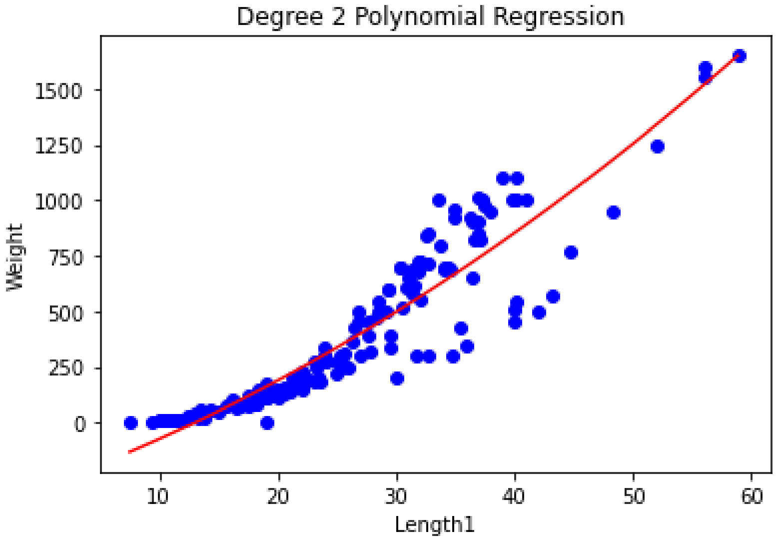
```
L1Input = Dataset.iloc[:, 2:3].values
WInput = Dataset.iloc[:, 1].values


#Fitting Polynomial Regression to the dataset
#poly_degree = [2,3,4,5, 6]
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
poly_regression = PolynomialFeatures(degree = 2)

L1Input_poly = poly_regression.fit_transform(L1Input)

linear_regression = LinearRegression()
linear_regression.fit(L1Input_poly, WInput)

# Visualising the Polynomial Regression results
L1Input_Grid = np.arange(min(L1Input), max(L1Input), 0.1)
L1Input_Grid = L1Input_Grid.reshape((len(L1Input_Grid), 1))
plt.scatter(L1Input,WInput, color = 'blue')
plt.plot(L1Input_Grid, linear_regression.predict(poly_regression.fit_transform(L1In
put_Grid)), color = 'red')
plt.title('Degree 2 Polynomial Regression ')
plt.xlabel('Length1')
plt.ylabel('Weight')
plt.show()
```


Degree 2 Polynomial Regression
Weight
Length1
1500
1250
1000
750
500
250
0
10
20
30
40
50
60

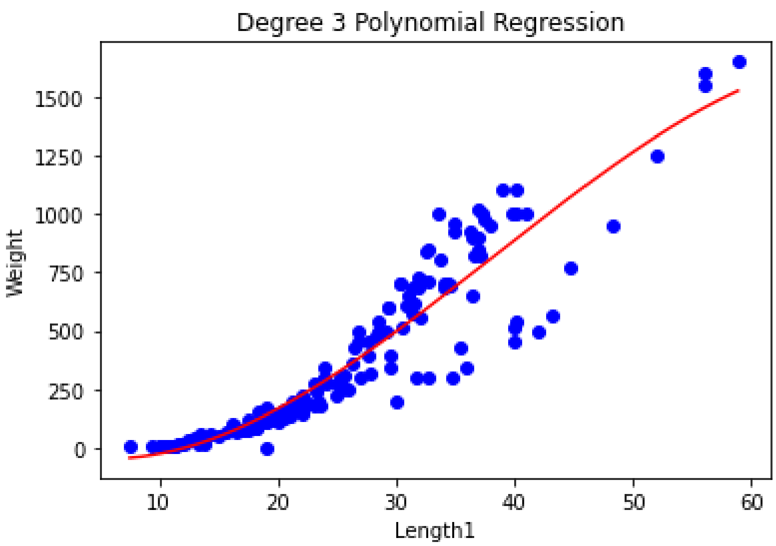
In [598]:

```
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
poly_regression = PolynomialFeatures(degree = 3)

L1Input_poly = poly_regression.fit_transform(L1Input)

linear_regression = LinearRegression()
linear_regression.fit(L1Input_poly, WInput)

# Visualising the Polynomial Regression results
L1Input_Grid = np.arange(min(L1Input), max(L1Input), 0.1)
L1Input_Grid = L1Input_Grid.reshape((len(L1Input_Grid), 1))
plt.scatter(L1Input,WInput, color = 'blue')
plt.plot(L1Input_Grid, linear_regression.predict(poly_regression.fit_transform(L1In
put_Grid)), color = 'red')
plt.title('Degree 3 Polynomial Regression ')
plt.xlabel('Length1')
plt.ylabel('Weight')
plt.show()
```



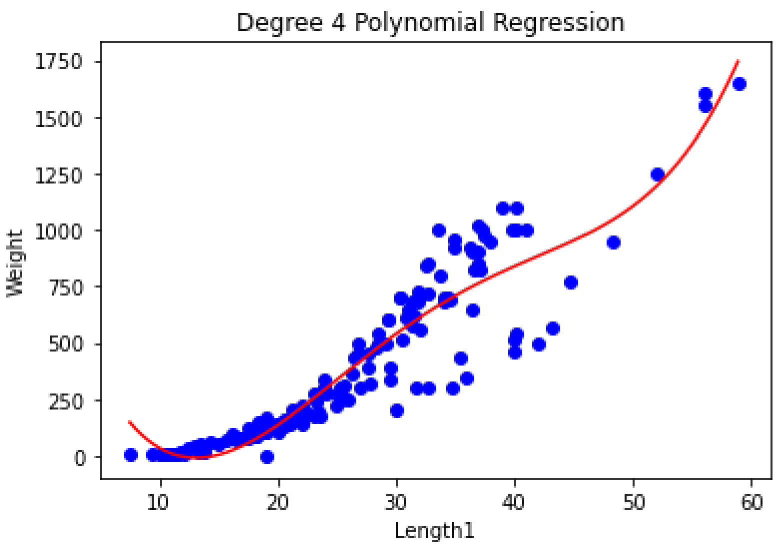
In [599]:

```
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
poly_regression = PolynomialFeatures(degree = 4)

L1Input_poly = poly_regression.fit_transform(L1Input)

linear_regression = LinearRegression()
linear_regression.fit(L1Input_poly, WInput)

# Visualising the Polynomial Regression results
L1Input_Grid = np.arange(min(L1Input), max(L1Input), 0.1)
L1Input_Grid = L1Input_Grid.reshape((len(L1Input_Grid), 1))
plt.scatter(L1Input,WInput, color = 'blue')
plt.plot(L1Input_Grid, linear_regression.predict(poly_regression.fit_transform(L1In
put_Grid)), color = 'red')
plt.title('Degree 4 Polynomial Regression ')
plt.xlabel('Length1')
plt.ylabel('Weight')
plt.show()
```



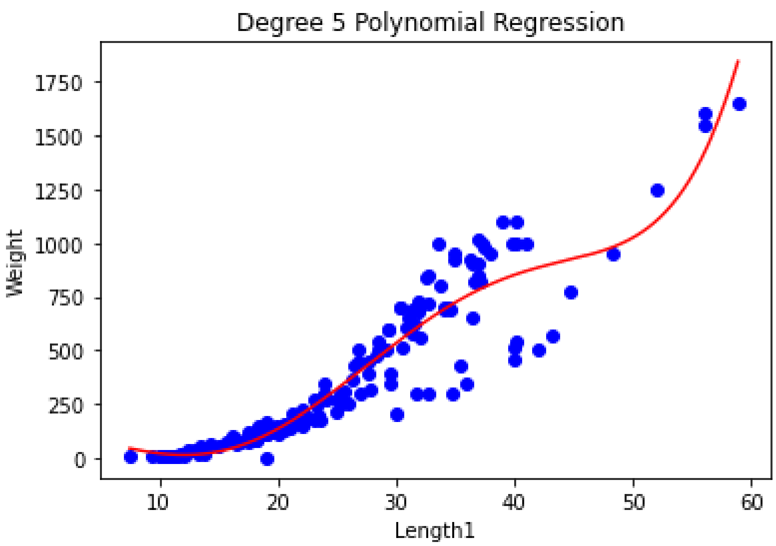
In [600]:

```
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
poly_regression = PolynomialFeatures(degree = 5)

L1Input_poly = poly_regression.fit_transform(L1Input)

linear_regression = LinearRegression()
linear_regression.fit(L1Input_poly, WInput)

# Visualising the Polynomial Regression results
L1Input_Grid = np.arange(min(L1Input), max(L1Input), 0.1)
L1Input_Grid = L1Input_Grid.reshape((len(L1Input_Grid), 1))
plt.scatter(L1Input,WInput, color = 'blue')
plt.plot(L1Input_Grid, linear_regression.predict(poly_regression.fit_transform(L1In
put_Grid)), color = 'red')
plt.title('Degree 5 Polynomial Regression ')
plt.xlabel('Length1')
plt.ylabel('Weight')
plt.show()
```



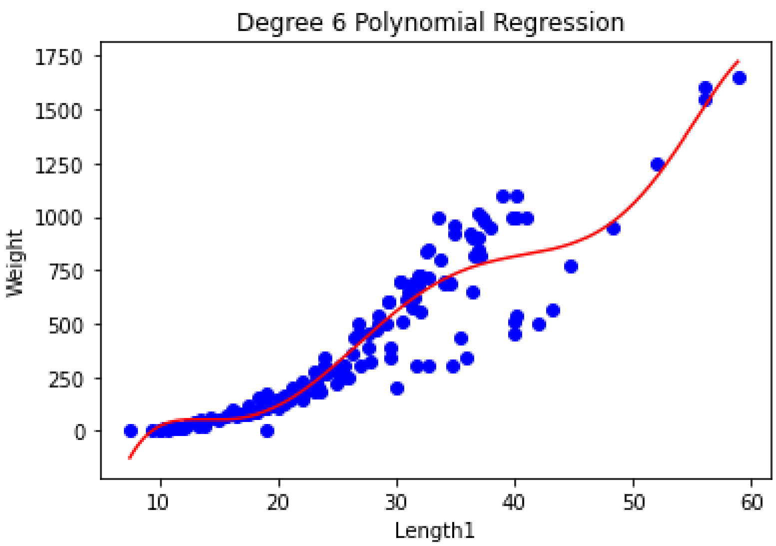
In [601]:

```
from sklearn.linear_model import LinearRegression
from sklearn.preprocessing import PolynomialFeatures
poly_regression = PolynomialFeatures(degree = 6)

L1Input_poly = poly_regression.fit_transform(L1Input)

linear_regression = LinearRegression()
linear_regression.fit(L1Input_poly, WInput)

# Visualising the Polynomial Regression results
L1Input_Grid = np.arange(min(L1Input), max(L1Input), 0.1)
L1Input_Grid = L1Input_Grid.reshape((len(L1Input_Grid), 1))
plt.scatter(L1Input,WInput, color = 'blue')
plt.plot(L1Input_Grid, linear_regression.predict(poly_regression.fit_transform(L1In
put_Grid)), color = 'red')
plt.title('Degree 6 Polynomial Regression ')
plt.xlabel('Length1')
plt.ylabel('Weight')
plt.show()
```



4. From all the models in Q2 and Q3, which model is the best and why? What criteria you will use?

When we are working with regression our main aim is to draw a best fit line our the data point. As per my research and implementation, when we got the minimum train error and test data that will be the best model. Moreover, in best model there is low bias and low variance. In polynomial regression, model is dependended on the number of degrees. Higher the number of degree model can give more accurate result.

As per my opinion, degree 6 graph is best because there is low train and test error. Bias is depended on the training dataset and variance is depended on test dataset. In polynomial regression, initially we are using less training data to build our model and that means there is high bias and low variance and model is underfitting. Then we increasing our polynomial degree value that means model used more data in training in compression of testing. So initially, training error is high and testing error. There is comes a point where in the model less training error and training error and where model try to fit the best fit line. After that train error is decreasing and test error is increasing and it creates overfitting problem. To stop overfitting, we are using more data points to build our model.

In gradient decent algotihm there is more error in comparison of polynomial regression. So,Here degree 6 model is giving more accurate result in comparison of other model.

References

[1] desicochrane/ml-regression-uni-washington. (2020). Retrieved 29 October 2020, from https://github.com/desicochrane/ml-regression-uni-washington/blob/master/Week_2/Week2_Assignment2.ipynb (https://github.com/desicochrane/ml-regression-uni-washington/blob/master/Week_2/Week2_Assignment2.ipynb)

[2] Polynomial Regression, Retrived From https://towardsdatascience.com/polynomial-regression-bbe8b9d97491 (https://towardsdatascience.com/polynomial-regression-bbe8b9d97491)