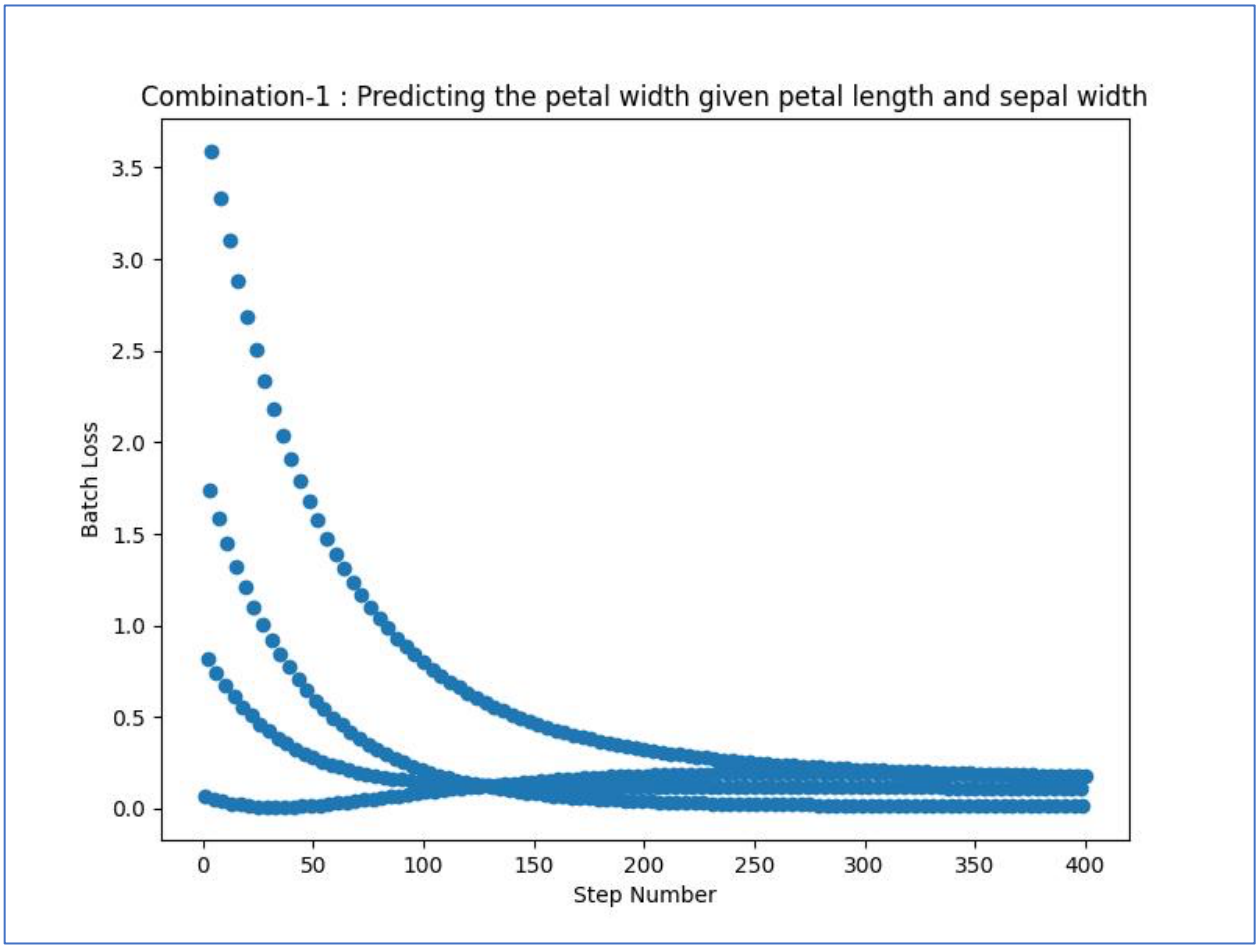
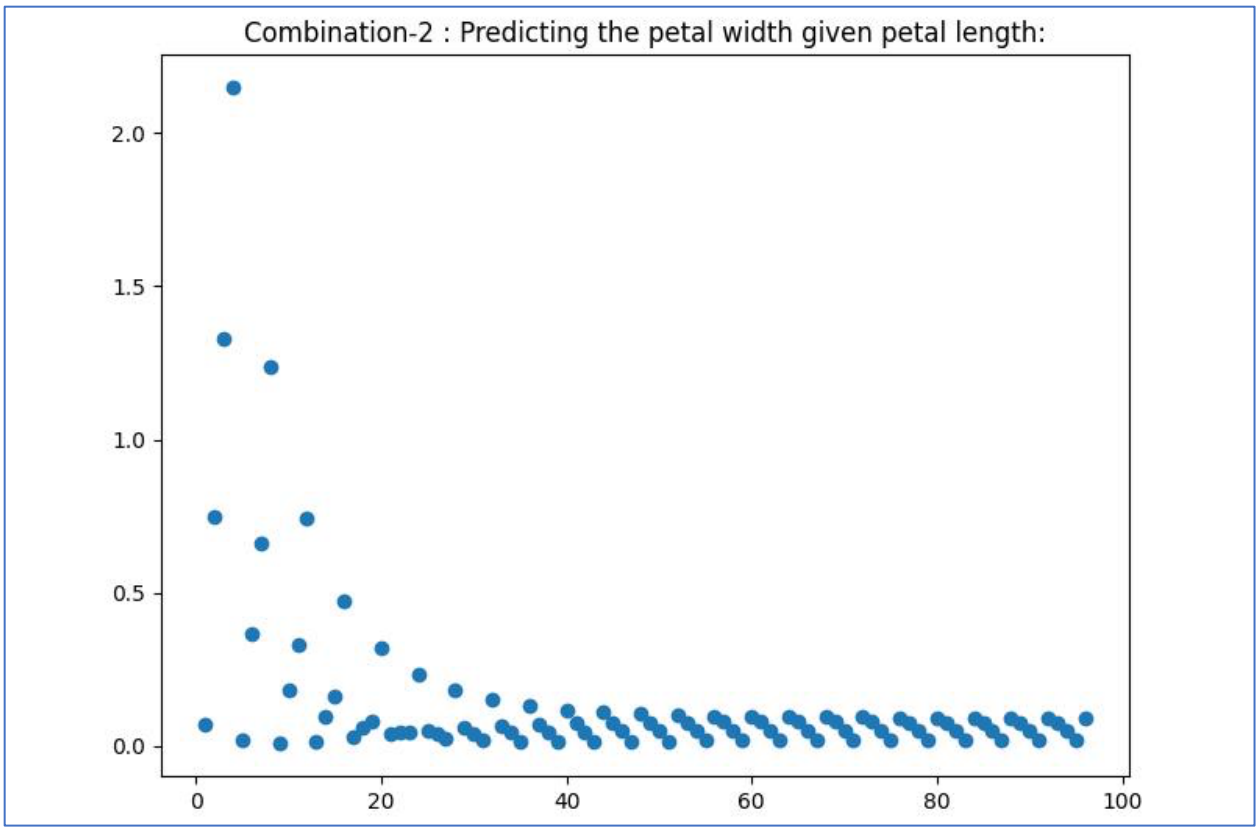
REPORT

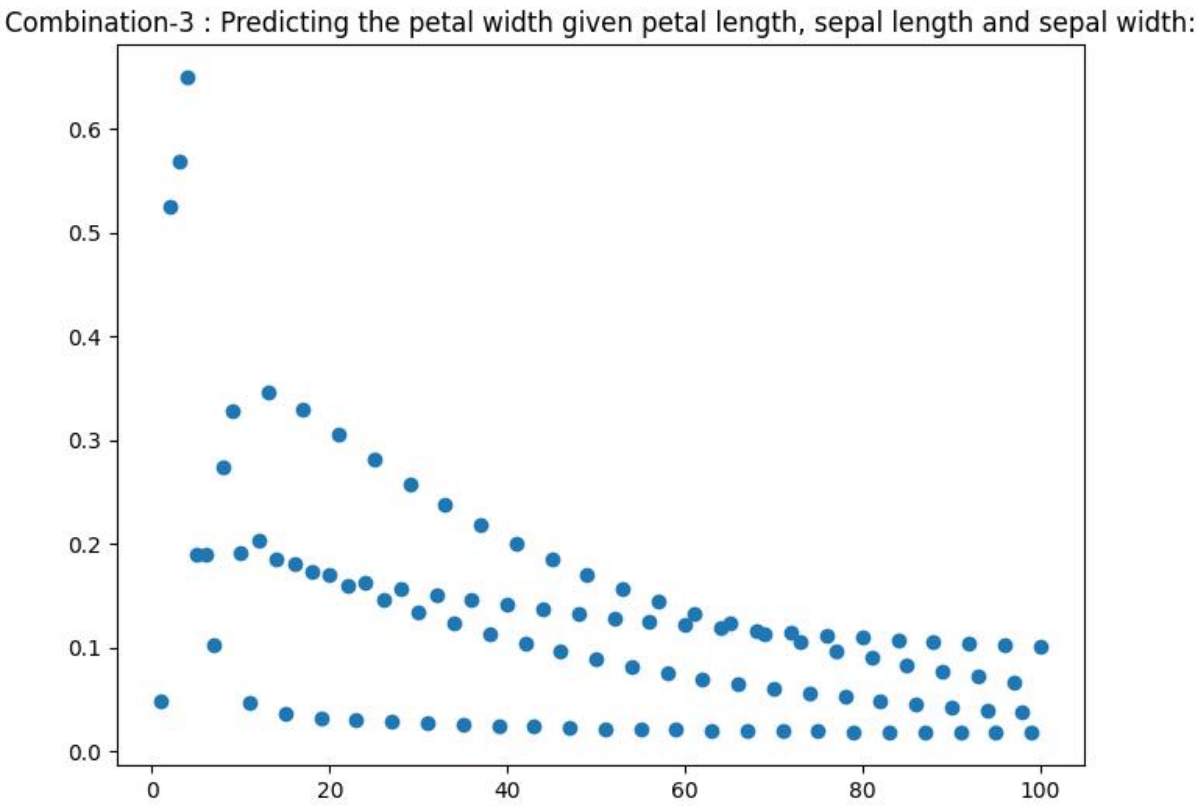
Part-2: Iris Flower Dataset:

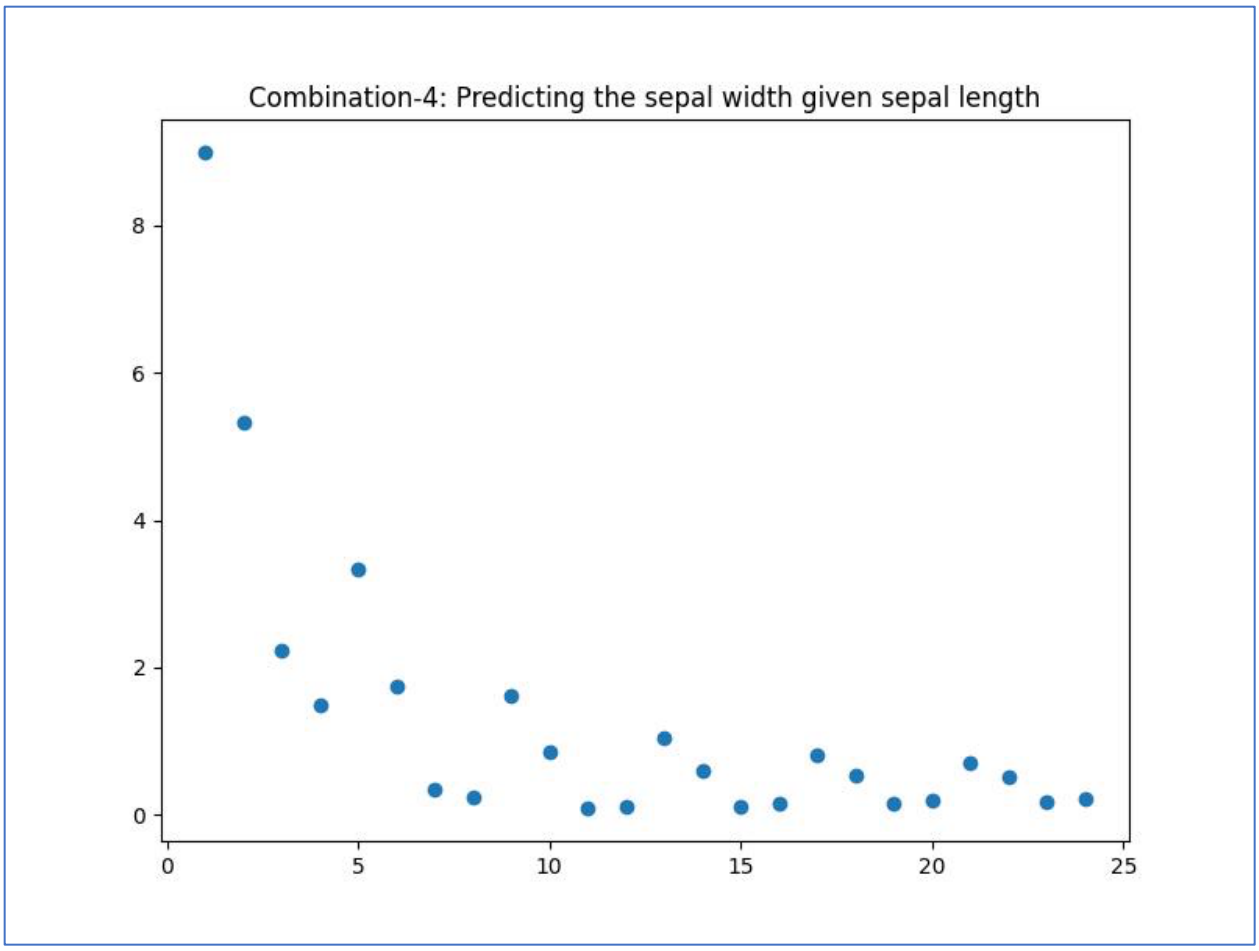
The following images have been generated from training the iris flower dataset with respect to different combinations with hyperparameters as

1. learning_rate = 0.005
2. batch_size=32,
3. regularization=0,
4. max_epochs=100,
5. patience=3




Combination-2 : Predicting the petal width given petal length:
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100


Combination-3 : Predicting the petal width given petal length, sepal length and sepal width:
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100



The output generated at terminal is given below:

(base) raviailani@Ravis-Air ml-assignment1 % /usr/local/bin/python3 /Users/raviailani/Documents/ml-assignment1/Iris_Model.py

Combination-1 : Predicting the petal width given petal length and sepal width
Running epoch: 1 / 100
Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100
Running epoch: 7 / 100
Running epoch: 8 / 100
Running epoch: 9 / 100
Running epoch: 10 / 100
Running epoch: 11 / 100
Running epoch: 12 / 100

Running epoch: 13 / 100
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Running epoch: 90 / 100
Running epoch: 91 / 100
Running epoch: 92 / 100
Running epoch: 93 / 100
Running epoch: 94 / 100
Running epoch: 95 / 100
Running epoch: 96 / 100
Running epoch: 97 / 100
Running epoch: 98 / 100
Running epoch: 99 / 100
Running epoch: 100 / 100

Weights and Bias: [0.07689073 0.24870653 0.03095569]

Score: Final validation Loss: 0.32309906177437037

Target: 2.3 - Predicted: 1.5549018301855893
Target: 1.9 - Predicted: 1.5069639591356936
Target: 2.0 - Predicted: 1.5549018301855893
Target: 2.3 - Predicted: 1.635399427010586
Target: 2.4 - Predicted: 1.685140733285994
Target: 2.4 - Predicted: 1.6620735153738027
Target: 1.8 - Predicted: 1.530031177047885
Target: 2.3 - Predicted: 1.7443745474243122
Target: 1.8 - Predicted: 1.4554192176347729
Target: 2.3 - Predicted: 1.7787377084249258
Target: 2.5 - Predicted: 1.702322313786301
Target: 1.8 - Predicted: 1.6372028622360986
Target: 1.9 - Predicted: 1.4667151607231952
Target: 2.3 - Predicted: 1.5377202496852822
Target: 2.1 - Predicted: 1.6123322090983945

##

Combination-2 : Predicting the petal width given petal length:
Running epoch: 1 / 100
Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100
Running epoch: 7 / 100
Running epoch: 8 / 100
Running epoch: 9 / 100
Running epoch: 10 / 100
Running epoch: 11 / 100
Running epoch: 12 / 100
Running epoch: 13 / 100
Running epoch: 14 / 100
Running epoch: 15 / 100
Running epoch: 16 / 100
Running epoch: 17 / 100

Running epoch: 18 / 100
Running epoch: 19 / 100
Running epoch: 20 / 100
Running epoch: 21 / 100
Running epoch: 22 / 100
Running epoch: 23 / 100
Running epoch: 24 / 100

Weights and Bias: [0.31971679 0.04082721]

Score: Final validation Loss: 0.1805092541783016

Target: 2.3 - Predicted: 1.7033545232812741
Target: 1.9 - Predicted: 1.6713828440950846
Target: 2.0 - Predicted: 1.7033545232812741
Target: 2.3 - Predicted: 1.7672978816536526
Target: 2.4 - Predicted: 1.8312412400260307
Target: 2.4 - Predicted: 1.8312412400260307
Target: 1.8 - Predicted: 1.6713828440950846
Target: 2.3 - Predicted: 1.9271562775845987
Target: 1.8 - Predicted: 1.575467806536517
Target: 2.3 - Predicted: 1.9910996359569768
Target: 2.5 - Predicted: 1.8632129192122202
Target: 1.8 - Predicted: 1.7992695608398417
Target: 1.9 - Predicted: 1.6394111649088956
Target: 2.3 - Predicted: 1.6713828440950846
Target: 2.1 - Predicted: 1.7672978816536526

##

Combination-3 : Predicting the petal width given petal length, sepal length and sepal width:
Running epoch: 1 / 100
Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100
Running epoch: 7 / 100
Running epoch: 8 / 100
Running epoch: 9 / 100
Running epoch: 10 / 100

Running epoch: 11 / 100
Running epoch: 12 / 100
Running epoch: 13 / 100
Running epoch: 14 / 100
Running epoch: 15 / 100
Running epoch: 16 / 100
Running epoch: 17 / 100
Running epoch: 18 / 100
Running epoch: 19 / 100
Running epoch: 20 / 100
Running epoch: 21 / 100
Running epoch: 22 / 100
Running epoch: 23 / 100
Running epoch: 24 / 100
Running epoch: 25 / 100

Weights and Bias: [0.07109498 -0.05045008 0.26753553 -0.00489796]

Score: Final validation Loss: 0.19424388345514135

Target: 2.3 - Predicted: 1.711272946971462
Target: 1.9 - Predicted: 1.635668934728035
Target: 2.0 - Predicted: 1.6970539504895905
Target: 2.3 - Predicted: 1.7090525288451617
Target: 2.4 - Predicted: 1.7696691340212098
Target: 2.4 - Predicted: 1.8132421523775035
Target: 1.8 - Predicted: 1.6276434075764201
Target: 2.3 - Predicted: 1.8955673025569248
Target: 1.8 - Predicted: 1.5544922454146868
Target: 2.3 - Predicted: 2.0231499105888258
Target: 2.5 - Predicted: 1.8299056889166927
Target: 1.8 - Predicted: 1.76516010418714
Target: 1.9 - Predicted: 1.6545528893935246
Target: 2.3 - Predicted: 1.693693381521593
Target: 2.1 - Predicted: 1.7739540419242623

##

Combination-4: Predicting the sepal width given sepal length

Running epoch: 1 / 100

Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100

Weights and Bias: [0.4405533 0.08120195]

Score: Final validation Loss: 0.08728725511534462

Target: 3.0 - Predicted: 3.032909087547061
Target: 2.7 - Predicted: 2.6364111136390385
Target: 3.0 - Predicted: 2.944798426678611
Target: 3.4 - Predicted: 2.8126324353759373
Target: 3.4 - Predicted: 2.856687765810162
Target: 3.1 - Predicted: 3.032909087547061
Target: 3.0 - Predicted: 2.6804664440732635
Target: 3.2 - Predicted: 3.0769644179812854
Target: 3.0 - Predicted: 2.7245217745074877
Target: 3.0 - Predicted: 3.4734623918893077
Target: 3.3 - Predicted: 3.032909087547061
Target: 3.1 - Predicted: 2.900743096244387
Target: 2.5 - Predicted: 2.856687765810162
Target: 3.1 - Predicted: 3.12101974841551
Target: 3.1 - Predicted: 3.12101974841551

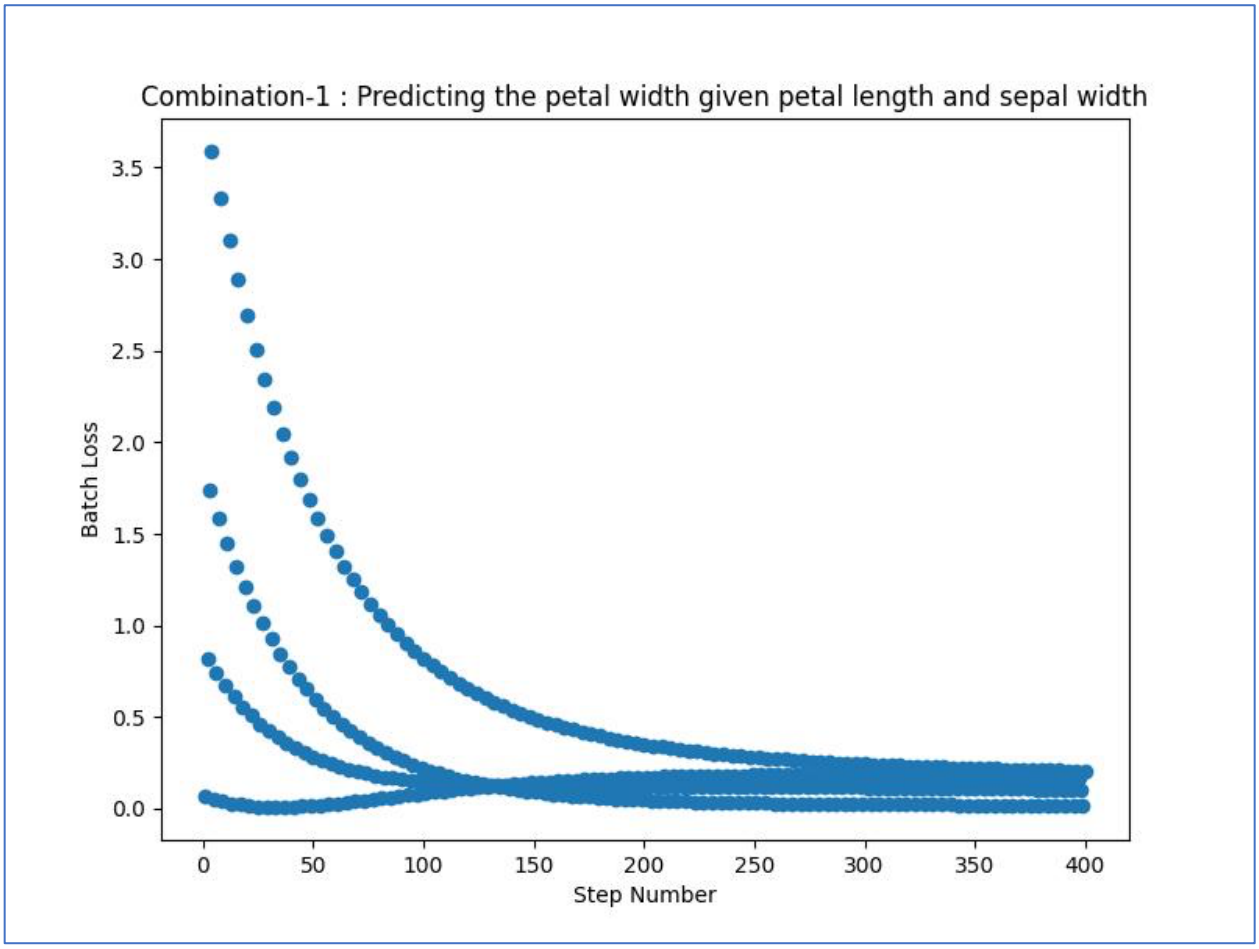
Plots saved
Goodbye!

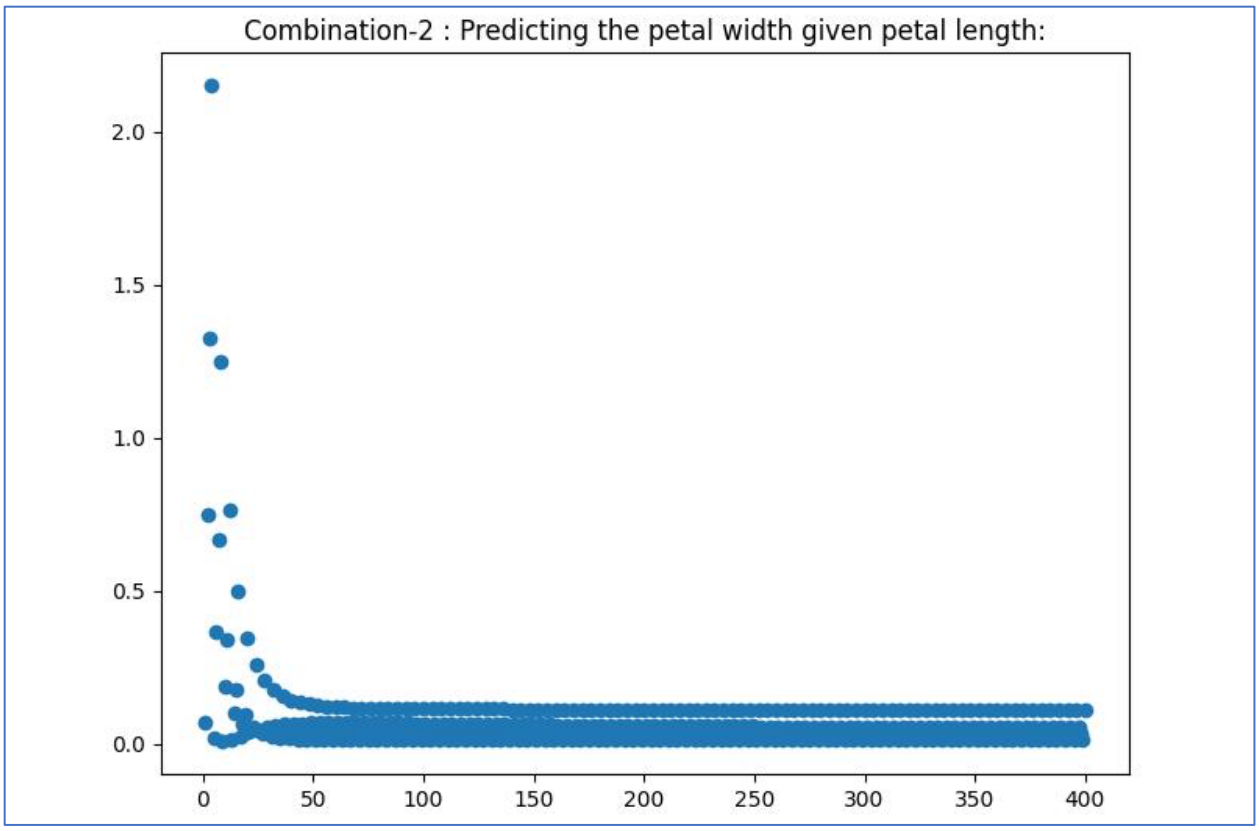
Thus the best results came from

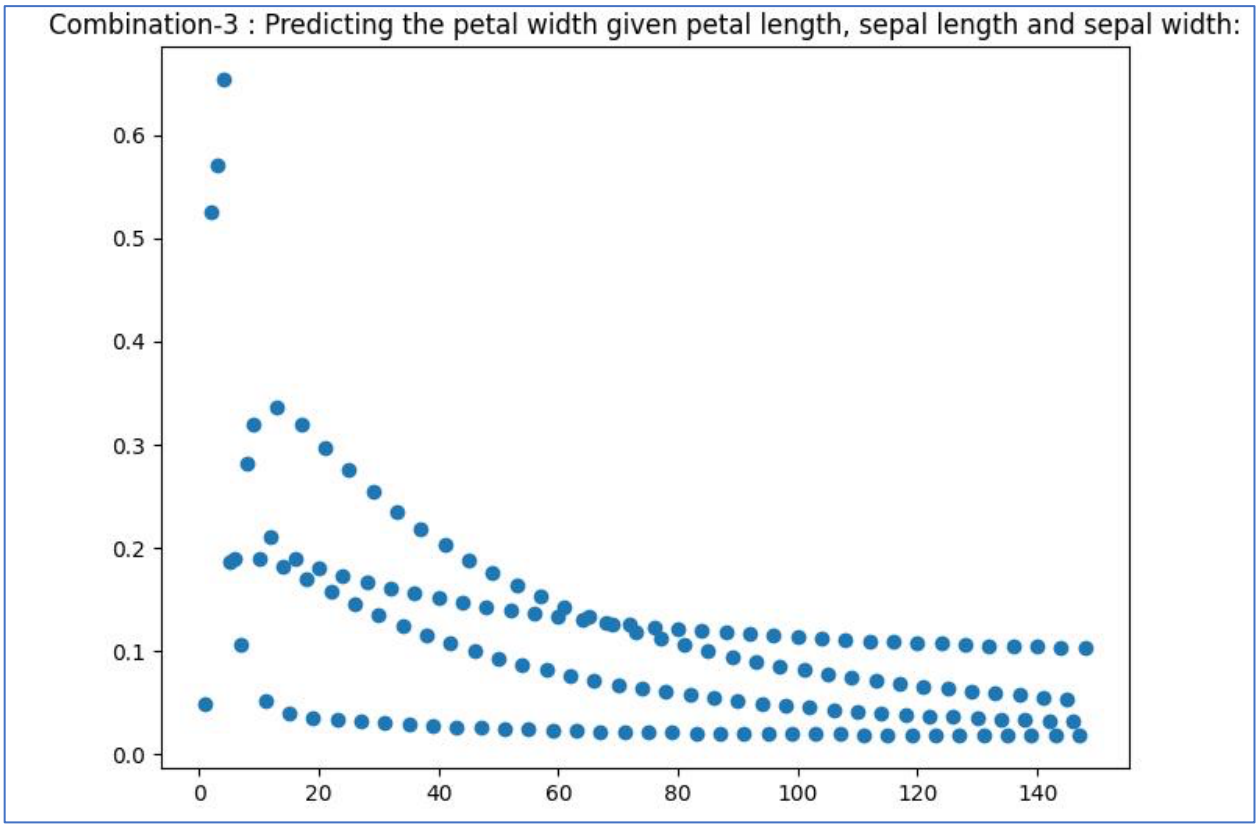
- **Combination-4: Predicting the sepal width given sepal length**
- **Score: Final validation Loss: 0.08728725511534462**

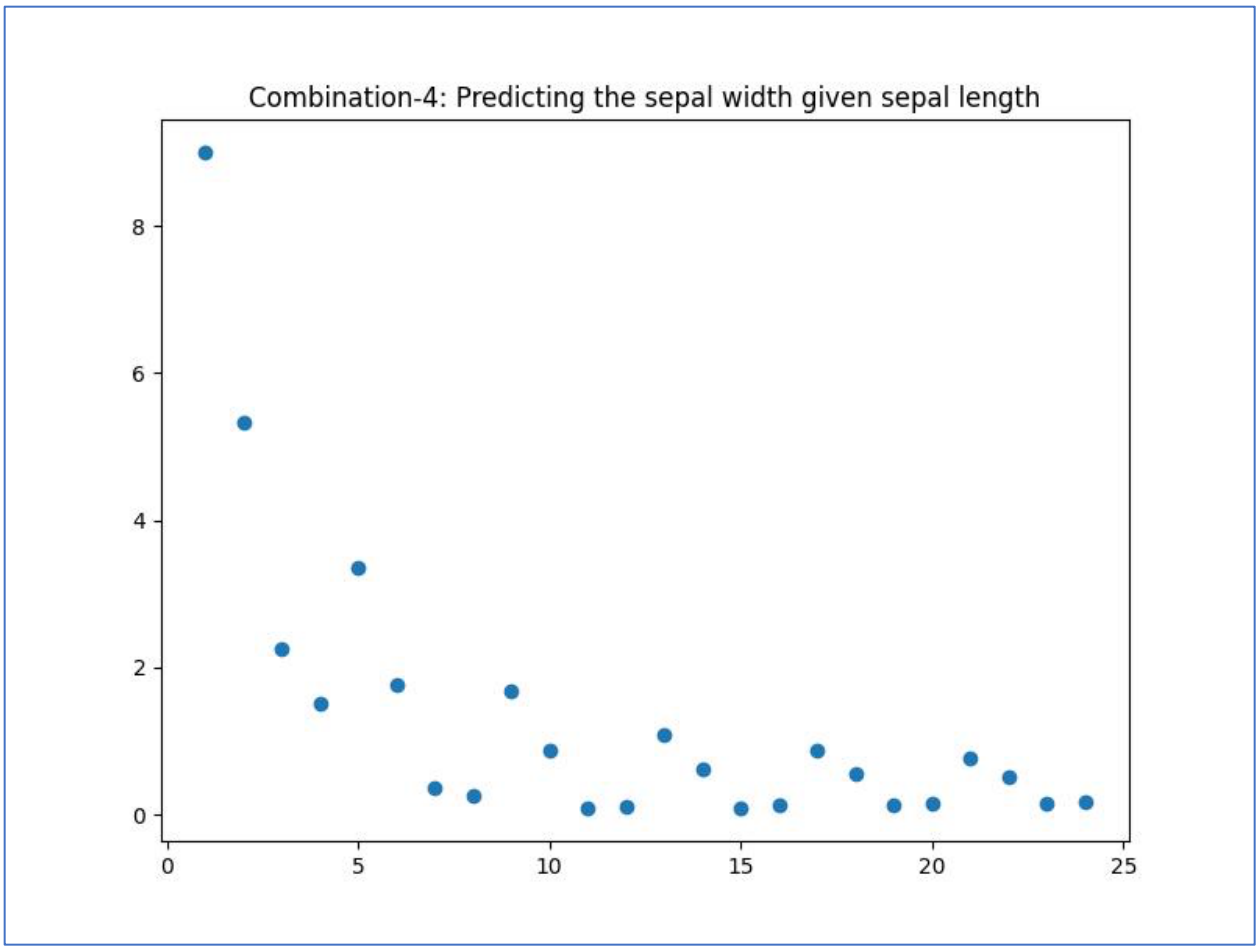
After adding regularization, the changed parameters are:

1. learning_rate = 0.005
2. batch_size=32,
3. regularization=0.60,
4. max_epochs=100,
5. patience=3




Combination-2 : Predicting the petal width given petal length:
2.0
1.5
1.0
0.5
0.0
0
50
100
150
200
250
300
350
400


Combination-3 : Predicting the petal width given petal length, sepal length and sepal width:
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
120
140



The terminal output for the program has been recorded as:

(base) raviailani@Ravis-Air ml-assignment1 % /usr/local/bin/python3 /Users/raviailani/Documents/ml-assignment1/Iris_Model.py

Combination-1 : Predicting the petal width given petal length and sepal width
Running epoch: 1 / 100
Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100
Running epoch: 7 / 100
Running epoch: 8 / 100
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Running epoch: 97 / 100
Running epoch: 98 / 100
Running epoch: 99 / 100
Running epoch: 100 / 100

Weights and Bias: [0.07723208 0.24108857 0.03077383]

Score: Final validation Loss: 0.36799855163615514

Target: 2.1 - Predicted: 1.5720715693626526
Target: 1.9 - Predicted: 1.429296891831563
Target: 2.3 - Predicted: 1.516130647031344
Target: 1.8 - Predicted: 1.5961804264197479
Target: 2.4 - Predicted: 1.620289283476843
Target: 2.3 - Predicted: 1.7331103605452012
Target: 2.4 - Predicted: 1.6434589081281972
Target: 2.5 - Predicted: 1.6598445569681746
Target: 2.0 - Predicted: 1.516130647031344
Target: 2.3 - Predicted: 1.5952411940140068
Target: 1.8 - Predicted: 1.4196952188029628
Target: 1.9 - Predicted: 1.4688521653228943
Target: 2.3 - Predicted: 1.4997449981913666
Target: 2.3 - Predicted: 1.700339062865247
Target: 1.8 - Predicted: 1.4920217899742485

##

Combination-2 : Predicting the petal width given petal length:
Running epoch: 1 / 100
Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100
Running epoch: 7 / 100
Running epoch: 8 / 100
Running epoch: 9 / 100
Running epoch: 10 / 100
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Running epoch: 96 / 100
Running epoch: 97 / 100
Running epoch: 98 / 100
Running epoch: 99 / 100
Running epoch: 100 / 100

Weights and Bias: [0.32103622 -0.01247897]

Score: Final validation Loss: 0.21763994816741186

Target: 2.1 - Predicted: 1.721116600707334
Target: 1.9 - Predicted: 1.592702113625329
Target: 2.3 - Predicted: 1.6569093571663314
Target: 1.8 - Predicted: 1.753220222477835
Target: 2.4 - Predicted: 1.7853238442483361
Target: 2.3 - Predicted: 1.9458419531008422
Target: 2.4 - Predicted: 1.7853238442483361
Target: 2.5 - Predicted: 1.8174274660188374
Target: 2.0 - Predicted: 1.6569093571663314
Target: 2.3 - Predicted: 1.721116600707334
Target: 1.8 - Predicted: 1.5284948700843264
Target: 1.9 - Predicted: 1.62480573539583
Target: 2.3 - Predicted: 1.62480573539583
Target: 2.3 - Predicted: 1.8816347095598398
Target: 1.8 - Predicted: 1.62480573539583

##

Combination-3 : Predicting the petal width given petal length, sepal length and sepal width:
Running epoch: 1 / 100
Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100
Running epoch: 7 / 100
Running epoch: 8 / 100
Running epoch: 9 / 100
Running epoch: 10 / 100
Running epoch: 11 / 100
Running epoch: 12 / 100
Running epoch: 13 / 100
Running epoch: 14 / 100
Running epoch: 15 / 100
Running epoch: 16 / 100
Running epoch: 17 / 100
Running epoch: 18 / 100
Running epoch: 19 / 100
Running epoch: 20 / 100
Running epoch: 21 / 100
Running epoch: 22 / 100

Running epoch: 23 / 100
Running epoch: 24 / 100
Running epoch: 25 / 100
Running epoch: 26 / 100
Running epoch: 27 / 100
Running epoch: 28 / 100
Running epoch: 29 / 100
Running epoch: 30 / 100
Running epoch: 31 / 100
Running epoch: 32 / 100
Running epoch: 33 / 100
Running epoch: 34 / 100
Running epoch: 35 / 100
Running epoch: 36 / 100
Running epoch: 37 / 100

Weights and Bias: [0.06287951 -0.06002773 0.28344304 -0.00786873]

Score: Final validation Loss: 0.19479093275603987

Target: 2.1 - Predicted: 1.7705063500798333
Target: 1.9 - Predicted: 1.6554180643392107
Target: 2.3 - Predicted: 1.7072446129891323
Target: 1.8 - Predicted: 1.7674108972101357
Target: 2.4 - Predicted: 1.8146190547336833
Target: 2.3 - Predicted: 2.0252228586154173
Target: 2.4 - Predicted: 1.7714589312577431
Target: 2.5 - Predicted: 1.8309578128402193
Target: 2.0 - Predicted: 1.6946687103908211
Target: 2.3 - Predicted: 1.708482372706426
Target: 1.8 - Predicted: 1.5498517393907192
Target: 1.9 - Predicted: 1.640317065949968
Target: 2.3 - Predicted: 1.6854734392015902
Target: 2.3 - Predicted: 1.8999371441513093
Target: 1.8 - Predicted: 1.6285966989698062

##

Combination-4: Predicting the sepal width given sepal length
Running epoch: 1 / 100
Running epoch: 2 / 100

Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100

Weights and Bias: [0.43517051 0.08013529]

Score: Final validation Loss: 0.09548696311710575

Target: 3.1 - Predicted: 3.08281183353018
Target: 2.5 - Predicted: 2.821709524987294
Target: 3.0 - Predicted: 2.9957777306825513
Target: 3.1 - Predicted: 2.8652265764111085
Target: 3.1 - Predicted: 2.9957777306825513
Target: 3.0 - Predicted: 3.4309482449206947
Target: 3.4 - Predicted: 2.821709524987294
Target: 3.3 - Predicted: 2.9957777306825513
Target: 3.0 - Predicted: 2.9087436278349226
Target: 3.4 - Predicted: 2.7781924735634798
Target: 3.0 - Predicted: 2.691158370715851
Target: 2.7 - Predicted: 2.6041242678682224
Target: 3.1 - Predicted: 3.08281183353018
Target: 3.2 - Predicted: 3.0392947821063654
Target: 3.0 - Predicted: 2.647641319292037

Plots saved
Goodbye!

Part-3: Traffic Data Dataset

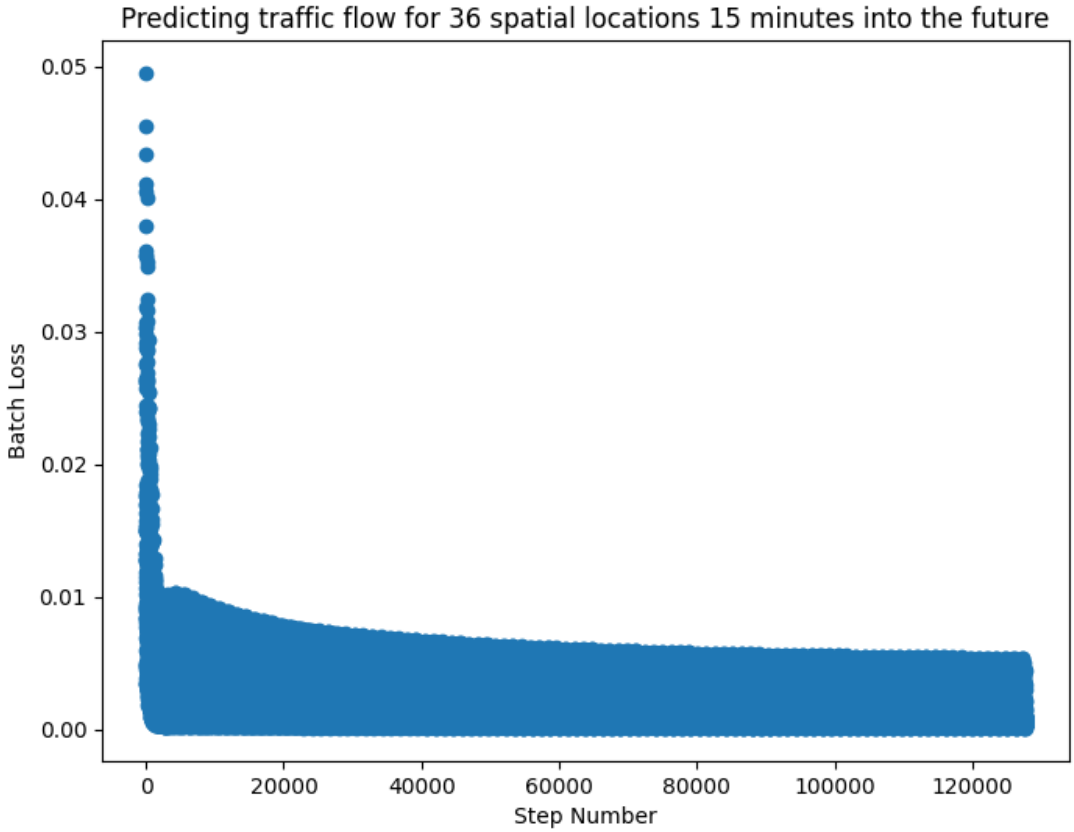
Explanation of code:

This code is implementing a linear regression model to predict the traffic flow at 36 spatial locations 15 minutes into the future. The code first loads the data in a .mat file using the scipy.io.loadmat function. The training and testing input data are loaded as sparse matrices, which are then converted to dense matrices and stored as numpy arrays.

For the training data, a dataframe training_set_x is created. The total number of entries in the data is 45396 (36 locations and 1261 entries for each location), and each entry is a 36x48 table. The entries of the dense matrix are then appended to the training_set_x dataframe. A column named Target is then added to the dataframe and populated with the output training data. A new dataframe tr_x is created, and the rows from the training_set_x dataframe are extracted and appended to tr_x. The target values are extracted from training_set_x into the dataframe tr_y. The first column of tr_x is then dropped, as it contains the target values which have been extracted into tr_y.

The process for the testing data is similar to the process for the training data. A dataframe testing_set_x is created, and the entries of the dense matrix representation of the testing data are appended to the dataframe. A column named Target is then added to the dataframe and populated with the output testing data. A new dataframe te_x is created, and the rows from the testing_set_x dataframe are extracted and appended to te_x. The target values are extracted from testing_set_x into the dataframe te_y. The first column of te_x is then dropped, as it contains the target values which have been extracted into te_y.

Finally, a linear regression model is fit using the training inputs and targets, and the model's predictions are made on the testing inputs. The performance of the model is evaluated using the root mean squared error (RMSE) of the model's predictions on the testing targets. The code also plots the batch validation loss, which is a measure of the model's performance on the validation set after each iteration of training, as a scatter plot.



Setting-1: The best setting came out

- **with learning rate as 0.005**
- **Score method RMSE= 0.047563018151353734**

The terminal output for the following program is being presented below:

(base) raviailani@Ravis-Air ml-assignment1 % /usr/local/bin/python3 /Users/raviailani/Documents/ml-assignment1/TrafficData.py
---------- Prepairing training set ----------
---------- Prepairing testing set ----------
---------- Initiating model ----------
Running epoch: 1 / 100
Running epoch: 2 / 100
Running epoch: 3 / 100
Running epoch: 4 / 100
Running epoch: 5 / 100
Running epoch: 6 / 100
Running epoch: 7 / 100
Running epoch: 8 / 100

Running epoch: 9 / 100
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Running epoch: 95 / 100
Running epoch: 96 / 100

```
Running epoch: 97 / 100
Running epoch: 98 / 100
Running epoch: 99 / 100
Running epoch: 100 / 100

Weights and Bias:  [-3.67559014e-02 -5.44292918e-02 -3.36541174e-02 -1.00266360e-02
 -1.12546933e-02  2.74534942e-02  1.13850344e-01  2.05665806e-01
  3.06822247e-01  4.30009212e-01  9.62336997e-05  0.00000000e+00
  0.00000000e+00  0.00000000e+00  0.00000000e+00 -1.80923409e-02
 -5.00621114e-03  9.86932311e-03  1.88991443e-03 -3.96145263e-03
  3.98686483e-03  2.77152795e-02  2.84583473e-02 -4.30600249e-03
  3.73860406e-03 -6.65574974e-04  3.62397480e-03 -4.45808493e-03
 -9.39750770e-03 -4.85866568e-03 -1.10841050e-02 -1.73561289e-02
  0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
  0.00000000e+00  0.00000000e+00  0.00000000e+00  6.67793886e-03
  5.11375022e-04  1.67083405e-03 -7.44001344e-04 -1.34197403e-03
  2.14224212e-03 -7.04034389e-04 -2.20393439e-03  8.61960356e-04
  9.62336997e-05]


Score: Final validation Loss: 0.002262240695666005
Score method RMSE=  0.047563018151353734

Plots saved
Goodbye!
```