Ha Yun Anna Yoon
ME 249 Project 2 Report

For Project 2, I worked on all of the tasks by myself.

Task 1

In task 1.1, I was given CodeP2.1 from the class that contains data array for the project. Implementation of the remaining equations for weights and biases were completed via the backpropagation method using Newton-Raphson finite difference approximation and the learning rate parameter. The total batch squared error cutout limit was changed to 0.00035. The parameters were adjusted to converge to a batch squared error less than 0.00035.

In task 1.2, I was given CodeP2.2 from class that contains the Keras neural network model. First, I ran the program to get a loss value below 0.03, and then I changed the epoch to be 400. In the end, I was able to get a last epoch with loss less than 0.025, I ended up getting 0.0239. As indicated in the instructions, I also tried training the network with starting values that are all 50% different from the values in the original program. To reach a loss value below 0.03 with the changed initial values, I had to double the number of epochs compared to the starting values in the original program.

The resulting values for weights and biases from both methods were collected. Based on the results, I would say that the results of the two models agree. If the two models were given the same starting values for the weights and bias values, I would expect that they would yield a similar answer—not necessarily exactly the same, but close enough to each other. It was seen in the resulting values that the weights and biases were pretty close to each other, and the discrepancy might be a result of the loss values that we were able to get down to. The tables comparing the weights and biases (Table 1) for First Principles and Keras method as well as the measured vs predicted values (Table 2) using the two methods are shown below. Figure 1 show the log-log plots of predicted y3 vs the data y3 values for both First Principles and Keras models.

Table 1. Weights and Biases of the two models using First Principles and Keras methods.

	First Principles	Keras
w01	1.2317446777456715	0.93278986
w02	0.39071987719447326	-0.099556476
w03	0.6908682132924195	0.90238297
b1	-0.15913730444025148	-0.24067132
w12	0.717440495245393	-0.5746556
b2	-0.12656640856995455	0.5076427
w23	0.6472143707613583	-1.4124379
b3	0.07574054459128032	0.5199998
	rms = 0.006458164948	mae = loss = 0.0239

Table 2. Measured data and two predicted y3 values based on the two models using First Principles and Keras methods.

x01	x02	x03	Y3data	First Principles Predicted y3	Keras Predicted y3
20	13.0	310.8	30.97	31.49863838103	32.515316
20	14.5	308	32.3	32.0120270208347	32.08422
20	15.3	306	31.5	32.268743338089	31.818192
20.2	13.0	310.8	30.91	31.682038191219	32.729336
20	14.5	308	32.5	32.0120270208347	32.08422
20	15.3	306	31.4	32.268743338089	32.034702
24	13.0	310.8	35.59	35.166634584733	36.638195
36	14.5	308	46.4	46.68401183563	46.472282

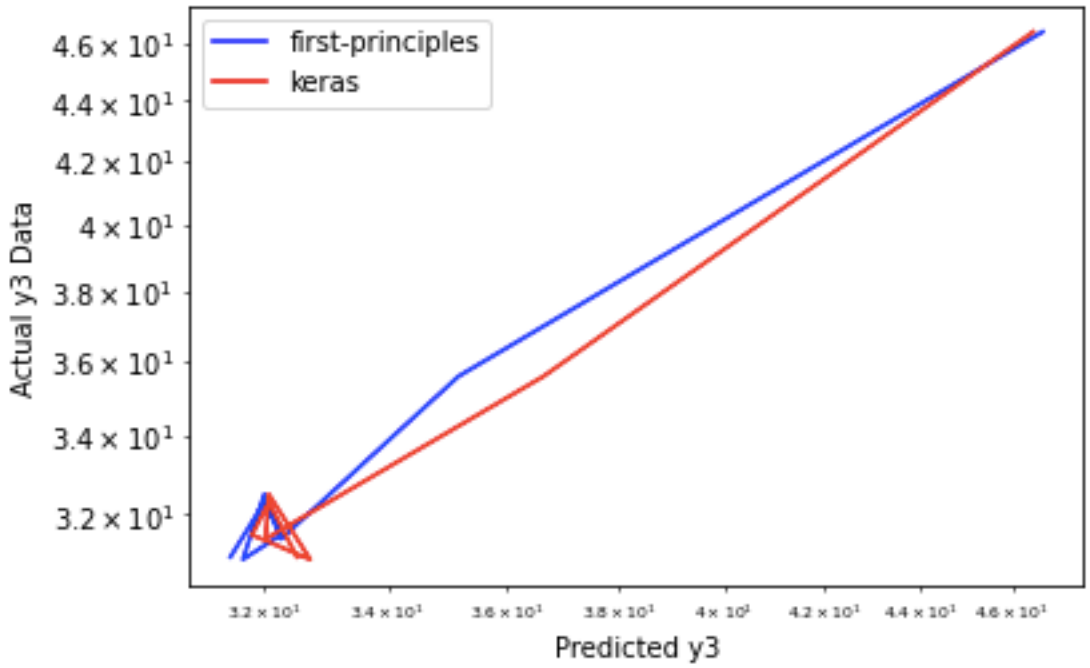


Figure 1. Log-log plot of the predicted y3 values vs the data y3 values based on the two models—First Principles and Keras methods. The two predicted values are fairly similar to each other and to the actual y3 data.

Task 2

In task 2.1, I was given CodeP2.3 from the class that contains the two arrays xdata and ydata that contain the input and output parameters for the system of interest. I was also given CodeP2.4 from the class that contains the general architecture of the neural network we will use for our subsequent tasks. The CodeP2.4 was edited to extend the data points of xdata and ydata to include the datapoints from CodeP2.3. These data were normalized with the median value of each of the parameters from our data given. The normalized data were printed to confirm that the data has been normalized as expected.

In task 2.2, I used the given CodeP2.4 to create a sequential neural network. In the first hidden dense layer, I have three input variables, 16 neurons, and relu activation function. In the second hidden dense layer, I put 32 neurons with relu activation function. In the third hidden dense layer, I put 16 neurons with relu activation function. Finally, there is an output dense layer with 2 neurons. The learning parameter for this model was changed to 0.001, and the epoch was changed to 600. This network was trained by successive forward passes for each point in the dataset, and the backpropagation pass was used to update the weights and biases at the end of each epoch. I set the threshold for mean absolute error to be less than 0.05. The lowest loss I was able to get was 0.049724594006935754.

Then the trained model was used to predict α values for $268 < T_1 < 318\ K$ and $500 < \dot{Q}_s < 2500\ kW$ with $\gamma = 0.25$. The resulting α values variation was plotted using surface plot (Figure 2) as a function of T_1 and $\dot{Q}_s$ over these ranges.

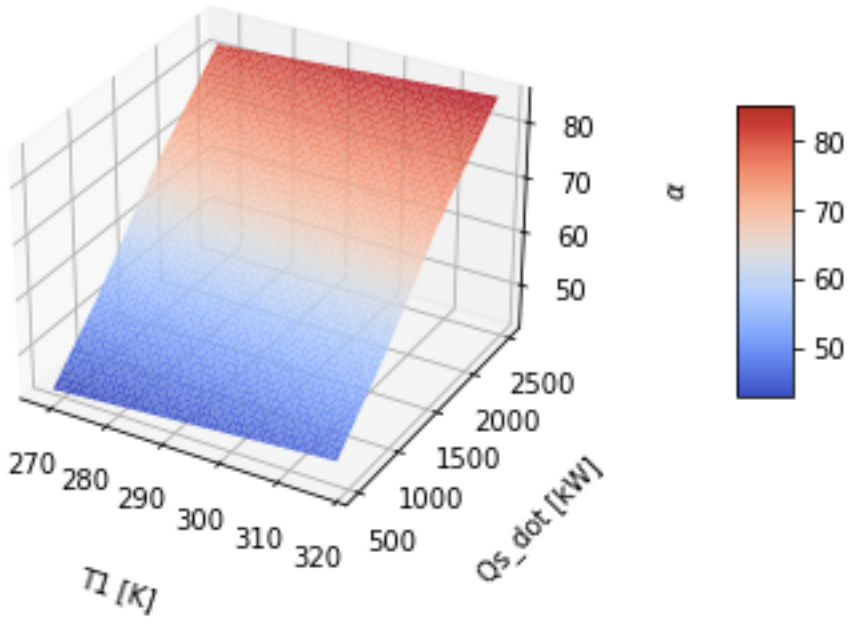


Figure 2. A surface plot for predicted α values for $268 < T_1 < 318$ K and $500 < \dot{Q}_s < 2500$ kW with $\gamma = 0.25$. It seems that the T_1 variation does not affect the predicted α values as much, but the $\dot{Q}_s$ variation affects the predicted α values.

In task 2.3 part a, I was given test data to test the trained model. I took the given test data and normalized with the respective parameter median values used to normalize the training data set. The resulting normalized test data were inputted to the trained model using model.predict() function. The α values from the test data were log-log plotted against the predicted α values to evaluate the agreement (Figure 3). The rms deviation between the predictions and the collection of the test data were 0.161 for α values and 0.959 for η_{sys}.

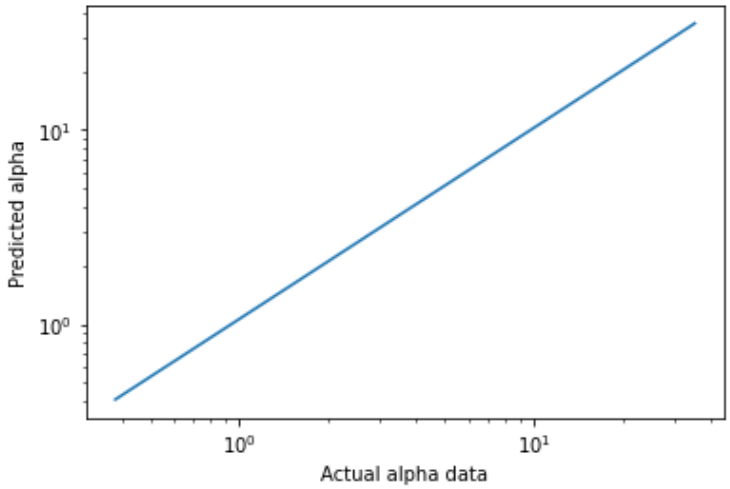


Figure 3. A log-log plot to evaluate the agreement of α in the test data vs predicted α values using the trained model. The rms for α is 0.161, which is fairly good.

In task 2.3 part b, I was given a table that indicates the anticipated combination of air inlet temperature and solar heat input along with the information that the air to fuel ratio will vary ($\gamma = 0\ and\ 0.5$). I normalized the values in each of the parameters with the respective median value used to normalize the train data. The normalized values were inputted with the model.predict() to predict the α values over the course of the day. The resulting predicted α values were plotted against time over the course of the day (Figure 4).

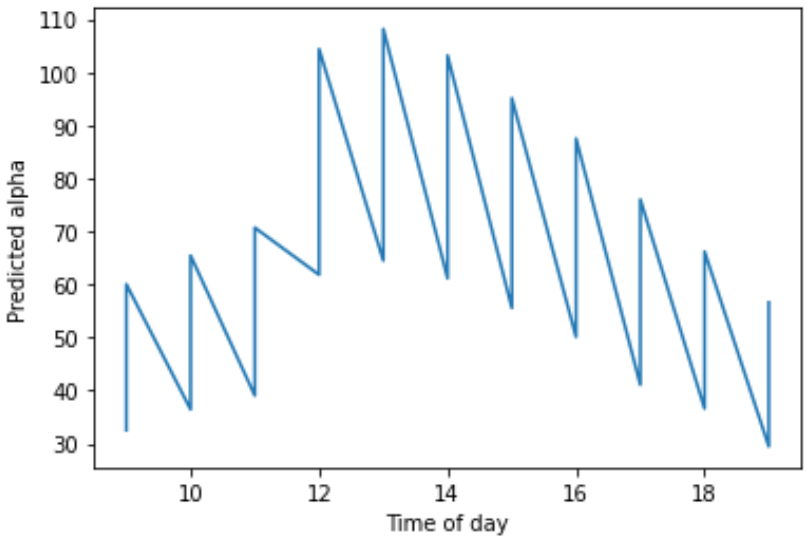


Figure 4. Plot of the predicted α values over the time of day (24 hour clock) given the operating conditions provided. The fluctuation of the predicted α values within the same time period is due to the variation in air to fuel ratio ($\gamma = 0\ and\ 0.5$). It is clear that the predicted α values increase around 12PM and decrease as we progress through the afternoon into evening.

In task 2.4, I created more versions of neural network model trained in Task 2.2. The original model created in task 2.2 were compared with the other four models trained—described

below. Model version 1 had the same number of neurons and layers with activation function changed to ELU from the original Relu. Model version 2 included an additional layer with number of neurons in the layers set to 16, 32, 16, 16, 2 with relu activation functions for all layers. Model version 3 had the same number of layers as the original model with number of neurons decreased to 8, 16, 8, 2 with relu activation functions for all layers. Model version 4 had the same number of layers as the original model with number of neurons increased to 20, 40, 20, 2 with relu activation functions for all layers. The summary of minimum loss values obtained, and the number of epochs needed to obtain the min loss for each of the model (min loss value threshold ~ 0.5) are in Table 3.

Table 3. Result summary of different models and their minimum loss values, number of epochs to get to the min loss, and comparison to the original model. Based on the result, best to worst models are: 1) using elu activation functions, 2) relu with more layers, 3) relu with same number of layers but more neurons each, and 4) relu with same number of layers with less neurons each.

Model Name	minimum loss value	# of epoch	compared to baseline
Original Model	0.0543997	598	baseline
Model v1	0.0559068	350	smaller
Model v2	0.0530908	476	smaller
Model v3	0.0558974	588	similar
Model v4	0.0423302	433	smaller

Based on the result, best to worst models are: 1) using elu activation functions, 2) relu with more layers, 3) relu with same number of layers but more neurons each, and 4) relu with same number of layers with less neurons each. Therefore, I conclude that the best design features for the network for the application in Part 2 is to use elu activation function with more neurons in each of the dense hidden layers.

Appendix

In [1]:

```
'''#Intro to Neural Network Modeling
# Python Neural Network Model of Spray Cooling Test System

>>>>> start CodeP2.1
    V.P. Carey ME249, Spring 2021'''
#import math and numpy packages
import math
import numpy


#assembling data array
#store array where rows are data vectors [x01, x02, x03, y3]
xydata = []

xydata = [[20./20.2, 13.0/14.5, 310.8/308.0, 30.97/32.4], [20./20.2, 14.5/14.
xydata.append([20./20.2, 15.3/14.5, 306.0/308.0, 31.5/32.4])
xydata.append([20.2/20.2, 13.0/14.5, 310.8/308.0, 30.91/32.4])
xydata.append([20./20.2, 14.5/14.5, 308.0/308.0, 32.5/32.4])
xydata.append([20./20.2, 15.3/14.5, 306.0/308.0, 31.4/32.4])
xydata.append([24./20.2, 13.0/14.5, 310.8/308.0, 35.59/32.4])
xydata.append([36./20.2, 14.5/14.5, 308.0/308.0, 46.4/32.4])
print (xydata)

#set starting values
w01n =  1.24
w02n =  0.40
w03n =  0.70
b1n =  -0.15
w12n =  0.72
b2n =  -0.12
w23n =  0.65
b3n =  0.08

#start of batch loop
for k in range (0,40):
    icount = 0
    #initialize error and derivative parameters
    E3ti = 0.
    dE3da3 = 0.
    dE3dw01ti = 0.
    dE3dw02ti = 0.
    dE3dw03ti = 0.
    dE3db1ti = 0.
    dE3dw12ti = 0.
    dE3db2ti = 0.
    dE3dw23ti = 0.
    dE3db3ti = 0.

    w01 = w01n
    w02 = w02n
    w03 = w03n
```

```
b1 = b1n
w12 = w12n
b2 = b2n
w23 = w23n
b3 = b3n

#doing calcuations for each data point
for i in range(0,8):
    #compute activation functions and their derivatives
    z1 = w01*xydata[i][0]+w02*xydata[i][1]+w03*xydata[i][2]+b1
    sig1 = z1
    sigp1 = 1.0
    if z1 < 0.0:
        sig1 = math.exp(z1) - 1.0
        sigp1 = math.exp(z1)
    a1 = sig1

    z2 = w12*a1+b2
    sig2 = z2
    sigp2 = 1.0
    if z2 < 0.0:
        sig2 = math.exp(z2) - 1.0
        sigp2 = math.exp(z2)
    a2 = sig2

    z3 = w23*a2+b3
    sig3 = z3
    sigp3 = 1.0
    if z3 < 0.0:
        sig3 = math.exp(z3) - 1.0
        sigp3 = math.exp(z3)
    a3 = sig3


    #compute derivatives for backpropagation
    #add to sum for batch average calculation
    E3ti = E3ti +(a3 - xydata[i][3])*(a3 - xydata[i][3])
    dE3da3 = 2.*(a3 - xydata[i][3])

    dE3dw01ti = dE3dw01ti + dE3da3*sigp3*w23*sigp2*w12*sigp1*xydata[i][0]
    dE3dw02ti = dE3dw02ti + dE3da3*sigp3*w23*sigp2*w12*sigp1*xydata[i][1]
    dE3dw03ti = dE3dw03ti + dE3da3*sigp3*w23*sigp2*w12*sigp1*xydata[i][2]
    dE3db1ti = dE3db1ti + dE3da3*sigp3*w23*sigp2*w12*sigp1

    dE3dw12ti = dE3dw12ti + dE3da3*sigp3*w23*sigp2*a1
    dE3db2ti = dE3db2ti + dE3da3*sigp3*w23*sigp2

    dE3dw23ti = dE3dw23ti + dE3da3*sigp3*a2
    dE3db3ti = dE3db3ti + dE3da3*sigp3

    icount = i + 1
    # end  calculations for each data point in batch
```

```
    #compute batch averaged values
    E3 = E3ti/icount
    dE3dw01 = dE3dw01ti/icount
    dE3dw02 = dE3dw02ti/icount
    dE3dw03 = dE3dw03ti/icount
    dE3db1 = dE3db1ti/icount
    dE3dw12 = dE3dw12ti/icount
    dE3db2 = dE3db2ti/icount
    dE3dw23 = dE3dw23ti/icount
    dE3db3 = dE3db3ti/icount

    #set gam = learning rate
    gam = 0.03
    if E3 < 0.07:
        gam = 0.009

    w01n = w01 + gam*(-E3)/dE3dw01
    w02n = w02 + gam*(-E3)/dE3dw02
    w03n = w03 + gam*(-E3)/dE3dw03
    b1n = b1 + gam*(-E3)/dE3db1
    w12n = w12 + gam*(-E3)/dE3dw12
    b2n = b2 + gam*(-E3)/dE3db2

    w23n = w23 + gam*(-E3)/dE3dw23
    b3n = b3 + gam*(-E3)/dE3db3

    #printing for each iteration
    print ('==============================')
    print ('last w01, w02, w03, w12, w23:')
    print ('last b1, b2, b3:')
    print (w01, w02, w03, w12, w23)
    print (b1, b2, b3)
    print ('E3 = ', E3, 'icount =', icount)
    print ('next ws:', w01n, w02n, w03n, w12n, w23n)
    print ('next bs:', b1n, b2n, b3n)
    print ('    ')

    #quit if squared error is below target
    if E3 < 0.00035:
        break

print ('==============================')
print ('last w01, w02, w03, w12, w23:')
print ('last b1, b2, b3:')
print (w01, w02, w03, w12, w23)
print (b1, b2, b3)
print ('    ')
#decomment print statements below if you want to print neuron outputs
#print ('z1 =', z1)
#print ('a1 =', a1)
#print ('z2 =', z2)
#print ('a2 =', a2)
#print ('z3 =', z3)
```

```
#print ('a3 =', a3)

#print comparison of data and trained network predictions
# restore raw data values
xydatar = [[20., 13.0, 310.8, 30.97], [20., 14.5, 308.0, 32.3]]
xydatar.append([20., 15.3, 306.0, 31.5])
xydatar.append([20.2, 13.0, 310.8, 30.91])
xydatar.append([20., 14.5, 308.0, 32.5])
xydatar.append([20., 15.3, 306.0, 31.4])
xydatar.append([24., 13.0, 310.8, 35.59])
xydatar.append([36., 14.5, 308.0, 46.4])
print ('Tdbin, Twbin, qdot, Tdbout, ypredicted:')
for i in range(0,8):
    z1 = w01*xydata[i][0]+w02*xydata[i][1]+w03*xydata[i][2]+b1
    sig1 = z1
    sigp1 = 1.0
    if z1 < 0.0:
        sig1 = math.exp(z1) - 1.0
        sigp1 = math.exp(z1)
    a1 = sig1

    z2 = w12*a1+b2
    sig2 = z2
    sigp2 = 1.0
    if z2 < 0.0:
        sig2 = math.exp(z2) - 1.0
        sigp2 = math.exp(z2)
    a2 = sig2

    z3 = w23*a2+b3
    sig3 = z3
    sigp3 = 1.0
    if z3 < 0.0:
        sig3 = math.exp(z3) - 1.0
        sigp3 = math.exp(z3)
    a3 = sig3

    print (xydatar[i][0], xydatar[i][1], xydatar[i][2], xydatar[i][3], a3*32.
```

```
[[0.9900990099009901, 0.896551724137931, 1.009090909090909, 0.9558641975308642
], [0.9900990099009901, 1.0, 1.0, 0.9969135802469136], [0.9900990099009901, 1.
0551724137931036, 0.9935064935064936, 0.9722222222222222], [1.0, 0.89655172413
7931, 1.009090909090909, 0.9540123456790124], [0.9900990099009901, 1.0, 1.0, 1
.0030864197530864], [0.9900990099009901, 1.0551724137931036, 0.993506493506493
6, 0.9691358024691358], [1.188118811881188, 0.896551724137931, 1.0090909090909
09, 1.098456790123457], [1.7821782178217822, 1.0, 1.0, 1.4320987654320987]]
==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.24 0.4 0.7 0.72 0.65
-0.15 -0.12 0.08
E3 =  0.00202817893051773 icount = 8
next ws: 1.2395842004849886 0.3995251230041434 0.6995350552723261 0.7198562254
547948 0.649860208771567
```

```
next bs: -0.15046548493782352 -0.12033514915523294 0.0797821530490986

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2395842004849886 0.3995251230041434 0.6995350552723261 0.7198562254547948 0.
649860208771567
-0.15046548493782352 -0.12033514915523294 0.0797821530490986
E3 =  0.0018852257532186052 icount = 8
next ws: 1.239180605627035 0.399064501023702 0.6990839671244636 0.719716618546
577 0.6497244293405798
next bs: -0.15091708613217156 -0.1206602370864072 0.07957089133827658

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.239180605627035 0.399064501023702 0.6990839671244636 0.719716618546577 0.649
7244293405798
-0.15091708613217156 -0.1206602370864072 0.07957089133827658
E3 =  0.0017523813082271 37 icount = 8
next ws: 1.2387886417033136 0.3986174779186808 0.6986460935787717 0.7195809879
720887 0.6495924788329756
next bs: -0.15135544635031273 -0.1209757322203131 0.07936590644243985

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2387886417033136 0.3986174779186808 0.6986460935787717 0.7195809879720887 0.
6495924788329756
-0.15135544635031273 -0.1209757322203131 0.07936590644243985
E3 =  0.0016289317351831172 icount = 8
next ws: 1.238407741934573 0.3981834068215117 0.6982208013186909 0.71944914431
57252 0.6494641759186996
next bs: -0.15178119964193323 -0.12128209619452976 0.07916689470900333

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.238407741934573 0.3981834068215117 0.6982208013186909 0.7194491443157252 0.6
494641759186996
-0.15178119964193323 -0.12128209619452976 0.07916689470900333
E3 =  0.0015142136750016 06 icount = 8
next ws: 1.2380373444440234 0.3977616479762124 0.6978074635218237 0.7193208993
968568 0.6493393401897525
next bs: -0.15219497350282402 -0.12157978544468785 0.07897355620546954

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2380373444440234 0.3977616479762124 0.6978074635218237 0.7193208993968568 0.
6493393401897525
-0.15219497350282402 -0.12157978544468785 0.07897355620546954
E3 =  0.0014076107139392 03 icount = 8
next ws: 1.2376768899291055 0.39735156628986235 0.6974054573992086 0.719196065
5175778 0.6492177914392265
next bs: -0.15259739133135208 -0.121869252999038 0.07878559353472148
```

```
==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2376768899291055 0.39735156628986235 0.6974054573992086 0.7191960655175778 0
.6492177914392265
-0.15259739133135208 -0.121869252999038 0.07878559353472148
E3 =  0.0013085500811198642 icount = 8
next ws: 1.2373258189676108 0.3969525285178638 0.6970141613605588 0.7190744545
846743 0.6490993488156311
next bs: -0.1529890752576638 -0.12215095053776788 0.0786027104807734

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2373258189676108 0.3969525285178638 0.6970141613605588 0.7190744545846743 0.
6490993488156311
-0.1529890752576638 -0.12215095053776788 0.0786027104807734
E3 =  0.0012164995823033403 icount = 8
next ws: 1.236983568855 0.3965638999801277 0.6966329517002857 0.71895587707135
4 0.6489838298186811
next bs: -0.15337064945041765 -0.12242533079230593 0.07842461043622488

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.236983568855 0.3965638999801277 0.6966329517002857 0.718955877071354 0.64898
38298186811
-0.15337064945041765 -0.12242533079230593 0.07842461043622488
E3 =  0.0011309647541177205 icount = 8
next ws: 1.2366495698357824 0.39618504067186416 0.696261198664777 0.7188401407
728999 0.6488710490915331
next bs: -0.15374274404005647 -0.12269285038435322 0.0782509945468265

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2366495698357824 0.39618504067186416 0.696261198664777 0.7188401407728999 0.
6488710490915331
-0.15374274404005647 -0.12269285038435322 0.0782509945468265
E3 =  0.0010514862244056788 icount = 8
next ws: 1.2363232405442695 0.39581530058598136 0.6958982617134323 0.718727049
2945207 0.6487608169488154
next bs: -0.1541059998453953 -0.12295397323859956 0.0780815594864499

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2363232405442695 0.39581530058598136 0.6958982617134323 0.7187270492945207 0
.6487608169488154
-0.1541059998453953 -0.12295397323859956 0.0780815594864499
E3 =  0.000977637265794909 icount = 8
next ws: 1.236003982402412 0.39545401399800223 0.6955434837179588 0.7186164001
871046 0.6486529375575923
next bs: -0.15446107415800872 -0.12320917475158448 0.07791599474439924

==============================
last w01, w02, w03, w12, w23:
```

```
last b1, b2, b3:
1.236003982402412 0.39545401399800223 0.6955434837179588 0.7186164001871046 0.
6486529375575923
-0.15446107415800872 -0.12320917475158448 0.07791599474439924
E3 =  0.000909021531163883 icount = 8
next ws: 1.2356911726247397 0.39510049236923767 0.6951961837463942 0.718507982
6140226 0.6485472066563629
next bs: -0.15480864793650176 -0.12345894696908456 0.07775397926179753

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2356911726247397 0.39510049236923767 0.6951961837463942 0.7185079826140226 0
.6485472066563629
-0.15480864793650176 -0.12345894696908456 0.07775397926179753
E3 =  0.0008452709614332549 icount = 8
next ws: 1.2353841553365126 0.39475401538438953 0.6948556479343685 0.718401574
3842336 0.6484434086500519
next bs: -0.15514943490604463 -0.12370380512707196 0.07759517718740779

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2353841553365126 0.39475401538438953 0.6948556479343685 0.7184015743842336 0
.6484434086500519
-0.15514943490604463 -0.12370380512707196 0.07759517718740779
E3 =  0.0007860438582345493 icount = 8
next ws: 1.23508223009484 0.394413819430888 0.6945211177303616 0.7182969381150
562 0.648341312848191
next bs: -0.15548419327328072 -0.12394429606513267 0.07743923242378224

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.23508223009484 0.394413819430888 0.6945211177303616 0.7182969381150562 0.648
341312848191
-0.15548419327328072 -0.12394429606513267 0.07743923242378224
E3 =  0.0007310231167565462 icount = 8
next ws: 1.2347846367696247 0.3940790825075416 0.6941917744709254 0.7181938161
775541 0.6482406685047739
next bs: -0.15581374109588056 -0.12418100925706863 0.077285761482154

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2347846367696247 0.3940790825075416 0.6941917744709254 0.7181938161775541 0.
6482406685047739
-0.15581374109588056 -0.12418100925706863 0.077285761482154
E3 =  0.0006799146179094892 icount = 8
next ws: 1.234490535215556 0.39374890404809504 0.6938667187215655 0.7180919239
034601 0.6481411981469138
next bs: -0.1561389768636207 -0.12441459157425934 0.0771343439247074

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.234490535215556 0.39374890404809504 0.6938667187215655 0.7180919239034601 0.
```

```
6481411981469138
-0.1561389768636207 -0.12441459157425934 0.0771343439247074
E3 =  0.0006324457846912208 icount = 8
next ws: 1.2341989773118012 0.3934222773342937 0.6935449419767978 0.7179909402
502455 0.6480425884013634
next bs: -0.1564609076855579 -0.12464576749754805 0.07698450928480434

================================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2341989773118012 0.3934222773342937 0.6935449419767978 0.7179909402502455 0.
6480425884013634
-0.1564609076855579 -0.12464576749754805 0.07698450928480434
E3 =  0.0005883643168007826 icount = 8
next ws: 1.2339088675095673 0.3930980508194523 0.6932252869041592 0.7178904946
474869 0.6479444770615411
next bs: -0.15678068887874655 -0.12487536749711993 0.07683571870678484

================================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2339088675095673 0.3930980508194523 0.6932252869041592 0.7178904946474869 0.
6479444770615411
-0.15678068887874655 -0.12487536749711993 0.07683571870678484
E3 =  0.0005474371330248956 icount = 8
next ws: 1.2336189055187174 0.39277487233814395 0.6929063898699888 0.717790147
9229485 0.6478464343249896
next bs: -0.15709968118658524 -0.125104369042783 0.07668733842003389

================================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2336189055187174 0.39277487233814395 0.6929063898699888 0.7177901479229485 0
.6478464343249896
-0.15709968118658524 -0.125104369042783 0.07668733842003389
E3 =  0.0005094495785741164 icount = 8
next ws: 1.2333275001822752 0.39245110593317656 0.6925865950439918 0.717689363
7050957 0.6477479346509275
next bs: -0.15741953626830535 -0.1253339578692048 0.07653860011747567

================================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2333275001822752 0.39245110593317656 0.6925865950439918 0.7176893637050957 0
.6477479346509275
-0.15741953626830535 -0.1253339578692048 0.07653860011747567
E3 =  0.0004742050068173452 icount = 8
next ws: 1.233032634765999 0.39212470294630913 0.6922638208931235 0.7175874638
180038 0.6476483128468841
next bs: -0.1577423295321621 -0.12556562316135045 0.07638853940295802

================================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.233032634765999 0.39212470294630913 0.6922638208931235 0.7175874638180038 0.
6476483128468841
-0.1577423295321621 -0.12556562316135045 0.07638853940295802
```

```
E3 =  0.00044152494994462464 icount = 8
next ws: 1.2327316458003326 0.3917929926469378 0.6919353426232621 0.7174835553
019213 0.647546692190067
next bs: -0.15807077651691392 -0.12580131260013716 0.07623589553557197

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2327316458003326 0.3917929926469378 0.6919353426232621 0.7174835553019213 0.
647546692190067
-0.15807077651691392 -0.12580131260013716 0.07623589553557197
E3 =  0.0004112503197786423 icount = 8
next ws: 1.2324208375366001 0.3914523219457121 0.6915974163055622 0.7173764037
260559 0.6474418595907473
next bs: -0.15840860656513536 -0.12604370010422292 0.07607893830907304

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2324208375366001 0.3914523219457121 0.6915974163055622 0.7173764037260559 0.
6474418595907473
-0.15840860656513536 -0.12604370010422292 0.07607893830907304
E3 =  0.00038324461210528863 icount = 8
next ws: 1.2320947562527569 0.391097388139053 0.6912445792881466 0.71726419600
49825 0.647332031738242
next bs: -0.15876125792937293 -0.12629668387166876 0.07591514602823164

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2320947562527569 0.391097388139053 0.6912445792881466 0.7172641960049825 0.6
47332031738242
-0.15876125792937293 -0.12629668387166876 0.07591514602823164
E3 =  0.00035740147568798426 icount = 8
next ws: 1.2317446777456715 0.39071987719447326 0.6908682132924195 0.717144049
5245393 0.6472143707613583
next bs: -0.15913730444025148 -0.12656640856995455 0.07574054459128032

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2317446777456715 0.39071987719447326 0.6908682132924195 0.7171440495245393 0
.6472143707613583
-0.15913730444025148 -0.12656640856995455 0.07574054459128032
E3 =  0.00033366315594520607 icount = 8
next ws: 1.2313549702288527 0.39030528310865487 0.6904531584302075 0.717010843
2593911 0.6470838297434378
next bs: -0.15955181403702529 -0.1268636716607517 0.07554815164701947

==============================
last w01, w02, w03, w12, w23:
last b1, b2, b3:
1.2317446777456715 0.39071987719447326 0.6908682132924195 0.7171440495245393 0
.6472143707613583
-0.15913730444025148 -0.12656640856995455 0.07574054459128032

Tdbin, Twbin, qdot, Tdbout, ypredicted:
```

```
20.0 13.0 310.8 30.97 31.498638381033796
20.0 14.5 308.0 32.3 32.012027020834694
20.0 15.3 306.0 31.5 32.268743338089074
20.2 13.0 310.8 30.91 31.682038191218748
20.0 14.5 308.0 32.5 32.012027020834694
20.0 15.3 306.0 31.4 32.268743338089074
24.0 13.0 310.8 35.59 35.16663458473277
36.0 14.5 308.0 46.4 46.6840118356306
```

In [2]:

```
'''>>>>> start CodeP2.2
    V.P. Carey ME249, Spring 2021

Intro to Neural Network Modeling
Keras model for comparison with first principles model'''

#import useful packages
import keras
import pandas as pd
from keras.models import Sequential
import numpy as np
import keras.backend as kb
import tensorflow as tf
#the follwoing 2 lines are only needed for Mac OS machines
import os
os.environ['KMP_DUPLICATE_LIB_OK']='True'

#raw data in dictionary form x01, x02, x03, y3
my_dict = {
    'x01' : [20., 20., 20., 20.2, 20., 20.2, 24.0, 36.],
    'x02' : [13., 14.5, 15.3, 13., 14.5, 15.3, 13., 14.5],
    'x03' : [310.8, 308.0, 306.0, 310.8, 308.0, 306.0, 310.8, 308.0],
    'y3' : [30.97, 32.3, 31.5, 30.91, 32.5, 31.4, 35.59, 46.4]
}
#normalized inputs in array
xdata = []
xdata = [[20./20.2, 13.0/14.5, 310.8/308.0], [20./20.2, 14.5/14.5, 308.0/308.
xdata.append([20./20.2, 15.3/14.5, 306.0/308.0])
xdata.append([20.2/20.2, 13.0/14.5, 310.8/308.0])
xdata.append([20./20.2, 14.5/14.5, 308.0/308.0])
xdata.append([20.2/20.2, 15.3/14.5, 306.0/308.0])
xdata.append([24./20.2, 13.0/14.5, 310.8/308.0])
xdata.append([36./20.2, 14.5/14.5, 308.0/308.0])
#data frame
df = pd.DataFrame(my_dict)
#devide by the median to normalize
df.x01= df.x01/20.2 #div by 2 for Task1.2.b
df.x02= df.x02/14.5
df.x03= df.x03/308.0
#normalize output array
df.y3= df.y3/32.401
df.head
print (df.x01, df.x02, df.x03, df.y3)

xarray= np.array(xdata)
print (xdata)
print (xarray)
```

```
Using TensorFlow backend.
0    0.990099
1    0.990099
2    0.990099
3    1.000000
4    0.990099
5    1.000000
6    1.188119
7    1.782178
Name: x01, dtype: float64 0    0.896552
1    1.000000
2    1.055172
3    0.896552
4    1.000000
5    1.055172
6    0.896552
7    1.000000
Name: x02, dtype: float64 0    1.009091
1    1.000000
2    0.993506
3    1.009091
4    1.000000
5    0.993506
6    1.009091
7    1.000000
Name: x03, dtype: float64 0    0.955835
1    0.996883
2    0.972192
3    0.953983
4    1.003055
5    0.969106
6    1.098423
7    1.432055
Name: y3, dtype: float64
[[0.9900990099009901, 0.896551724137931, 1.009090909090909], [0.99009900990099
01, 1.0, 1.0], [0.9900990099009901, 1.0551724137931036, 0.9935064935064936], [
1.0, 0.896551724137931, 1.009090909090909], [0.9900990099009901, 1.0, 1.0], [1
.0, 1.0551724137931036, 0.9935064935064936], [1.188118811881188, 0.89655172413
7931, 1.009090909090909], [1.7821782178217822, 1.0, 1.0]]
[[0.99009901 0.89655172 1.00909091]
 [0.99009901 1.         1.        ]
 [0.99009901 1.05517241 0.99350649]
 [1.         0.89655172 1.00909091]
 [0.99009901 1.         1.        ]
 [1.         1.05517241 0.99350649]
 [1.18811881 0.89655172 1.00909091]
 [1.78217822 1.         1.        ]]
```

In [3]:

```
# define model

#As seen below, we have created three dense layers each with just one neuron.
#A dense layer is a layer in neural network that's fully connected.
#In other words, all the neurons in one layer are connected to all other neur
#In the first layer, we need to provide the input shape, which is 3 in this c
#The activation function we have chosen is ReLU, which stands for rectified l

from keras import backend as K
#initialize weights with values between -0.2 and 1.2
initializer = tf.keras.initializers.RandomUniform(minval= -0.2, maxval=1.2)

# define three layer model with one neuron in each layer
model = keras.Sequential([
    keras.layers.Dense(1, activation=K.relu, input_shape=[3]),
    keras.layers.Dense(1, activation=K.tanh),
    keras.layers.Dense(1)
  ])
```

In [4]:

```
#We're using RMSprop as our optimizer here. RMSprop stands for Root Mean Squa
#It's one of the most popular gradient descent optimization algorithms for de
#RMSprop is an optimizer that's reliable and fast.
#We're compiling the mode using the model.compile function. The loss function
#is mean absolute error. After the compilation of the model, we'll use the fi

#Running model.fit successive times extends the calculation to addtional epoc

sgd = tf.keras.optimizers.RMSprop(0.0035)
model.compile(loss='mean_absolute_error',optimizer='sgd')
```

In [7]:

```
#After the compilation of the model, we'll use the fit method with 500 epochs
#I started with epochs value of 100 and then tested the model after training.
#The prediction was not that good. Then I modified the number of epochs to 20
#Accuracy had improved slightly, but figured I'd give it one more try. Finall
#I found acceptable prediction accuracy.

#The fit method takes three parameters; namely, x, y, and number of epochs.
#During model training, if all the batches of data are seen by the model once
#we say that one epoch has been completed.

# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 20,
    restore_best_weights = True,
    verbose=1)
# Add a checkpoint where loss is minimum, and save that model
mc = keras.callbacks.ModelCheckpoint('best_model.SB', monitor='loss',
                     mode='min',  verbose=1, save_best_only=True)

historyData = model.fit(xarray,df.y3,epochs=400,callbacks=[es]) #changed to 1

loss_hist = historyData.history['loss']
#The above line will return a dictionary, access it's info like this:
best_epoch = np.argmin(historyData.history['loss']) + 1
print ('best epoch = ', best_epoch)
print('smallest loss =', np.min(loss_hist))
```

```
Epoch 1/400
8/8 [==============================] - 0s 703us/step - loss: 0.0160
Epoch 2/400
8/8 [==============================] - 0s 750us/step - loss: 0.0193
Epoch 3/400
8/8 [==============================] - 0s 687us/step - loss: 0.0289
Epoch 4/400
8/8 [==============================] - 0s 765us/step - loss: 0.0133
Epoch 5/400
8/8 [==============================] - 0s 521us/step - loss: 0.0153
Epoch 6/400
8/8 [==============================] - 0s 633us/step - loss: 0.0205
Epoch 7/400
8/8 [==============================] - 0s 807us/step - loss: 0.0279
Epoch 8/400
8/8 [==============================] - 0s 540us/step - loss: 0.0137
Epoch 9/400
8/8 [==============================] - 0s 622us/step - loss: 0.0155
Epoch 10/400
8/8 [==============================] - 0s 759us/step - loss: 0.0199
Epoch 11/400
8/8 [==============================] - 0s 780us/step - loss: 0.0283
Epoch 12/400
8/8 [==============================] - 0s 866us/step - loss: 0.0136
Epoch 13/400
8/8 [==============================] - 0s 707us/step - loss: 0.0158
Epoch 14/400
8/8 [==============================] - 0s 841us/step - loss: 0.0193
Epoch 15/400
8/8 [==============================] - 0s 673us/step - loss: 0.0287
Epoch 16/400
8/8 [==============================] - 0s 662us/step - loss: 0.0135
Epoch 17/400
8/8 [==============================] - 0s 808us/step - loss: 0.0150
Epoch 18/400
8/8 [==============================] - 0s 705us/step - loss: 0.0205
Epoch 19/400
8/8 [==============================] - 0s 1ms/step - loss: 0.0276
Epoch 20/400
8/8 [==============================] - 0s 945us/step - loss: 0.0141
Epoch 21/400
8/8 [==============================] - 0s 1ms/step - loss: 0.0153
Epoch 22/400
8/8 [==============================] - 0s 759us/step - loss: 0.0200
Epoch 23/400
8/8 [==============================] - 0s 678us/step - loss: 0.0280
Epoch 24/400
8/8 [==============================] - 0s 955us/step - loss: 0.0139
Restoring model weights from the end of the best epoch
Epoch 00024: early stopping
best epoch =  4
smallest loss = 0.01327359676361084
```

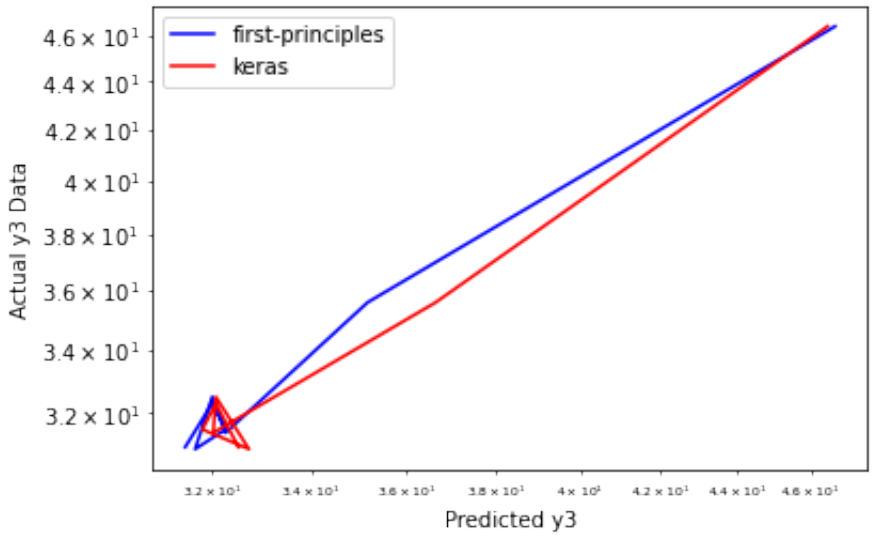
In [8]:

```
from __future__ import print_function
#For results of training network:

#keras.layer.get_weights() function retrieves weight values
first_layer_weights = model.layers[0].get_weights()[0]
w01 = first_layer_weights[0][0]
w02 = first_layer_weights[1][0]
w03 = first_layer_weights[2][0]
first_layer_bias  = model.layers[0].get_weights()[1]
b1 = first_layer_bias
second_layer_weights = model.layers[1].get_weights()[0]
w12 = second_layer_weights[0][0]
second_layer_bias  = model.layers[1].get_weights()[1]
b2 = second_layer_bias
third_layer_weights = model.layers[2].get_weights()[0]
w23 = third_layer_weights[0][0]
third_layer_bias  = model.layers[2].get_weights()[1]
b3 = third_layer_bias

#print weights and biases
print (first_layer_weights)
print ('w01 = ', w01, 'w02 = ', w02, 'w03 = ', w03)
print (first_layer_bias)
print ('b1 = ', b1)
print (second_layer_weights)
print ('w12 = ', w12)
print (second_layer_bias)
print ('b2 = ', b2)
print (third_layer_weights)
print ('w23 = ', w23)
print (third_layer_bias)
print ('b3 = ', b3)

#use model.predict() function to print model predictions for data conditions
xarray= np.array(xdata)
print ('x01/20.2,  x02/14.5,   x03/308.0,  y3/32.4,  a3:')
test = []
for i in range(0,8):
    test = [[xarray[i][0], xarray[i][1], xarray[i][2]]]
    testarray = np.array(test)
    a3 = model.predict(testarray)
    print (xarray[i][0], xarray[i][1], xarray[i][2], df.y3[i], a3)
print('  ')
print ('x01,  x02,   x03,  y3,  a3*32.4:')
for i in range(0,8):
    test = [[xarray[i][0], xarray[i][1], xarray[i][2]]]
    testarray = np.array(test)
    a3 = model.predict(testarray)
    print (xarray[i][0]*20.2, xarray[i][1]*14.5, xarray[i][2]*308.0, df.y3[i]
```

```
[[ 1.047099  ]
 [ 0.01080906]
 [-1.0649904 ]]
w01 =  1.047099 w02 =  0.010809059 w03 =  -1.0649904
[0.0358692]
b1 =  [0.0358692]
[[-0.42079762]]
w12 =  -0.42079762
[-0.38960966]
b2 =  [-0.38960966]
[[-1.8120942]]
w23 =  -1.8120942
[0.2925]
b3 =  [0.2925]
x01/20.2,  x02/14.5,   x03/308.0,  y3/32.4,  a3:
0.9900990099009901 0.896551724137931 1.009090909090909 0.9558346964599856 [[0.
9698342]]
0.9900990099009901 1.0 1.0 0.9968828122588808 [[0.9769068]]
0.9900990099009901 1.0551724137931036 0.9935064935064936 0.9721922162896206 [[
0.9818119]]
1.0 0.896551724137931 1.009090909090909 0.9539829017622912 [[0.976624]]
0.9900990099009901 1.0 1.0 1.003055461251196 [[0.9769068]]
1.0 1.0551724137931036 0.9935064935064936 0.9691058917934631 [[0.988562]]
1.188118811881188 0.896551724137931 1.009090909090909 1.0984228881824636 [[1.1
012324]]
1.7821782178217822 1.0 1.0 1.4320545662170918 [[1.4395097]]

x01,  x02,   x03,  y3,  a3*32.4:
20.0 13.0 310.8 30.969044165303533 [[31.42263]]
20.0 14.5 308.0 32.29900311718774 [[31.651781]]
20.0 15.3 306.0 31.499027807783705 [[31.810707]]
20.2 13.0 310.8 30.909046017098234 [[31.64262]]
20.0 14.5 308.0 32.498996944538746 [[31.651781]]
20.2 15.3 306.0 31.3990308941082 [[32.02941]]
23.999999999999996 13.0 310.8 35.58890157711182 [[35.67993]]
36.0 14.5 308.0 46.398567945433776 [[46.640118]]
```

In [100…

```
#Task 1.2.c
#Make log-log plots of predicted y3 vs data

import matplotlib.pyplot as plt

pfp = [31.49, 32.01, 32.27, 31.68, 32.01, 32.27, 35.17, 46.68] #predicted y3
pkm = [32.52, 32.08, 31.82, 32.73, 32.08, 32.03, 36.65, 46.47] #predicted y3
y3a = [0,0,0,0,0,0,0,0] #actual y3 data

for i in range(8):
    y3a[i] = xydatar[i][3]

plt.figure()
plt.loglog(pfp, y3a, label ="first-principles", c='b')
plt.loglog(pkm, y3a, label ="keras", c='r')
plt.rc('xtick', labelsize=6)
plt.xlabel("Predicted y3")
plt.ylabel("Actual y3 Data")
plt.legend()
plt.show()
```



In [8]:

```
'''>>>>> start CodeP2.3
    V.P. Carey ME249, Spring 2021

Intro to Neural Network Modeling
Data arrays for hybrid solar/fossil-fuel gas turbine power system'''


#create input data array, normalizing input temp
#T1(K), gamma, , qsol(kW):
''' #DATA ADDED TO CODEP2.4
xdata = []
xdata =  [[ 318.0 , 0.0 , 500.0 ], [ 318.0 , 0.0 , 1000.0 ]]
xdata.append([ 318.0 , 0.0 , 1500.0 ])
```

```
xdata.append([ 318.0 , 0.0 , 2000.0 ])
xdata.append([ 318.0 , 0.0 , 2500.0 ])
xdata.append([ 318.0 , 0.25 , 500.0 ])
xdata.append([ 318.0 , 0.25 , 1000.0 ])
xdata.append([ 318.0 , 0.25 , 1500.0 ])
xdata.append([ 318.0 , 0.25 , 2000.0 ])
xdata.append([ 318.0 , 0.25 , 2500.0 ])
xdata.append([ 318.0 , 0.5 , 500.0 ])
xdata.append([ 318.0 , 0.5 , 1000.0 ])
xdata.append([ 318.0 , 0.5 , 1500.0 ])
xdata.append([ 318.0 , 0.5 , 2000.0 ])
xdata.append([ 318.0 , 0.5 , 2500.0 ])

xdata.append([ 303.0 , 0.0 , 500.0 ])
xdata.append([ 303.0 , 0.0 , 1000.0 ])
xdata.append([ 303.0 , 0.0 , 1500.0 ])
xdata.append([ 303.0 , 0.0 , 2000.0 ])
xdata.append([ 303.0 , 0.0 , 2500.0 ])
xdata.append([ 303.0 , 0.25 , 500.0 ])
xdata.append([ 303.0 , 0.25 , 1000.0 ])
xdata.append([ 303.0 , 0.25 , 1500.0 ])
xdata.append([ 303.0 , 0.25 , 2000.0 ])
xdata.append([ 303.0 , 0.25 , 2500.0 ])
xdata.append([ 303.0 , 0.5 , 500.0 ])
xdata.append([ 303.0 , 0.5 , 1000.0 ])
xdata.append([ 303.0 , 0.5 , 1500.0 ])
xdata.append([ 303.0 , 0.5 , 2000.0 ])
xdata.append([ 303.0 , 0.5 , 2500.0 ])

xdata.append([ 288.0 , 0.0 , 500.0 ])
xdata.append([ 288.0 , 0.0 , 1000.0 ])
xdata.append([ 288.0 , 0.0 , 1500.0 ])
xdata.append([ 288.0 , 0.0 , 2000.0 ])
xdata.append([ 288.0 , 0.0 , 2500.0 ])
xdata.append([ 288.0 , 0.25 , 500.0 ])
xdata.append([ 288.0 , 0.25 , 1000.0 ])
xdata.append([ 288.0 , 0.25 , 1500.0 ])
xdata.append([ 288.0 , 0.25 , 2000.0 ])
xdata.append([ 288.0 , 0.25 , 2500.0 ])
xdata.append([ 288.0 , 0.5 , 500.0 ])
xdata.append([ 288.0 , 0.5 , 1000.0 ])
xdata.append([ 288.0 , 0.5 , 1500.0 ])
xdata.append([ 288.0 , 0.5 , 2000.0 ])
xdata.append([ 288.0 , 0.5 , 2500.0 ])

xdata.append([ 268.0 , 0.0 , 500.0 ])
xdata.append([ 268.0 , 0.0 , 1000.0 ])
xdata.append([ 268.0 , 0.0 , 1500.0 ])
xdata.append([ 268.0 , 0.0 , 2000.0 ])
xdata.append([ 268.0 , 0.0 , 2500.0 ])
xdata.append([ 268.0 , 0.25 , 500.0 ])
xdata.append([ 268.0 , 0.25 , 1000.0 ])
xdata.append([ 268.0 , 0.25 , 1500.0 ])
```

```
xdata.append([ 268.0 , 0.25 , 2000.0 ])
xdata.append([ 268.0 , 0.25 , 2500.0 ])
xdata.append([ 268.0 , 0.5 , 500.0 ])
xdata.append([ 268.0 , 0.5 , 1000.0 ])
xdata.append([ 268.0 , 0.5 , 1500.0 ])
xdata.append([ 268.0 , 0.5 , 2000.0 ])
xdata.append([ 268.0 , 0.5 , 2500.0 ])

ydata =  [[ 35.1316 , 0.3808 ],[ 40.3764 , 0.38686 ]]
ydata.append([ 47.4620 , 0.3930 ])
ydata.append([ 57.5639 , 0.39949 ])
ydata.append([ 73.1286 , 0.40612 ])
ydata.append([ 49.1110 , 0.4023 ])
ydata.append([ 56.4428 , 0.40605 ])
ydata.append([ 66.3479 , 0.4098 ])
ydata.append([ 80.4695 , 0.413 ])
ydata.append([ 102.2276 , 0.4175 ])
ydata.append([ 63.0904 , 0.41540 ])
ydata.append([ 72.5092 , 0.4175 ])
ydata.append([ 85.2338, 0.4197 ])
ydata.append([ 103.3750 , 0.42192 ])
ydata.append([ 131.3266 , 0.4242 ])

ydata.append([ 34.273 , 0.3952 ])
ydata.append([ 38.99026 , 0.4012 ])
ydata.append([ 45.2133, 0.4073 ])
ydata.append([ 53.8000 , 0.4136 ])
ydata.append([ 66.4130 , 0.4201 ])
ydata.append([ 47.922 , 0.4178 ])
ydata.append([ 54.518 , 0.4215 ])
ydata.append([ 63.220 , 0.4252 ])
ydata.append([ 75.226 , 0.4290 ])
ydata.append([ 92.862 , 0.4329 ])
ydata.append([ 61.572 , 0.4315 ])
ydata.append([ 70.0468 , 0.43373 ])
ydata.append([ 81.226 , 0.43597 ])
ydata.append([ 96.653 , 0.4382 ])
ydata.append([ 119.3124 , 0.44045 ])

ydata.append([ 33.4521 , 0.40913 ])
ydata.append([ 37.6911, 0.4150 ])
ydata.append([ 43.1602 , 0.4209 ])
ydata.append([ 50.4858 , 0.4271 ])
ydata.append([ 60.8067 , 0.4334 ])
ydata.append([ 46.7865 , 0.4328 ])
ydata.append([ 52.7151 , 0.43646 ])
ydata.append([ 60.36425 , 0.44016 ])
ydata.append([ 70.6099 , 0.443926 ])
ydata.append([ 85.0447 , 0.4477 ])
ydata.append([ 60.1208 , 0.44721 ])
ydata.append([ 67.7391 , 0.44940 ])
ydata.append([ 77.56830 , 0.4516 ])
ydata.append([ 90.73410 , 0.4538 ])
```

```
ydata.append([ 109.2828 , 0.4560 ])

ydata.append([ 32.4123 , 0.42694 ])
ydata.append([ 36.0807 , 0.4325 ])
ydata.append([ 40.6854 , 0.4383 ])
ydata.append([ 46.6374 , 0.4442 ])
ydata.append([ 54.6293 , 0.4503 ])
ydata.append([ 45.3472 , 0.4519 ])
ydata.append([ 50.4796 , 0.4555 ])
ydata.append([ 56.9219 , 0.4591 ])
ydata.append([ 65.2492 , 0.4628 ])
ydata.append([ 76.4304 , 0.4665 ])
ydata.append([ 58.2822 , 0.4672 ])
ydata.append([ 64.8785 , 0.4693 ])
ydata.append([ 73.1584 , 0.4715 ])
ydata.append([ 83.8610 , 0.4738 ])
ydata.append([ 98.2316 , 0.4760 ])

print(xdata)
print(ydata)
'''
```

Out[8]:

```
' #DATA ADDED TO CODEP2.4\nxdata = []\nxdata =  [[ 318.0 , 0.0 , 500.0 ], [ 31
8.0 , 0.0 , 1000.0 ]]\nxdata.append([ 318.0 , 0.0 , 1500.0 ])\nxdata.append([
318.0 , 0.0 , 2000.0 ])\nxdata.append([ 318.0 , 0.0 , 2500.0 ])\nxdata.append(
[ 318.0 , 0.25 , 500.0 ])\nxdata.append([ 318.0 , 0.25 , 1000.0 ])\nxdata.appe
nd([ 318.0 , 0.25 , 1500.0 ])\nxdata.append([ 318.0 , 0.25 , 2000.0 ])\nxdata.
append([ 318.0 , 0.25 , 2500.0 ])\nxdata.append([ 318.0 , 0.5 , 500.0 ])\nxdat
a.append([ 318.0 , 0.5 , 1000.0 ])\nxdata.append([ 318.0 , 0.5 , 1500.0 ])\nxd
ata.append([ 318.0 , 0.5 , 2000.0 ])\nxdata.append([ 318.0 , 0.5 , 2500.0 ])\n
\nxdata.append([ 303.0 , 0.0 , 500.0 ])\nxdata.append([ 303.0 , 0.0 , 1000.0 ]
)\nxdata.append([ 303.0 , 0.0 , 1500.0 ])\nxdata.append([ 303.0 , 0.0 , 2000.0
])\nxdata.append([ 303.0 , 0.0 , 2500.0 ])\nxdata.append([ 303.0 , 0.25 , 500.
0 ])\nxdata.append([ 303.0 , 0.25 , 1000.0 ])\nxdata.append([ 303.0 , 0.25 , 1
500.0 ])\nxdata.append([ 303.0 , 0.25 , 2000.0 ])\nxdata.append([ 303.0 , 0.25
, 2500.0 ])\nxdata.append([ 303.0 , 0.5 , 500.0 ])\nxdata.append([ 303.0 , 0.5
, 1000.0 ])\nxdata.append([ 303.0 , 0.5 , 1500.0 ])\nxdata.append([ 303.0 , 0.
5 , 2000.0 ])\nxdata.append([ 303.0 , 0.5 , 2500.0 ])\n  \nxdata.append([ 288.
0 , 0.0 , 500.0 ])\nxdata.append([ 288.0 , 0.0 , 1000.0 ])\nxdata.append([ 288
.0 , 0.0 , 1500.0 ])\nxdata.append([ 288.0 , 0.0 , 2000.0 ])\nxdata.append([ 2
88.0 , 0.0 , 2500.0 ])\nxdata.append([ 288.0 , 0.25 , 500.0 ])\nxdata.append([
288.0 , 0.25 , 1000.0 ])\nxdata.append([ 288.0 , 0.25 , 1500.0 ])\nxdata.appen
d([ 288.0 , 0.25 , 2000.0 ])\nxdata.append([ 288.0 , 0.25 , 2500.0 ])\nxdata.a
ppend([ 288.0 , 0.5 , 500.0 ])\nxdata.append([ 288.0 , 0.5 , 1000.0 ])\nxdata.
append([ 288.0 , 0.5 , 1500.0 ])\nxdata.append([ 288.0 , 0.5 , 2000.0 ])\nxdat
a.append([ 288.0 , 0.5 , 2500.0 ])\n  \nxdata.append([ 268.0 , 0.0 , 500.0 ])\
nxdata.append([ 268.0 , 0.0 , 1000.0 ])\nxdata.append([ 268.0 , 0.0 , 1500.0 ]
)\nxdata.append([ 268.0 , 0.0 , 2000.0 ])\nxdata.append([ 268.0 , 0.0 , 2500.0
])\nxdata.append([ 268.0 , 0.25 , 500.0 ])\nxdata.append([ 268.0 , 0.25 , 1000
.0 ])\nxdata.append([ 268.0 , 0.25 , 1500.0 ])\nxdata.append([ 268.0 , 0.25 ,
2000.0 ])\nxdata.append([ 268.0 , 0.25 , 2500.0 ])\nxdata.append([ 268.0 , 0.5
, 500.0 ])\nxdata.append([ 268.0 , 0.5 , 1000.0 ])\nxdata.append([ 268.0 , 0.5
, 1500.0 ])\nxdata.append([ 268.0 , 0.5 , 2000.0 ])\nxdata.append([ 268.0 , 0.
5 , 2500.0 ])\n\nydata =  [[ 35.1316 , 0.3808 ],[ 40.3764 , 0.38686 ]]\nydata.
append([ 47.4620 , 0.3930 ])\nydata.append([ 57.5639 , 0.39949 ])\nydata.appen
```

```
d([ 73.1286 , 0.40612 ])\nydata.append([ 49.1110 , 0.4023 ])\nydata.append([ 5
6.4428 , 0.40605 ])\nydata.append([ 66.3479 , 0.4098 ])\nydata.append([ 80.469
5 , 0.413 ])\nydata.append([ 102.2276 , 0.4175 ])\nydata.append([ 63.0904 , 0.
41540 ])\nydata.append([ 72.5092 , 0.4175 ])\nydata.append([ 85.2338, 0.4197 ]
)\nydata.append([ 103.3750 , 0.42192 ])\nydata.append([ 131.3266 , 0.4242 ])\n
\nydata.append([ 34.273 , 0.3952 ])\nydata.append([ 38.99026 , 0.4012 ])\nydat
a.append([ 45.2133, 0.4073 ])\nydata.append([ 53.8000 , 0.4136 ])\nydata.appen
d([ 66.4130 , 0.4201 ])\nydata.append([ 47.922 , 0.4178 ])\nydata.append([ 54.
518 , 0.4215 ])\nydata.append([ 63.220 , 0.4252 ])\nydata.append([ 75.226 , 0.
4290 ])\nydata.append([ 92.862 , 0.4329 ])\nydata.append([ 61.572 , 0.4315 ])\
nydata.append([ 70.0468 , 0.43373 ])\nydata.append([ 81.226 , 0.43597 ])\nydat
a.append([ 96.653 , 0.4382 ])\nydata.append([ 119.3124 , 0.44045 ])\n  \nydata
.append([ 33.4521 , 0.40913 ])\nydata.append([ 37.6911, 0.4150 ])\nydata.appen
d([ 43.1602 , 0.4209 ])\nydata.append([ 50.4858 , 0.4271 ])\nydata.append([ 60
.8067 , 0.4334 ])\nydata.append([ 46.7865 , 0.4328 ])\nydata.append([ 52.7151
, 0.43646 ])\nydata.append([ 60.36425 , 0.44016 ])\nydata.append([ 70.6099 , 0
.443926 ])\nydata.append([ 85.0447 , 0.4477 ])\nydata.append([ 60.1208 , 0.447
21 ])\nydata.append([ 67.7391 , 0.44940 ])\nydata.append([ 77.56830 , 0.4516 ]
)\nydata.append([ 90.73410 , 0.4538 ])\nydata.append([ 109.2828 , 0.4560 ])\n
\nydata.append([ 32.4123 , 0.42694 ])\nydata.append([ 36.0807 , 0.4325 ])\nyda
ta.append([ 40.6854 , 0.4383 ])\nydata.append([ 46.6374 , 0.4442 ])\nydata.app
end([ 54.6293 , 0.4503 ])\nydata.append([ 45.3472 , 0.4519 ])\nydata.append([
50.4796 , 0.4555 ])\nydata.append([ 56.9219 , 0.4591 ])\nydata.append([ 65.249
2 , 0.4628 ])\nydata.append([ 76.4304 , 0.4665 ])\nydata.append([ 58.2822 , 0.
4672 ])\nydata.append([ 64.8785 , 0.4693 ])\nydata.append([ 73.1584 , 0.4715 ]
)\nydata.append([ 83.8610 , 0.4738 ])\nydata.append([ 98.2316 , 0.4760 ])\n\np
rint(xdata)\nprint(ydata)\n'
```

In [79]:

```
'''>>>>> start CodeP2.4
    V.P. Carey ME249, Spring 2021

Intro to Neural Network Modeling
Keras model for hybrid solar/fossil-fuel gas turbine power system'''

#import useful packages
import keras
import pandas as pd
from keras.models import Sequential
import numpy as np
import keras.backend as kb
import tensorflow as tf
import copy as cp
#the follwoing 2 lines are only needed for Mac OS machines
import os
os.environ['KMP_DUPLICATE_LIB_OK']='True'

#Task 2.1 Normalize Data

#initialize
xdatan=[]
ydatan=[]

T=[]
ga=[]
```

```
qs=[]
al=[]
ef=[]

def median(sample):        #function to calculate median
    n = len(sample)
    i = n//2
    if n%2:
        return sorted (sample [i])
    return sum(sorted(sample)[i-1:i+1])/2

#create input data array
#T1(K), gamma, , qsol(kW):
xdata = []
xdata =  [[ 318.0 , 0.0 , 500.0 ], [ 318.0 , 0.0 , 1000.0 ]]
xdata.append([ 318.0 , 0.0 , 1500.0 ])
xdata.append([ 318.0 , 0.0 , 2000.0 ])
xdata.append([ 318.0 , 0.0 , 2500.0 ])
xdata.append([ 318.0 , 0.25 , 500.0 ])
xdata.append([ 318.0 , 0.25 , 1000.0 ])
xdata.append([ 318.0 , 0.25 , 1500.0 ])
xdata.append([ 318.0 , 0.25 , 2000.0 ])
xdata.append([ 318.0 , 0.25 , 2500.0 ])
xdata.append([ 318.0 , 0.5 , 500.0 ])
xdata.append([ 318.0 , 0.5 , 1000.0 ])
xdata.append([ 318.0 , 0.5 , 1500.0 ])
xdata.append([ 318.0 , 0.5 , 2000.0 ])
xdata.append([ 318.0 , 0.5 , 2500.0 ])

xdata.append([ 303.0 , 0.0 , 500.0 ])
xdata.append([ 303.0 , 0.0 , 1000.0 ])
xdata.append([ 303.0 , 0.0 , 1500.0 ])
xdata.append([ 303.0 , 0.0 , 2000.0 ])
xdata.append([ 303.0 , 0.0 , 2500.0 ])
xdata.append([ 303.0 , 0.25 , 500.0 ])
xdata.append([ 303.0 , 0.25 , 1000.0 ])
xdata.append([ 303.0 , 0.25 , 1500.0 ])
xdata.append([ 303.0 , 0.25 , 2000.0 ])
xdata.append([ 303.0 , 0.25 , 2500.0 ])
xdata.append([ 303.0 , 0.5 , 500.0 ])
xdata.append([ 303.0 , 0.5 , 1000.0 ])
xdata.append([ 303.0 , 0.5 , 1500.0 ])
xdata.append([ 303.0 , 0.5 , 2000.0 ])
xdata.append([ 303.0 , 0.5 , 2500.0 ])

xdata.append([ 288.0 , 0.0 , 500.0 ])
xdata.append([ 288.0 , 0.0 , 1000.0 ])
xdata.append([ 288.0 , 0.0 , 1500.0 ])
xdata.append([ 288.0 , 0.0 , 2000.0 ])
xdata.append([ 288.0 , 0.0 , 2500.0 ])
xdata.append([ 288.0 , 0.25 , 500.0 ])
xdata.append([ 288.0 , 0.25 , 1000.0 ])
xdata.append([ 288.0 , 0.25 , 1500.0 ])
```

```
xdata.append([ 288.0 , 0.25 , 2000.0 ])
xdata.append([ 288.0 , 0.25 , 2500.0 ])
xdata.append([ 288.0 , 0.5 , 500.0 ])
xdata.append([ 288.0 , 0.5 , 1000.0 ])
xdata.append([ 288.0 , 0.5 , 1500.0 ])
xdata.append([ 288.0 , 0.5 , 2000.0 ])
xdata.append([ 288.0 , 0.5 , 2500.0 ])

xdata.append([ 268.0 , 0.0 , 500.0 ])
xdata.append([ 268.0 , 0.0 , 1000.0 ])
xdata.append([ 268.0 , 0.0 , 1500.0 ])
xdata.append([ 268.0 , 0.0 , 2000.0 ])
xdata.append([ 268.0 , 0.0 , 2500.0 ])
xdata.append([ 268.0 , 0.25 , 500.0 ])
xdata.append([ 268.0 , 0.25 , 1000.0 ])
xdata.append([ 268.0 , 0.25 , 1500.0 ])
xdata.append([ 268.0 , 0.25 , 2000.0 ])
xdata.append([ 268.0 , 0.25 , 2500.0 ])
xdata.append([ 268.0 , 0.5 , 500.0 ])
xdata.append([ 268.0 , 0.5 , 1000.0 ])
xdata.append([ 268.0 , 0.5 , 1500.0 ])
xdata.append([ 268.0 , 0.5 , 2000.0 ])
xdata.append([ 268.0 , 0.5 , 2500.0 ])

# alpha, effsys
ydata = []
ydata =  [[ 35.1316 , 0.3808 ],[ 40.3764 , 0.38686 ]]
ydata.append([ 47.4620 , 0.3930 ])
ydata.append([ 57.5639 , 0.39949 ])
ydata.append([ 73.1286 , 0.40612 ])
ydata.append([ 49.1110 , 0.4023 ])
ydata.append([ 56.4428 , 0.40605 ])
ydata.append([ 66.3479 , 0.4098 ])
ydata.append([ 80.4695 , 0.413 ])
ydata.append([ 102.2276 , 0.4175 ])
ydata.append([ 63.0904 , 0.41540 ])
ydata.append([ 72.5092 , 0.4175 ])
ydata.append([ 85.2338, 0.4197 ])
ydata.append([ 103.3750 , 0.42192 ])
ydata.append([ 131.3266 , 0.4242 ])

ydata.append([ 34.273 , 0.3952 ])
ydata.append([ 38.99026 , 0.4012 ])
ydata.append([ 45.2133, 0.4073 ])
ydata.append([ 53.8000 , 0.4136 ])
ydata.append([ 66.4130 , 0.4201 ])
ydata.append([ 47.922 , 0.4178 ])
ydata.append([ 54.518 , 0.4215 ])
ydata.append([ 63.220 , 0.4252 ])
ydata.append([ 75.226 , 0.4290 ])
ydata.append([ 92.862 , 0.4329 ])
ydata.append([ 61.572 , 0.4315 ])
ydata.append([ 70.0468 , 0.43373 ])
```

```
ydata.append([ 81.226 , 0.43597 ])
ydata.append([ 96.653 , 0.4382 ])
ydata.append([ 119.3124 , 0.44045 ])

ydata.append([ 33.4521 , 0.40913 ])
ydata.append([ 37.6911, 0.4150 ])
ydata.append([ 43.1602 , 0.4209 ])
ydata.append([ 50.4858 , 0.4271 ])
ydata.append([ 60.8067 , 0.4334 ])
ydata.append([ 46.7865 , 0.4328 ])
ydata.append([ 52.7151 , 0.43646 ])
ydata.append([ 60.36425 , 0.44016 ])
ydata.append([ 70.6099 , 0.443926 ])
ydata.append([ 85.0447 , 0.4477 ])
ydata.append([ 60.1208 , 0.44721 ])
ydata.append([ 67.7391 , 0.44940 ])
ydata.append([ 77.56830 , 0.4516 ])
ydata.append([ 90.73410 , 0.4538 ])
ydata.append([ 109.2828 , 0.4560 ])

ydata.append([ 32.4123 , 0.42694 ])
ydata.append([ 36.0807 , 0.4325 ])
ydata.append([ 40.6854 , 0.4383 ])
ydata.append([ 46.6374 , 0.4442 ])
ydata.append([ 54.6293 , 0.4503 ])
ydata.append([ 45.3472 , 0.4519 ])
ydata.append([ 50.4796 , 0.4555 ])
ydata.append([ 56.9219 , 0.4591 ])
ydata.append([ 65.2492 , 0.4628 ])
ydata.append([ 76.4304 , 0.4665 ])
ydata.append([ 58.2822 , 0.4672 ])
ydata.append([ 64.8785 , 0.4693 ])
ydata.append([ 73.1584 , 0.4715 ])
ydata.append([ 83.8610 , 0.4738 ])
ydata.append([ 98.2316 , 0.4760 ])

xdatar = np.array(cp.deepcopy(xdata)) #xdata copy
ydatar = np.array(cp.deepcopy(ydata)) #ydata copy

for x in range(len(xdatar)):
    T.append(xdatar[x][0])
    ga.append(xdatar[x][1])
    qs.append(xdatar[x][2])

for y in range(len(ydatar)):
    al.append(ydatar[y][0])
    ef.append(ydatar[y][1])

Tmed = median (T) #find median of the parameters
gamed = median(ga)
qsmed = median(qs)
almed = median(al)
efmed = median(ef)
```

```
for x in range(len(xdatar)):
    xdatan.append([xdatar[x][0]/Tmed, xdatar[x][1]/gamed, xdatar[x][2]/qsmed])

for y in range(len(ydatar)):
    ydatan.append([ydatar[y][0]/almed, ydatar[y][1]/efmed])

xarray= np.array(xdatan)
#print (xdata)
print('normalized xdata = ')
print (xarray)

yarray= np.array(ydatan)
#print (ydata)
print('normalized ydata = ')
print (yarray)
```

```
normalized xdata =
[[1.07614213 0.         0.33333333]
 [1.07614213 0.         0.66666667]
 [1.07614213 0.         1.        ]
 [1.07614213 0.         1.33333333]
 [1.07614213 0.         1.66666667]
 [1.07614213 1.         0.33333333]
 [1.07614213 1.         0.66666667]
 [1.07614213 1.         1.        ]
 [1.07614213 1.         1.33333333]
 [1.07614213 1.         1.66666667]
 [1.07614213 2.         0.33333333]
 [1.07614213 2.         0.66666667]
 [1.07614213 2.         1.        ]
 [1.07614213 2.         1.33333333]
 [1.07614213 2.         1.66666667]
 [1.02538071 0.         0.33333333]
 [1.02538071 0.         0.66666667]
 [1.02538071 0.         1.        ]
 [1.02538071 0.         1.33333333]
 [1.02538071 0.         1.66666667]
 [1.02538071 1.         0.33333333]
 [1.02538071 1.         0.66666667]
 [1.02538071 1.         1.        ]
 [1.02538071 1.         1.33333333]
 [1.02538071 1.         1.66666667]
 [1.02538071 2.         0.33333333]
 [1.02538071 2.         0.66666667]
 [1.02538071 2.         1.        ]
 [1.02538071 2.         1.33333333]
 [1.02538071 2.         1.66666667]
 [0.97461929 0.         0.33333333]
 [0.97461929 0.         0.66666667]
 [0.97461929 0.         1.        ]
 [0.97461929 0.         1.33333333]
 [0.97461929 0.         1.66666667]
 [0.97461929 1.         0.33333333]
 [0.97461929 1.         0.66666667]
```

```
 [0.97461929 1.         1.        ]
 [0.97461929 1.         1.33333333]
 [0.97461929 1.         1.66666667]
 [0.97461929 2.         0.33333333]
 [0.97461929 2.         0.66666667]
 [0.97461929 2.         1.        ]
 [0.97461929 2.         1.33333333]
 [0.97461929 2.         1.66666667]
 [0.90693739 0.         0.33333333]
 [0.90693739 0.         0.66666667]
 [0.90693739 0.         1.        ]
 [0.90693739 0.         1.33333333]
 [0.90693739 0.         1.66666667]
 [0.90693739 1.         0.33333333]
 [0.90693739 1.         0.66666667]
 [0.90693739 1.         1.        ]
 [0.90693739 1.         1.33333333]
 [0.90693739 1.         1.66666667]
 [0.90693739 2.         0.33333333]
 [0.90693739 2.         0.66666667]
 [0.90693739 2.         1.        ]
 [0.90693739 2.         1.33333333]
 [0.90693739 2.         1.66666667]]
normalized ydata =
[[0.57414566 0.88148148]
 [0.65985993 0.89550926]
 [0.77565786 0.90972222]
 [0.94075031 0.92474537]
 [1.19511974 0.94009259]
 [0.80260699 0.93125   ]
 [0.92242849 0.93993056]
 [1.0843047  0.94861111]
 [1.31508996 0.95601852]
 [1.67067635 0.96643519]
 [1.03106831 0.96157407]
 [1.18499706 0.96643519]
 [1.39295155 0.97152778]
 [1.68942798 0.97666667]
 [2.14623296 0.98194444]
 [0.56011381 0.91481481]
 [0.63720664 0.9287037 ]
 [0.738908   0.94282407]
 [0.87923797 0.95740741]
 [1.08536861 0.9724537 ]
 [0.7831755  0.96712963]
 [0.89097204 0.97569444]
 [1.03318633 0.98425926]
 [1.22939695 0.99305556]
 [1.51761704 1.00208333]
 [1.00625354 0.99884259]
 [1.14475477 1.00400463]
 [1.32745323 1.00918981]
 [1.57957226 1.01435185]
 [1.94988834 1.01956019]
 [0.54669808 0.94706019]
 [0.61597484 0.96064815]
 [0.70535477 0.97430556]
```

```
[0.82507495 0.98865741]
[0.99374646 1.00324074]
[0.76461835 1.00185185]
[0.86150776 1.01032407]
[0.98651563 1.01888889]
[1.15395735 1.02760648]
[1.38986114 1.03634259]
[0.98253699 1.03520833]
[1.10704069 1.04027778]
[1.26767648 1.04537037]
[1.48284138 1.05046296]
[1.78597746 1.05555556]
[0.52970492 0.98828704]
[0.58965653 1.00115741]
[0.66490982 1.01458333]
[0.76218165 1.02824074]
[0.89279098 1.04236111]
[0.74109629 1.04606481]
[0.82497363 1.05439815]
[0.93025829 1.06273148]
[1.06634896 1.0712963 ]
[1.24908011 1.07986111]
[0.95248928 1.08148148]
[1.06029072 1.08634259]
[1.19560675 1.09143519]
[1.37051627 1.09675926]
[1.60537087 1.10185185]]
```

In [80]:

```
# define neural network model

#As seen below, we have created four dense layers.
#A dense layer is a layer in neural network that's fully connected.
#In other words, all the neurons in one layer are connected to all other neur
#In the first layer, we need to provide the input shape, which is 1 in our ca
#The activation function we have chosen is elu, which stands for exponential

from keras import backend as K
#initialize weights with values between -0.2 and 1.2
initializer = tf.keras.initializers.RandomUniform(minval= -0.2, maxval=1.2)

model = keras.Sequential([
    keras.layers.Dense(16, activation=K.relu, input_shape=[3]),
    keras.layers.Dense(32, activation=K.relu),
    keras.layers.Dense(16, activation=K.relu),
    keras.layers.Dense(2)
  ])
```

In [81]:
```
#We're using RMSprop as our optimizer here. RMSprop stands for Root Mean Squa
#It's one of the most popular gradient descent optimization algorithms for de
#RMSprop is an optimizer that's reliable and fast.
#We're compiling the mode using the model.compile function. The loss function
#is mean squared error. After the compilation of the model, we'll use the fit
#Number of epochs can be varied.

#from tf.keras import optimizers

sgd = tf.keras.optimizers.RMSprop(0.001) #original value 0.050
model.compile(loss='mean_absolute_error',optimizer='sgd')
```

In [82]:
```
#After the compilation of the model, we'll use the fit method with 500 epochs
#I started with epochs value of 100 and then tested the model after training.
#The prediction was not that good. Then I modified the number of epochs to 20
#Accuracy had improved slightly, but figured I'd give it one more try. Finall
#I found acceptable prediction accuracy.

#The fit method takes three parameters; namely, x, y, and number of epochs.
#During model training, if all the batches of data are seen by the model once
#we say that one epoch has been completed.

# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 20,
    restore_best_weights = True,
    verbose=1)
# Add a checkpoint where loss is minimum, and save that model
mc = keras.callbacks.ModelCheckpoint('best_model.SB', monitor='loss',
                     mode='min',  verbose=1, save_best_only=True)

historyData = model.fit(xarray,yarray,epochs=600,callbacks=[es]) #epoch origi

loss_hist = historyData.history['loss']
#The above line will return a dictionary, access it's info like this:
best_epoch = np.argmin(historyData.history['loss']) + 1
print ('best epoch = ', best_epoch)
print('smallest loss =', np.min(loss_hist))
```

```
Epoch 1/600
60/60 [==============================] - 1s 15ms/step - loss: 0.9415
Epoch 2/600
60/60 [==============================] - 0s 197us/step - loss: 0.8720
Epoch 3/600
60/60 [==============================] - 0s 200us/step - loss: 0.7997
Epoch 4/600
60/60 [==============================] - 0s 206us/step - loss: 0.7253
Epoch 5/600
60/60 [==============================] - 0s 201us/step - loss: 0.6482
```

```
Epoch 6/600
60/60 [==============================] - 0s 318us/step - loss: 0.5672
Epoch 7/600
60/60 [==============================] - 0s 225us/step - loss: 0.4815
Epoch 8/600
60/60 [==============================] - 0s 210us/step - loss: 0.3893
Epoch 9/600
60/60 [==============================] - 0s 359us/step - loss: 0.3002
Epoch 10/600
60/60 [==============================] - 0s 427us/step - loss: 0.2413
Epoch 11/600
60/60 [==============================] - 0s 246us/step - loss: 0.2138
Epoch 12/600
60/60 [==============================] - 0s 373us/step - loss: 0.1975
Epoch 13/600
60/60 [==============================] - 0s 373us/step - loss: 0.1888
Epoch 14/600
60/60 [==============================] - 0s 180us/step - loss: 0.1835
Epoch 15/600
60/60 [==============================] - 0s 136us/step - loss: 0.1756
Epoch 16/600
60/60 [==============================] - 0s 152us/step - loss: 0.1704
Epoch 17/600
60/60 [==============================] - 0s 124us/step - loss: 0.1648
Epoch 18/600
60/60 [==============================] - 0s 156us/step - loss: 0.1604
Epoch 19/600
60/60 [==============================] - 0s 334us/step - loss: 0.1552
Epoch 20/600
60/60 [==============================] - 0s 263us/step - loss: 0.1513
Epoch 21/600
60/60 [==============================] - 0s 286us/step - loss: 0.1483
Epoch 22/600
60/60 [==============================] - 0s 352us/step - loss: 0.1425
Epoch 23/600
60/60 [==============================] - 0s 356us/step - loss: 0.1393
Epoch 24/600
60/60 [==============================] - 0s 487us/step - loss: 0.1371
Epoch 25/600
60/60 [==============================] - 0s 268us/step - loss: 0.1351
Epoch 26/600
60/60 [==============================] - 0s 366us/step - loss: 0.1300
Epoch 27/600
60/60 [==============================] - 0s 186us/step - loss: 0.1269
Epoch 28/600
60/60 [==============================] - 0s 229us/step - loss: 0.1244
Epoch 29/600
60/60 [==============================] - 0s 280us/step - loss: 0.1237
Epoch 30/600
60/60 [==============================] - 0s 195us/step - loss: 0.1216
Epoch 31/600
60/60 [==============================] - 0s 178us/step - loss: 0.1181
Epoch 32/600
60/60 [==============================] - 0s 156us/step - loss: 0.1161
Epoch 33/600
60/60 [==============================] - 0s 124us/step - loss: 0.1145
Epoch 34/600
```

```
60/60 [==============================] - 0s 134us/step - loss: 0.1123
Epoch 35/600
60/60 [==============================] - 0s 156us/step - loss: 0.1113
Epoch 36/600
60/60 [==============================] - 0s 128us/step - loss: 0.1094
Epoch 37/600
60/60 [==============================] - 0s 142us/step - loss: 0.1078
Epoch 38/600
60/60 [==============================] - 0s 191us/step - loss: 0.1067
Epoch 39/600
60/60 [==============================] - 0s 164us/step - loss: 0.1063
Epoch 40/600
60/60 [==============================] - 0s 167us/step - loss: 0.1043
Epoch 41/600
60/60 [==============================] - 0s 145us/step - loss: 0.1025
Epoch 42/600
60/60 [==============================] - 0s 135us/step - loss: 0.1015
Epoch 43/600
60/60 [==============================] - 0s 167us/step - loss: 0.1003
Epoch 44/600
60/60 [==============================] - 0s 293us/step - loss: 0.1007
Epoch 45/600
60/60 [==============================] - 0s 185us/step - loss: 0.0987
Epoch 46/600
60/60 [==============================] - 0s 117us/step - loss: 0.0972
Epoch 47/600
60/60 [==============================] - 0s 193us/step - loss: 0.0971
Epoch 48/600
60/60 [==============================] - 0s 163us/step - loss: 0.0965
Epoch 49/600
60/60 [==============================] - 0s 166us/step - loss: 0.0959
Epoch 50/600
60/60 [==============================] - 0s 214us/step - loss: 0.0949
Epoch 51/600
60/60 [==============================] - 0s 153us/step - loss: 0.0943
Epoch 52/600
60/60 [==============================] - 0s 231us/step - loss: 0.0943
Epoch 53/600
60/60 [==============================] - 0s 139us/step - loss: 0.0940
Epoch 54/600
60/60 [==============================] - 0s 152us/step - loss: 0.0933
Epoch 55/600
60/60 [==============================] - 0s 130us/step - loss: 0.0919
Epoch 56/600
60/60 [==============================] - 0s 133us/step - loss: 0.0924
Epoch 57/600
60/60 [==============================] - 0s 159us/step - loss: 0.0924
Epoch 58/600
60/60 [==============================] - 0s 144us/step - loss: 0.0902
Epoch 59/600
60/60 [==============================] - 0s 241us/step - loss: 0.0920
Epoch 60/600
60/60 [==============================] - 0s 192us/step - loss: 0.0898
Epoch 61/600
60/60 [==============================] - 0s 135us/step - loss: 0.0882
Epoch 62/600
60/60 [==============================] - 0s 154us/step - loss: 0.0882
```

```
Epoch 63/600
60/60 [==============================] - 0s 169us/step - loss: 0.0880
Epoch 64/600
60/60 [==============================] - 0s 150us/step - loss: 0.0873
Epoch 65/600
60/60 [==============================] - 0s 221us/step - loss: 0.0875
Epoch 66/600
60/60 [==============================] - 0s 194us/step - loss: 0.0865
Epoch 67/600
60/60 [==============================] - 0s 187us/step - loss: 0.0877
Epoch 68/600
60/60 [==============================] - 0s 168us/step - loss: 0.0871
Epoch 69/600
60/60 [==============================] - 0s 201us/step - loss: 0.0860
Epoch 70/600
60/60 [==============================] - 0s 142us/step - loss: 0.0884
Epoch 71/600
60/60 [==============================] - 0s 161us/step - loss: 0.0857
Epoch 72/600
60/60 [==============================] - 0s 170us/step - loss: 0.0865
Epoch 73/600
60/60 [==============================] - 0s 237us/step - loss: 0.0844
Epoch 74/600
60/60 [==============================] - 0s 254us/step - loss: 0.0838
Epoch 75/600
60/60 [==============================] - 0s 238us/step - loss: 0.0839
Epoch 76/600
60/60 [==============================] - 0s 236us/step - loss: 0.0834
Epoch 77/600
60/60 [==============================] - 0s 219us/step - loss: 0.0833
Epoch 78/600
60/60 [==============================] - 0s 263us/step - loss: 0.0826
Epoch 79/600
60/60 [==============================] - 0s 269us/step - loss: 0.0825
Epoch 80/600
60/60 [==============================] - 0s 531us/step - loss: 0.0839
Epoch 81/600
60/60 [==============================] - 0s 374us/step - loss: 0.0818
Epoch 82/600
60/60 [==============================] - 0s 369us/step - loss: 0.0813
Epoch 83/600
60/60 [==============================] - 0s 258us/step - loss: 0.0811
Epoch 84/600
60/60 [==============================] - 0s 788us/step - loss: 0.0806
Epoch 85/600
60/60 [==============================] - 0s 559us/step - loss: 0.0809
Epoch 86/600
60/60 [==============================] - 0s 235us/step - loss: 0.0802
Epoch 87/600
60/60 [==============================] - 0s 185us/step - loss: 0.0804
Epoch 88/600
60/60 [==============================] - 0s 235us/step - loss: 0.0795
Epoch 89/600
60/60 [==============================] - 0s 162us/step - loss: 0.0794
Epoch 90/600
60/60 [==============================] - 0s 262us/step - loss: 0.0800
Epoch 91/600
```

```
60/60 [==============================] - 0s 370us/step - loss: 0.0791
Epoch 92/600
60/60 [==============================] - 0s 481us/step - loss: 0.0789
Epoch 93/600
60/60 [==============================] - 0s 488us/step - loss: 0.0794
Epoch 94/600
60/60 [==============================] - 0s 271us/step - loss: 0.0785
Epoch 95/600
60/60 [==============================] - 0s 573us/step - loss: 0.0784
Epoch 96/600
60/60 [==============================] - 0s 559us/step - loss: 0.0782
Epoch 97/600
60/60 [==============================] - ETA: 0s - loss: 0.074 - 0s 502us/step
- loss: 0.0777
Epoch 98/600
60/60 [==============================] - 0s 296us/step - loss: 0.0783
Epoch 99/600
60/60 [==============================] - 0s 333us/step - loss: 0.0777
Epoch 100/600
60/60 [==============================] - 0s 234us/step - loss: 0.0773
Epoch 101/600
60/60 [==============================] - 0s 293us/step - loss: 0.0779
Epoch 102/600
60/60 [==============================] - 0s 191us/step - loss: 0.0792
Epoch 103/600
60/60 [==============================] - 0s 457us/step - loss: 0.0771
Epoch 104/600
60/60 [==============================] - 0s 348us/step - loss: 0.0770
Epoch 105/600
60/60 [==============================] - 0s 216us/step - loss: 0.0767
Epoch 106/600
60/60 [==============================] - 0s 267us/step - loss: 0.0763
Epoch 107/600
60/60 [==============================] - 0s 155us/step - loss: 0.0764
Epoch 108/600
60/60 [==============================] - 0s 204us/step - loss: 0.0763
Epoch 109/600
60/60 [==============================] - 0s 349us/step - loss: 0.0758
Epoch 110/600
60/60 [==============================] - 0s 211us/step - loss: 0.0758
Epoch 111/600
60/60 [==============================] - 0s 174us/step - loss: 0.0770
Epoch 112/600
60/60 [==============================] - 0s 240us/step - loss: 0.0766
Epoch 113/600
60/60 [==============================] - 0s 195us/step - loss: 0.0762
Epoch 114/600
60/60 [==============================] - 0s 233us/step - loss: 0.0755
Epoch 115/600
60/60 [==============================] - 0s 276us/step - loss: 0.0760
Epoch 116/600
60/60 [==============================] - 0s 214us/step - loss: 0.0785
Epoch 117/600
60/60 [==============================] - 0s 416us/step - loss: 0.0755
Epoch 118/600
60/60 [==============================] - 0s 183us/step - loss: 0.0768
Epoch 119/600
```

```
60/60 [==============================] - 0s 221us/step - loss: 0.0748
Epoch 120/600
60/60 [==============================] - 0s 342us/step - loss: 0.0744
Epoch 121/600
60/60 [==============================] - 0s 258us/step - loss: 0.0739
Epoch 122/600
60/60 [==============================] - 0s 228us/step - loss: 0.0735
Epoch 123/600
60/60 [==============================] - 0s 214us/step - loss: 0.0742
Epoch 124/600
60/60 [==============================] - 0s 259us/step - loss: 0.0745
Epoch 125/600
60/60 [==============================] - 0s 227us/step - loss: 0.0767
Epoch 126/600
60/60 [==============================] - 0s 248us/step - loss: 0.0750
Epoch 127/600
60/60 [==============================] - 0s 237us/step - loss: 0.0731
Epoch 128/600
60/60 [==============================] - 0s 218us/step - loss: 0.0746
Epoch 129/600
60/60 [==============================] - 0s 178us/step - loss: 0.0727
Epoch 130/600
60/60 [==============================] - 0s 205us/step - loss: 0.0727
Epoch 131/600
60/60 [==============================] - 0s 189us/step - loss: 0.0739
Epoch 132/600
60/60 [==============================] - 0s 170us/step - loss: 0.0726
Epoch 133/600
60/60 [==============================] - 0s 143us/step - loss: 0.0738
Epoch 134/600
60/60 [==============================] - 0s 178us/step - loss: 0.0726
Epoch 135/600
60/60 [==============================] - 0s 168us/step - loss: 0.0727
Epoch 136/600
60/60 [==============================] - 0s 168us/step - loss: 0.0724
Epoch 137/600
60/60 [==============================] - 0s 150us/step - loss: 0.0735
Epoch 138/600
60/60 [==============================] - 0s 173us/step - loss: 0.0715
Epoch 139/600
60/60 [==============================] - 0s 203us/step - loss: 0.0725
Epoch 140/600
60/60 [==============================] - 0s 198us/step - loss: 0.0720
Epoch 141/600
60/60 [==============================] - 0s 256us/step - loss: 0.0714
Epoch 142/600
60/60 [==============================] - 0s 129us/step - loss: 0.0718
Epoch 143/600
60/60 [==============================] - 0s 178us/step - loss: 0.0719
Epoch 144/600
60/60 [==============================] - 0s 205us/step - loss: 0.0710
Epoch 145/600
60/60 [==============================] - 0s 211us/step - loss: 0.0720
Epoch 146/600
60/60 [==============================] - 0s 196us/step - loss: 0.0719
Epoch 147/600
60/60 [==============================] - 0s 220us/step - loss: 0.0717
```

```
Epoch 148/600
60/60 [==============================] - 0s 209us/step - loss: 0.0709
Epoch 149/600
60/60 [==============================] - 0s 174us/step - loss: 0.0701
Epoch 150/600
60/60 [==============================] - 0s 242us/step - loss: 0.0702
Epoch 151/600
60/60 [==============================] - 0s 206us/step - loss: 0.0701
Epoch 152/600
60/60 [==============================] - 0s 187us/step - loss: 0.0699
Epoch 153/600
60/60 [==============================] - 0s 163us/step - loss: 0.0699
Epoch 154/600
60/60 [==============================] - 0s 194us/step - loss: 0.0698
Epoch 155/600
60/60 [==============================] - 0s 163us/step - loss: 0.0706
Epoch 156/600
60/60 [==============================] - 0s 213us/step - loss: 0.0699
Epoch 157/600
60/60 [==============================] - 0s 312us/step - loss: 0.0696
Epoch 158/600
60/60 [==============================] - 0s 177us/step - loss: 0.0718
Epoch 159/600
60/60 [==============================] - 0s 170us/step - loss: 0.0695
Epoch 160/600
60/60 [==============================] - 0s 173us/step - loss: 0.0693
Epoch 161/600
60/60 [==============================] - 0s 179us/step - loss: 0.0690
Epoch 162/600
60/60 [==============================] - 0s 163us/step - loss: 0.0713
Epoch 163/600
60/60 [==============================] - 0s 158us/step - loss: 0.0709
Epoch 164/600
60/60 [==============================] - 0s 181us/step - loss: 0.0703
Epoch 165/600
60/60 [==============================] - 0s 173us/step - loss: 0.0693
Epoch 166/600
60/60 [==============================] - 0s 177us/step - loss: 0.0694
Epoch 167/600
60/60 [==============================] - 0s 151us/step - loss: 0.0689
Epoch 168/600
60/60 [==============================] - 0s 149us/step - loss: 0.0690
Epoch 169/600
60/60 [==============================] - 0s 161us/step - loss: 0.0698
Epoch 170/600
60/60 [==============================] - 0s 182us/step - loss: 0.0689
Epoch 171/600
60/60 [==============================] - 0s 134us/step - loss: 0.0687
Epoch 172/600
60/60 [==============================] - 0s 167us/step - loss: 0.0687
Epoch 173/600
60/60 [==============================] - 0s 178us/step - loss: 0.0698
Epoch 174/600
60/60 [==============================] - 0s 201us/step - loss: 0.0704
Epoch 175/600
60/60 [==============================] - 0s 182us/step - loss: 0.0696
Epoch 176/600
```

```
60/60 [==============================] - 0s 305us/step - loss: 0.0683
Epoch 177/600
60/60 [==============================] - 0s 145us/step - loss: 0.0685
Epoch 178/600
60/60 [==============================] - 0s 158us/step - loss: 0.0692
Epoch 179/600
60/60 [==============================] - 0s 185us/step - loss: 0.0685
Epoch 180/600
60/60 [==============================] - 0s 168us/step - loss: 0.0682
Epoch 181/600
60/60 [==============================] - 0s 153us/step - loss: 0.0718
Epoch 182/600
60/60 [==============================] - 0s 163us/step - loss: 0.0682
Epoch 183/600
60/60 [==============================] - 0s 210us/step - loss: 0.0682
Epoch 184/600
60/60 [==============================] - 0s 244us/step - loss: 0.0680
Epoch 185/600
60/60 [==============================] - 0s 201us/step - loss: 0.0688
Epoch 186/600
60/60 [==============================] - 0s 250us/step - loss: 0.0679
Epoch 187/600
60/60 [==============================] - 0s 239us/step - loss: 0.0693
Epoch 188/600
60/60 [==============================] - 0s 290us/step - loss: 0.0680
Epoch 189/600
60/60 [==============================] - 0s 263us/step - loss: 0.0684
Epoch 190/600
60/60 [==============================] - 0s 224us/step - loss: 0.0683
Epoch 191/600
60/60 [==============================] - 0s 198us/step - loss: 0.0679
Epoch 192/600
60/60 [==============================] - 0s 330us/step - loss: 0.0680
Epoch 193/600
60/60 [==============================] - 0s 196us/step - loss: 0.0683
Epoch 194/600
60/60 [==============================] - 0s 180us/step - loss: 0.0687
Epoch 195/600
60/60 [==============================] - 0s 216us/step - loss: 0.0689
Epoch 196/600
60/60 [==============================] - 0s 282us/step - loss: 0.0702
Epoch 197/600
60/60 [==============================] - 0s 586us/step - loss: 0.0678
Epoch 198/600
60/60 [==============================] - 0s 310us/step - loss: 0.0675
Epoch 199/600
60/60 [==============================] - 0s 210us/step - loss: 0.0676
Epoch 200/600
60/60 [==============================] - 0s 292us/step - loss: 0.0672
Epoch 201/600
60/60 [==============================] - 0s 201us/step - loss: 0.0676
Epoch 202/600
60/60 [==============================] - 0s 220us/step - loss: 0.0689
Epoch 203/600
60/60 [==============================] - 0s 173us/step - loss: 0.0673
Epoch 204/600
60/60 [==============================] - 0s 208us/step - loss: 0.0674
```

```
Epoch 205/600
60/60 [==============================] - 0s 283us/step - loss: 0.0670
Epoch 206/600
60/60 [==============================] - 0s 238us/step - loss: 0.0694
Epoch 207/600
60/60 [==============================] - 0s 244us/step - loss: 0.0697
Epoch 208/600
60/60 [==============================] - 0s 363us/step - loss: 0.0672
Epoch 209/600
60/60 [==============================] - 0s 503us/step - loss: 0.0671
Epoch 210/600
60/60 [==============================] - 0s 544us/step - loss: 0.0689
Epoch 211/600
60/60 [==============================] - 0s 503us/step - loss: 0.0670
Epoch 212/600
60/60 [==============================] - 0s 287us/step - loss: 0.0676
Epoch 213/600
60/60 [==============================] - 0s 183us/step - loss: 0.0691
Epoch 214/600
60/60 [==============================] - 0s 231us/step - loss: 0.0670
Epoch 215/600
60/60 [==============================] - 0s 268us/step - loss: 0.0667
Epoch 216/600
60/60 [==============================] - 0s 201us/step - loss: 0.0670
Epoch 217/600
60/60 [==============================] - 0s 207us/step - loss: 0.0670
Epoch 218/600
60/60 [==============================] - 0s 363us/step - loss: 0.0664
Epoch 219/600
60/60 [==============================] - 0s 191us/step - loss: 0.0664
Epoch 220/600
60/60 [==============================] - 0s 178us/step - loss: 0.0664
Epoch 221/600
60/60 [==============================] - 0s 153us/step - loss: 0.0663
Epoch 222/600
60/60 [==============================] - 0s 214us/step - loss: 0.0669
Epoch 223/600
60/60 [==============================] - 0s 203us/step - loss: 0.0665
Epoch 224/600
60/60 [==============================] - 0s 197us/step - loss: 0.0668
Epoch 225/600
60/60 [==============================] - 0s 236us/step - loss: 0.0664
Epoch 226/600
60/60 [==============================] - 0s 333us/step - loss: 0.0677
Epoch 227/600
60/60 [==============================] - 0s 268us/step - loss: 0.0669
Epoch 228/600
60/60 [==============================] - 0s 184us/step - loss: 0.0659
Epoch 229/600
60/60 [==============================] - 0s 182us/step - loss: 0.0667
Epoch 230/600
60/60 [==============================] - 0s 190us/step - loss: 0.0656
Epoch 231/600
60/60 [==============================] - 0s 160us/step - loss: 0.0663
Epoch 232/600
60/60 [==============================] - 0s 246us/step - loss: 0.0672
Epoch 233/600
```

```
60/60 [==============================] - 0s 195us/step - loss: 0.0670
Epoch 234/600
60/60 [==============================] - 0s 202us/step - loss: 0.0659
Epoch 235/600
60/60 [==============================] - 0s 216us/step - loss: 0.0654
Epoch 236/600
60/60 [==============================] - 0s 167us/step - loss: 0.0661
Epoch 237/600
60/60 [==============================] - 0s 241us/step - loss: 0.0656
Epoch 238/600
60/60 [==============================] - 0s 319us/step - loss: 0.0663
Epoch 239/600
60/60 [==============================] - 0s 183us/step - loss: 0.0660
Epoch 240/600
60/60 [==============================] - 0s 188us/step - loss: 0.0659
Epoch 241/600
60/60 [==============================] - 0s 209us/step - loss: 0.0656
Epoch 242/600
60/60 [==============================] - 0s 205us/step - loss: 0.0652
Epoch 243/600
60/60 [==============================] - 0s 200us/step - loss: 0.0653
Epoch 244/600
60/60 [==============================] - 0s 259us/step - loss: 0.0659
Epoch 245/600
60/60 [==============================] - 0s 161us/step - loss: 0.0656
Epoch 246/600
60/60 [==============================] - 0s 147us/step - loss: 0.0661
Epoch 247/600
60/60 [==============================] - 0s 173us/step - loss: 0.0670
Epoch 248/600
60/60 [==============================] - 0s 240us/step - loss: 0.0652
Epoch 249/600
60/60 [==============================] - 0s 205us/step - loss: 0.0650
Epoch 250/600
60/60 [==============================] - 0s 222us/step - loss: 0.0656
Epoch 251/600
60/60 [==============================] - 0s 291us/step - loss: 0.0655
Epoch 252/600
60/60 [==============================] - 0s 250us/step - loss: 0.0649
Epoch 253/600
60/60 [==============================] - 0s 188us/step - loss: 0.0656
Epoch 254/600
60/60 [==============================] - 0s 274us/step - loss: 0.0664
Epoch 255/600
60/60 [==============================] - 0s 204us/step - loss: 0.0675
Epoch 256/600
60/60 [==============================] - 0s 217us/step - loss: 0.0651
Epoch 257/600
60/60 [==============================] - 0s 200us/step - loss: 0.0655
Epoch 258/600
60/60 [==============================] - 0s 190us/step - loss: 0.0644
Epoch 259/600
60/60 [==============================] - 0s 203us/step - loss: 0.0643
Epoch 260/600
60/60 [==============================] - 0s 212us/step - loss: 0.0653
Epoch 261/600
60/60 [==============================] - 0s 245us/step - loss: 0.0645
```

```
Epoch 262/600
60/60 [==============================] - 0s 200us/step - loss: 0.0657
Epoch 263/600
60/60 [==============================] - 0s 167us/step - loss: 0.0650
Epoch 264/600
60/60 [==============================] - 0s 166us/step - loss: 0.0644
Epoch 265/600
60/60 [==============================] - 0s 157us/step - loss: 0.0654
Epoch 266/600
60/60 [==============================] - 0s 171us/step - loss: 0.0669
Epoch 267/600
60/60 [==============================] - 0s 152us/step - loss: 0.0654
Epoch 268/600
60/60 [==============================] - 0s 168us/step - loss: 0.0651
Epoch 269/600
60/60 [==============================] - 0s 167us/step - loss: 0.0645
Epoch 270/600
60/60 [==============================] - 0s 208us/step - loss: 0.0641
Epoch 271/600
60/60 [==============================] - 0s 234us/step - loss: 0.0640
Epoch 272/600
60/60 [==============================] - 0s 211us/step - loss: 0.0638
Epoch 273/600
60/60 [==============================] - 0s 184us/step - loss: 0.0648
Epoch 274/600
60/60 [==============================] - 0s 202us/step - loss: 0.0641
Epoch 275/600
60/60 [==============================] - 0s 228us/step - loss: 0.0638
Epoch 276/600
60/60 [==============================] - 0s 274us/step - loss: 0.0647
Epoch 277/600
60/60 [==============================] - 0s 374us/step - loss: 0.0669
Epoch 278/600
60/60 [==============================] - 0s 189us/step - loss: 0.0650
Epoch 279/600
60/60 [==============================] - 0s 271us/step - loss: 0.0637
Epoch 280/600
60/60 [==============================] - 0s 186us/step - loss: 0.0652
Epoch 281/600
60/60 [==============================] - 0s 189us/step - loss: 0.0642
Epoch 282/600
60/60 [==============================] - 0s 247us/step - loss: 0.0642
Epoch 283/600
60/60 [==============================] - 0s 171us/step - loss: 0.0653
Epoch 284/600
60/60 [==============================] - 0s 194us/step - loss: 0.0636
Epoch 285/600
60/60 [==============================] - 0s 427us/step - loss: 0.0638
Epoch 286/600
60/60 [==============================] - 0s 217us/step - loss: 0.0635
Epoch 287/600
60/60 [==============================] - 0s 208us/step - loss: 0.0633
Epoch 288/600
60/60 [==============================] - 0s 208us/step - loss: 0.0636
Epoch 289/600
60/60 [==============================] - 0s 194us/step - loss: 0.0647
Epoch 290/600
```

```
60/60 [==============================] - 0s 187us/step - loss: 0.0648
Epoch 291/600
60/60 [==============================] - 0s 213us/step - loss: 0.0641
Epoch 292/600
60/60 [==============================] - 0s 226us/step - loss: 0.0633
Epoch 293/600
60/60 [==============================] - 0s 366us/step - loss: 0.0634
Epoch 294/600
60/60 [==============================] - 0s 210us/step - loss: 0.0630
Epoch 295/600
60/60 [==============================] - 0s 172us/step - loss: 0.0631
Epoch 296/600
60/60 [==============================] - 0s 259us/step - loss: 0.0632
Epoch 297/600
60/60 [==============================] - 0s 210us/step - loss: 0.0632
Epoch 298/600
60/60 [==============================] - 0s 217us/step - loss: 0.0633
Epoch 299/600
60/60 [==============================] - 0s 190us/step - loss: 0.0638
Epoch 300/600
60/60 [==============================] - 0s 273us/step - loss: 0.0630
Epoch 301/600
60/60 [==============================] - 0s 232us/step - loss: 0.0638
Epoch 302/600
60/60 [==============================] - 0s 170us/step - loss: 0.0640
Epoch 303/600
60/60 [==============================] - 0s 188us/step - loss: 0.0643
Epoch 304/600
60/60 [==============================] - 0s 212us/step - loss: 0.0642
Epoch 305/600
60/60 [==============================] - 0s 329us/step - loss: 0.0635
Epoch 306/600
60/60 [==============================] - 0s 262us/step - loss: 0.0629
Epoch 307/600
60/60 [==============================] - 0s 319us/step - loss: 0.0635
Epoch 308/600
60/60 [==============================] - 0s 278us/step - loss: 0.0649
Epoch 309/600
60/60 [==============================] - 0s 305us/step - loss: 0.0638
Epoch 310/600
60/60 [==============================] - 0s 249us/step - loss: 0.0631
Epoch 311/600
60/60 [==============================] - 0s 353us/step - loss: 0.0631
Epoch 312/600
60/60 [==============================] - 0s 317us/step - loss: 0.0626
Epoch 313/600
60/60 [==============================] - 0s 154us/step - loss: 0.0629
Epoch 314/600
60/60 [==============================] - 0s 202us/step - loss: 0.0625
Epoch 315/600
60/60 [==============================] - 0s 194us/step - loss: 0.0640
Epoch 316/600
60/60 [==============================] - 0s 190us/step - loss: 0.0642
Epoch 317/600
60/60 [==============================] - 0s 164us/step - loss: 0.0645
Epoch 318/600
60/60 [==============================] - 0s 247us/step - loss: 0.0628
```

```
Epoch 319/600
60/60 [==============================] - 0s 186us/step - loss: 0.0631
Epoch 320/600
60/60 [==============================] - 0s 270us/step - loss: 0.0634
Epoch 321/600
60/60 [==============================] - 0s 183us/step - loss: 0.0628
Epoch 322/600
60/60 [==============================] - 0s 156us/step - loss: 0.0633
Epoch 323/600
60/60 [==============================] - 0s 386us/step - loss: 0.0627
Epoch 324/600
60/60 [==============================] - 0s 206us/step - loss: 0.0624
Epoch 325/600
60/60 [==============================] - 0s 206us/step - loss: 0.0626
Epoch 326/600
60/60 [==============================] - 0s 246us/step - loss: 0.0623
Epoch 327/600
60/60 [==============================] - 0s 495us/step - loss: 0.0619
Epoch 328/600
60/60 [==============================] - 0s 300us/step - loss: 0.0622
Epoch 329/600
60/60 [==============================] - 0s 265us/step - loss: 0.0623
Epoch 330/600
60/60 [==============================] - 0s 406us/step - loss: 0.0627
Epoch 331/600
60/60 [==============================] - 0s 181us/step - loss: 0.0618
Epoch 332/600
60/60 [==============================] - 0s 237us/step - loss: 0.0624
Epoch 333/600
60/60 [==============================] - 0s 845us/step - loss: 0.0632
Epoch 334/600
60/60 [==============================] - 0s 475us/step - loss: 0.0622
Epoch 335/600
60/60 [==============================] - 0s 360us/step - loss: 0.0624
Epoch 336/600
60/60 [==============================] - 0s 229us/step - loss: 0.0619
Epoch 337/600
60/60 [==============================] - 0s 391us/step - loss: 0.0622
Epoch 338/600
60/60 [==============================] - 0s 305us/step - loss: 0.0619
Epoch 339/600
60/60 [==============================] - 0s 383us/step - loss: 0.0619
Epoch 340/600
60/60 [==============================] - 0s 406us/step - loss: 0.0637
Epoch 341/600
60/60 [==============================] - 0s 393us/step - loss: 0.0653
Epoch 342/600
60/60 [==============================] - 0s 261us/step - loss: 0.0624
Epoch 343/600
60/60 [==============================] - 0s 211us/step - loss: 0.0627
Epoch 344/600
60/60 [==============================] - 0s 227us/step - loss: 0.0626
Epoch 345/600
60/60 [==============================] - 0s 197us/step - loss: 0.0617
Epoch 346/600
60/60 [==============================] - 0s 341us/step - loss: 0.0615
Epoch 347/600
```

```
60/60 [==============================] - 0s 285us/step - loss: 0.0622
Epoch 348/600
60/60 [==============================] - 0s 226us/step - loss: 0.0616
Epoch 349/600
60/60 [==============================] - 0s 257us/step - loss: 0.0627
Epoch 350/600
60/60 [==============================] - 0s 433us/step - loss: 0.0620
Epoch 351/600
60/60 [==============================] - 0s 246us/step - loss: 0.0614
Epoch 352/600
60/60 [==============================] - 0s 212us/step - loss: 0.0629
Epoch 353/600
60/60 [==============================] - 0s 358us/step - loss: 0.0629
Epoch 354/600
60/60 [==============================] - 0s 257us/step - loss: 0.0617
Epoch 355/600
60/60 [==============================] - 0s 154us/step - loss: 0.0621
Epoch 356/600
60/60 [==============================] - 0s 236us/step - loss: 0.0614
Epoch 357/600
60/60 [==============================] - 0s 192us/step - loss: 0.0623
Epoch 358/600
60/60 [==============================] - 0s 513us/step - loss: 0.0617
Epoch 359/600
60/60 [==============================] - 0s 308us/step - loss: 0.0609
Epoch 360/600
60/60 [==============================] - 0s 153us/step - loss: 0.0624
Epoch 361/600
60/60 [==============================] - ETA: 0s - loss: 0.070 - 0s 214us/step
- loss: 0.0629
Epoch 362/600
60/60 [==============================] - 0s 227us/step - loss: 0.0607
Epoch 363/600
60/60 [==============================] - 0s 185us/step - loss: 0.0610
Epoch 364/600
60/60 [==============================] - 0s 380us/step - loss: 0.0611
Epoch 365/600
60/60 [==============================] - 0s 575us/step - loss: 0.0625
Epoch 366/600
60/60 [==============================] - 0s 288us/step - loss: 0.0612
Epoch 367/600
60/60 [==============================] - 0s 217us/step - loss: 0.0624
Epoch 368/600
60/60 [==============================] - 0s 250us/step - loss: 0.0604
Epoch 369/600
60/60 [==============================] - 0s 195us/step - loss: 0.0603
Epoch 370/600
60/60 [==============================] - 0s 487us/step - loss: 0.0627
Epoch 371/600
60/60 [==============================] - 0s 589us/step - loss: 0.0611
Epoch 372/600
60/60 [==============================] - ETA: 0s - loss: 0.059 - 0s 322us/step
- loss: 0.0637
Epoch 373/600
60/60 [==============================] - 0s 379us/step - loss: 0.0617
Epoch 374/600
60/60 [==============================] - 0s 240us/step - loss: 0.0606
```

```
Epoch 375/600
60/60 [==============================] - 0s 200us/step - loss: 0.0617
Epoch 376/600
60/60 [==============================] - 0s 176us/step - loss: 0.0624
Epoch 377/600
60/60 [==============================] - 0s 172us/step - loss: 0.0610
Epoch 378/600
60/60 [==============================] - 0s 218us/step - loss: 0.0609
Epoch 379/600
60/60 [==============================] - 0s 210us/step - loss: 0.0607
Epoch 380/600
60/60 [==============================] - 0s 337us/step - loss: 0.0605
Epoch 381/600
60/60 [==============================] - 0s 285us/step - loss: 0.0619
Epoch 382/600
60/60 [==============================] - 0s 456us/step - loss: 0.0600
Epoch 383/600
60/60 [==============================] - 0s 280us/step - loss: 0.0601
Epoch 384/600
60/60 [==============================] - 0s 278us/step - loss: 0.0619
Epoch 385/600
60/60 [==============================] - 0s 636us/step - loss: 0.0601
Epoch 386/600
60/60 [==============================] - 0s 299us/step - loss: 0.0618
Epoch 387/600
60/60 [==============================] - 0s 237us/step - loss: 0.0609
Epoch 388/600
60/60 [==============================] - 0s 239us/step - loss: 0.0620
Epoch 389/600
60/60 [==============================] - 0s 245us/step - loss: 0.0603
Epoch 390/600
60/60 [==============================] - 0s 278us/step - loss: 0.0606
Epoch 391/600
60/60 [==============================] - 0s 355us/step - loss: 0.0599
Epoch 392/600
60/60 [==============================] - 0s 597us/step - loss: 0.0615
Epoch 393/600
60/60 [==============================] - 0s 182us/step - loss: 0.0602
Epoch 394/600
60/60 [==============================] - 0s 273us/step - loss: 0.0602
Epoch 395/600
60/60 [==============================] - 0s 274us/step - loss: 0.0600
Epoch 396/600
60/60 [==============================] - 0s 253us/step - loss: 0.0606
Epoch 397/600
60/60 [==============================] - 0s 251us/step - loss: 0.0604
Epoch 398/600
60/60 [==============================] - 0s 300us/step - loss: 0.0609
Epoch 399/600
60/60 [==============================] - 0s 240us/step - loss: 0.0610
Epoch 400/600
60/60 [==============================] - 0s 370us/step - loss: 0.0604
Epoch 401/600
60/60 [==============================] - 0s 345us/step - loss: 0.0608
Epoch 402/600
60/60 [==============================] - 0s 390us/step - loss: 0.0599
Epoch 403/600
```

```
60/60 [==============================] - 0s 490us/step - loss: 0.0596
Epoch 404/600
60/60 [==============================] - 0s 383us/step - loss: 0.0604
Epoch 405/600
60/60 [==============================] - 0s 794us/step - loss: 0.0599
Epoch 406/600
60/60 [==============================] - 0s 381us/step - loss: 0.0599
Epoch 407/600
60/60 [==============================] - 0s 220us/step - loss: 0.0603
Epoch 408/600
60/60 [==============================] - 0s 223us/step - loss: 0.0601
Epoch 409/600
60/60 [==============================] - 0s 455us/step - loss: 0.0598
Epoch 410/600
60/60 [==============================] - 0s 219us/step - loss: 0.0610
Epoch 411/600
60/60 [==============================] - 0s 233us/step - loss: 0.0603
Epoch 412/600
60/60 [==============================] - 0s 205us/step - loss: 0.0619
Epoch 413/600
60/60 [==============================] - 0s 175us/step - loss: 0.0597
Epoch 414/600
60/60 [==============================] - 0s 172us/step - loss: 0.0605
Epoch 415/600
60/60 [==============================] - 0s 282us/step - loss: 0.0593
Epoch 416/600
60/60 [==============================] - 0s 334us/step - loss: 0.0594
Epoch 417/600
60/60 [==============================] - 0s 208us/step - loss: 0.0590
Epoch 418/600
60/60 [==============================] - 0s 263us/step - loss: 0.0593
Epoch 419/600
60/60 [==============================] - 0s 227us/step - loss: 0.0613
Epoch 420/600
60/60 [==============================] - 0s 232us/step - loss: 0.0590
Epoch 421/600
60/60 [==============================] - 0s 198us/step - loss: 0.0607
Epoch 422/600
60/60 [==============================] - 0s 424us/step - loss: 0.0596
Epoch 423/600
60/60 [==============================] - 0s 250us/step - loss: 0.0600
Epoch 424/600
60/60 [==============================] - 0s 193us/step - loss: 0.0624
Epoch 425/600
60/60 [==============================] - 0s 237us/step - loss: 0.0593
Epoch 426/600
60/60 [==============================] - 0s 222us/step - loss: 0.0587
Epoch 427/600
60/60 [==============================] - 0s 200us/step - loss: 0.0592
Epoch 428/600
60/60 [==============================] - 0s 429us/step - loss: 0.0588
Epoch 429/600
60/60 [==============================] - 0s 256us/step - loss: 0.0597
Epoch 430/600
60/60 [==============================] - 0s 240us/step - loss: 0.0596
Epoch 431/600
60/60 [==============================] - 0s 168us/step - loss: 0.0588
```

```
Epoch 432/600
60/60 [==============================] - 0s 176us/step - loss: 0.0591
Epoch 433/600
60/60 [==============================] - 0s 235us/step - loss: 0.0594
Epoch 434/600
60/60 [==============================] - 0s 184us/step - loss: 0.0591
Epoch 435/600
60/60 [==============================] - 0s 263us/step - loss: 0.0601
Epoch 436/600
60/60 [==============================] - 0s 283us/step - loss: 0.0587
Epoch 437/600
60/60 [==============================] - 0s 267us/step - loss: 0.0595
Epoch 438/600
60/60 [==============================] - 0s 218us/step - loss: 0.0587
Epoch 439/600
60/60 [==============================] - 0s 264us/step - loss: 0.0587
Epoch 440/600
60/60 [==============================] - 0s 211us/step - loss: 0.0600
Epoch 441/600
60/60 [==============================] - 0s 270us/step - loss: 0.0600
Epoch 442/600
60/60 [==============================] - 0s 418us/step - loss: 0.0598
Epoch 443/600
60/60 [==============================] - 0s 205us/step - loss: 0.0586
Epoch 444/600
60/60 [==============================] - 0s 167us/step - loss: 0.0585
Epoch 445/600
60/60 [==============================] - 0s 192us/step - loss: 0.0596
Epoch 446/600
60/60 [==============================] - 0s 223us/step - loss: 0.0617
Epoch 447/600
60/60 [==============================] - 0s 220us/step - loss: 0.0581
Epoch 448/600
60/60 [==============================] - 0s 497us/step - loss: 0.0591
Epoch 449/600
60/60 [==============================] - 0s 250us/step - loss: 0.0581
Epoch 450/600
60/60 [==============================] - 0s 175us/step - loss: 0.0597
Epoch 451/600
60/60 [==============================] - 0s 189us/step - loss: 0.0594
Epoch 452/600
60/60 [==============================] - 0s 235us/step - loss: 0.0587
Epoch 453/600
60/60 [==============================] - 0s 233us/step - loss: 0.0585
Epoch 454/600
60/60 [==============================] - 0s 472us/step - loss: 0.0586
Epoch 455/600
60/60 [==============================] - 0s 265us/step - loss: 0.0581
Epoch 456/600
60/60 [==============================] - 0s 213us/step - loss: 0.0582
Epoch 457/600
60/60 [==============================] - ETA: 0s - loss: 0.052 - 0s 329us/step
- loss: 0.0580
Epoch 458/600
60/60 [==============================] - 0s 266us/step - loss: 0.0614
Epoch 459/600
60/60 [==============================] - 0s 344us/step - loss: 0.0618
```

```
Epoch 460/600
60/60 [==============================] - 0s 316us/step - loss: 0.0581
Epoch 461/600
60/60 [==============================] - 0s 358us/step - loss: 0.0585
Epoch 462/600
60/60 [==============================] - 0s 284us/step - loss: 0.0620
Epoch 463/600
60/60 [==============================] - 0s 321us/step - loss: 0.0603
Epoch 464/600
60/60 [==============================] - 0s 226us/step - loss: 0.0578
Epoch 465/600
60/60 [==============================] - 0s 187us/step - loss: 0.0588
Epoch 466/600
60/60 [==============================] - 0s 202us/step - loss: 0.0583
Epoch 467/600
60/60 [==============================] - 0s 172us/step - loss: 0.0577
Epoch 468/600
60/60 [==============================] - 0s 182us/step - loss: 0.0588
Epoch 469/600
60/60 [==============================] - 0s 211us/step - loss: 0.0615
Epoch 470/600
60/60 [==============================] - 0s 243us/step - loss: 0.0611
Epoch 471/600
60/60 [==============================] - 0s 513us/step - loss: 0.0587
Epoch 472/600
60/60 [==============================] - 0s 383us/step - loss: 0.0577
Epoch 473/600
60/60 [==============================] - 0s 815us/step - loss: 0.0589
Epoch 474/600
60/60 [==============================] - 0s 353us/step - loss: 0.0579
Epoch 475/600
60/60 [==============================] - 0s 229us/step - loss: 0.0622
Epoch 476/600
60/60 [==============================] - 0s 336us/step - loss: 0.0583
Epoch 477/600
60/60 [==============================] - 0s 230us/step - loss: 0.0575
Epoch 478/600
60/60 [==============================] - 0s 326us/step - loss: 0.0576
Epoch 479/600
60/60 [==============================] - 0s 330us/step - loss: 0.0583
Epoch 480/600
60/60 [==============================] - 0s 188us/step - loss: 0.0572
Epoch 481/600
60/60 [==============================] - 0s 194us/step - loss: 0.0579
Epoch 482/600
60/60 [==============================] - 0s 260us/step - loss: 0.0579
Epoch 483/600
60/60 [==============================] - 0s 259us/step - loss: 0.0600
Epoch 484/600
60/60 [==============================] - 0s 274us/step - loss: 0.0574
Epoch 485/600
60/60 [==============================] - 0s 468us/step - loss: 0.0579
Epoch 486/600
60/60 [==============================] - 0s 200us/step - loss: 0.0581
Epoch 487/600
60/60 [==============================] - 0s 205us/step - loss: 0.0576
Epoch 488/600
```

```
60/60 [==============================] - 0s 236us/step - loss: 0.0569
Epoch 489/600
60/60 [==============================] - 0s 202us/step - loss: 0.0583
Epoch 490/600
60/60 [==============================] - 0s 247us/step - loss: 0.0601
Epoch 491/600
60/60 [==============================] - 0s 330us/step - loss: 0.0578
Epoch 492/600
60/60 [==============================] - 0s 198us/step - loss: 0.0583
Epoch 493/600
60/60 [==============================] - 0s 353us/step - loss: 0.0571
Epoch 494/600
60/60 [==============================] - 0s 231us/step - loss: 0.0570
Epoch 495/600
60/60 [==============================] - 0s 223us/step - loss: 0.0568
Epoch 496/600
60/60 [==============================] - 0s 248us/step - loss: 0.0577
Epoch 497/600
60/60 [==============================] - 0s 180us/step - loss: 0.0586
Epoch 498/600
60/60 [==============================] - 0s 206us/step - loss: 0.0568
Epoch 499/600
60/60 [==============================] - 0s 177us/step - loss: 0.0568
Epoch 500/600
60/60 [==============================] - 0s 167us/step - loss: 0.0578
Epoch 501/600
60/60 [==============================] - 0s 215us/step - loss: 0.0578
Epoch 502/600
60/60 [==============================] - 0s 178us/step - loss: 0.0570
Epoch 503/600
60/60 [==============================] - 0s 208us/step - loss: 0.0579
Epoch 504/600
60/60 [==============================] - 0s 483us/step - loss: 0.0568
Epoch 505/600
60/60 [==============================] - 0s 354us/step - loss: 0.0576
Epoch 506/600
60/60 [==============================] - 0s 206us/step - loss: 0.0567
Epoch 507/600
60/60 [==============================] - 0s 186us/step - loss: 0.0570
Epoch 508/600
60/60 [==============================] - 0s 204us/step - loss: 0.0571
Epoch 509/600
60/60 [==============================] - 0s 188us/step - loss: 0.0570
Epoch 510/600
60/60 [==============================] - 0s 339us/step - loss: 0.0585
Epoch 511/600
60/60 [==============================] - 0s 390us/step - loss: 0.0590
Epoch 512/600
60/60 [==============================] - 0s 311us/step - loss: 0.0564
Epoch 513/600
60/60 [==============================] - 0s 443us/step - loss: 0.0596
Epoch 514/600
60/60 [==============================] - 0s 323us/step - loss: 0.0590
Epoch 515/600
60/60 [==============================] - 0s 251us/step - loss: 0.0567
Epoch 516/600
60/60 [==============================] - 0s 195us/step - loss: 0.0583
```

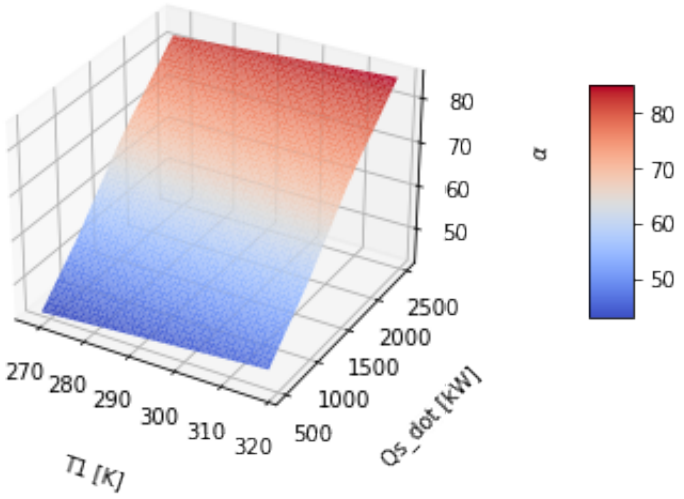
```
Epoch 517/600
60/60 [==============================] - 0s 169us/step - loss: 0.0578
Epoch 518/600
60/60 [==============================] - 0s 198us/step - loss: 0.0577
Epoch 519/600
60/60 [==============================] - 0s 217us/step - loss: 0.0599
Epoch 520/600
60/60 [==============================] - 0s 198us/step - loss: 0.0621
Epoch 521/600
60/60 [==============================] - 0s 188us/step - loss: 0.0579
Epoch 522/600
60/60 [==============================] - 0s 165us/step - loss: 0.0579
Epoch 523/600
60/60 [==============================] - 0s 322us/step - loss: 0.0578
Epoch 524/600
60/60 [==============================] - 0s 273us/step - loss: 0.0571
Epoch 525/600
60/60 [==============================] - 0s 183us/step - loss: 0.0568
Epoch 526/600
60/60 [==============================] - 0s 199us/step - loss: 0.0586
Epoch 527/600
60/60 [==============================] - 0s 198us/step - loss: 0.0566
Epoch 528/600
60/60 [==============================] - 0s 230us/step - loss: 0.0570
Epoch 529/600
60/60 [==============================] - 0s 226us/step - loss: 0.0587
Epoch 530/600
60/60 [==============================] - 0s 183us/step - loss: 0.0583
Epoch 531/600
60/60 [==============================] - 0s 371us/step - loss: 0.0570
Epoch 532/600
60/60 [==============================] - 0s 350us/step - loss: 0.0561
Epoch 533/600
60/60 [==============================] - 0s 160us/step - loss: 0.0558
Epoch 534/600
60/60 [==============================] - 0s 190us/step - loss: 0.0574
Epoch 535/600
60/60 [==============================] - 0s 320us/step - loss: 0.0556
Epoch 536/600
60/60 [==============================] - 0s 537us/step - loss: 0.0596
Epoch 537/600
60/60 [==============================] - 0s 481us/step - loss: 0.0571
Epoch 538/600
60/60 [==============================] - 0s 199us/step - loss: 0.0578
Epoch 539/600
60/60 [==============================] - 0s 221us/step - loss: 0.0566
Epoch 540/600
60/60 [==============================] - 0s 211us/step - loss: 0.0559
Epoch 541/600
60/60 [==============================] - 0s 358us/step - loss: 0.0582
Epoch 542/600
60/60 [==============================] - 0s 157us/step - loss: 0.0557
Epoch 543/600
60/60 [==============================] - 0s 161us/step - loss: 0.0561
Epoch 544/600
60/60 [==============================] - 0s 168us/step - loss: 0.0568
Epoch 545/600
```

```
60/60 [==============================] - 0s 210us/step - loss: 0.0562
Epoch 546/600
60/60 [==============================] - 0s 156us/step - loss: 0.0556
Epoch 547/600
60/60 [==============================] - 0s 144us/step - loss: 0.0565
Epoch 548/600
60/60 [==============================] - 0s 146us/step - loss: 0.0562
Epoch 549/600
60/60 [==============================] - 0s 258us/step - loss: 0.0577
Epoch 550/600
60/60 [==============================] - 0s 211us/step - loss: 0.0564
Epoch 551/600
60/60 [==============================] - 0s 201us/step - loss: 0.0570
Epoch 552/600
60/60 [==============================] - 0s 227us/step - loss: 0.0586
Epoch 553/600
60/60 [==============================] - 0s 200us/step - loss: 0.0579
Epoch 554/600
60/60 [==============================] - 0s 236us/step - loss: 0.0573
Epoch 555/600
60/60 [==============================] - 0s 244us/step - loss: 0.0555
Epoch 556/600
60/60 [==============================] - 0s 147us/step - loss: 0.0583
Epoch 557/600
60/60 [==============================] - 0s 146us/step - loss: 0.0567
Epoch 558/600
60/60 [==============================] - 0s 171us/step - loss: 0.0591
Epoch 559/600
60/60 [==============================] - 0s 258us/step - loss: 0.0555
Epoch 560/600
60/60 [==============================] - 0s 243us/step - loss: 0.0558
Epoch 561/600
60/60 [==============================] - 0s 258us/step - loss: 0.0556
Epoch 562/600
60/60 [==============================] - 0s 170us/step - loss: 0.0553
Epoch 563/600
60/60 [==============================] - 0s 222us/step - loss: 0.0554
Epoch 564/600
60/60 [==============================] - 0s 213us/step - loss: 0.0563
Epoch 565/600
60/60 [==============================] - 0s 268us/step - loss: 0.0568
Epoch 566/600
60/60 [==============================] - 0s 294us/step - loss: 0.0564
Epoch 567/600
60/60 [==============================] - 0s 351us/step - loss: 0.0552
Epoch 568/600
60/60 [==============================] - 0s 315us/step - loss: 0.0558
Epoch 569/600
60/60 [==============================] - 0s 292us/step - loss: 0.0571
Epoch 570/600
60/60 [==============================] - 0s 370us/step - loss: 0.0564
Epoch 571/600
60/60 [==============================] - 0s 506us/step - loss: 0.0551
Epoch 572/600
60/60 [==============================] - 0s 384us/step - loss: 0.0552
Epoch 573/600
60/60 [==============================] - 0s 337us/step - loss: 0.0552
```

```
Epoch 574/600
60/60 [==============================] - 0s 353us/step - loss: 0.0596
Epoch 575/600
60/60 [==============================] - 0s 419us/step - loss: 0.0553
Epoch 576/600
60/60 [==============================] - 0s 374us/step - loss: 0.0559
Epoch 577/600
60/60 [==============================] - 0s 327us/step - loss: 0.0552
Epoch 578/600
60/60 [==============================] - 0s 503us/step - loss: 0.0549
Epoch 579/600
60/60 [==============================] - 0s 409us/step - loss: 0.0549
Epoch 580/600
60/60 [==============================] - 0s 393us/step - loss: 0.0550
Epoch 581/600
60/60 [==============================] - 0s 422us/step - loss: 0.0553
Epoch 582/600
60/60 [==============================] - 0s 189us/step - loss: 0.0553
Epoch 583/600
60/60 [==============================] - 0s 185us/step - loss: 0.0556
Epoch 584/600
60/60 [==============================] - 0s 217us/step - loss: 0.0546
Epoch 585/600
60/60 [==============================] - 0s 228us/step - loss: 0.0548
Epoch 586/600
60/60 [==============================] - 0s 160us/step - loss: 0.0553
Epoch 587/600
60/60 [==============================] - 0s 178us/step - loss: 0.0560
Epoch 588/600
60/60 [==============================] - 0s 179us/step - loss: 0.0546
Epoch 589/600
60/60 [==============================] - 0s 177us/step - loss: 0.0556
Epoch 590/600
60/60 [==============================] - 0s 212us/step - loss: 0.0556
Epoch 591/600
60/60 [==============================] - 0s 225us/step - loss: 0.0549
Epoch 592/600
60/60 [==============================] - 0s 202us/step - loss: 0.0549
Epoch 593/600
60/60 [==============================] - 0s 179us/step - loss: 0.0553
Epoch 594/600
60/60 [==============================] - 0s 194us/step - loss: 0.0561
Epoch 595/600
60/60 [==============================] - 0s 200us/step - loss: 0.0555
Epoch 596/600
60/60 [==============================] - 0s 185us/step - loss: 0.0566
Epoch 597/600
60/60 [==============================] - 0s 176us/step - loss: 0.0554
Epoch 598/600
60/60 [==============================] - 0s 260us/step - loss: 0.0544
Epoch 599/600
60/60 [==============================] - 0s 174us/step - loss: 0.0544
Epoch 600/600
60/60 [==============================] - 0s 209us/step - loss: 0.0553
best epoch =  598
smallest loss = 0.054399729271729785
```

In [42]:

```
#Task2.2
import matplotlib.pyplot as plt
import numpy as np
#from mpl_toolkits.mplot3d import  Axes3D
#from matplotlib import cm # to colormap 3D surfaces from blue to red
#from matplotlib.ticker import LinearLocator, FormatStrFormatter

fig = plt.figure()
ax = plt.axes(projection='3d')

X = np.linspace(268, 318)
Y = np.linspace(500, 2500)
Zp = []
Xp = []
Yp = []
gamma = 0.25
testdata = []

Xn = X/Tmed
gn = gamma/gamed
Yn = Y/qsmed

for x in range(len(Xn)):
    for y in range(len(Yn)):
        testdata.append([Xn[x], gn, Yn[y]])
        Xp.append(Xn[x]*Tmed)
        Yp.append(Yn[y]*qsmed)

for x in range(len(testdata)):
    test = [[testdata[x][0], testdata[x][1], testdata[x][2]]]
    testarray = np.array(test)
    outptn = model.predict(testarray)
    Zp.append(outptn[0][0]*almed)

surf = ax.plot_trisurf(Xp, Yp, Zp, cmap=cm.coolwarm)
fig.colorbar(surf, shrink=0.5, aspect=5, pad=0.2)
ax.set_zlabel(r'$\alpha$', rotation=60)
ax.set_ylabel('Qs_dot [kW]')
ax.set_xlabel('T1 [K]', rotation=150)
ax.xaxis.labelpad=15
ax.yaxis.labelpad=15
ax.zaxis.labelpad=15

plt.show()
```



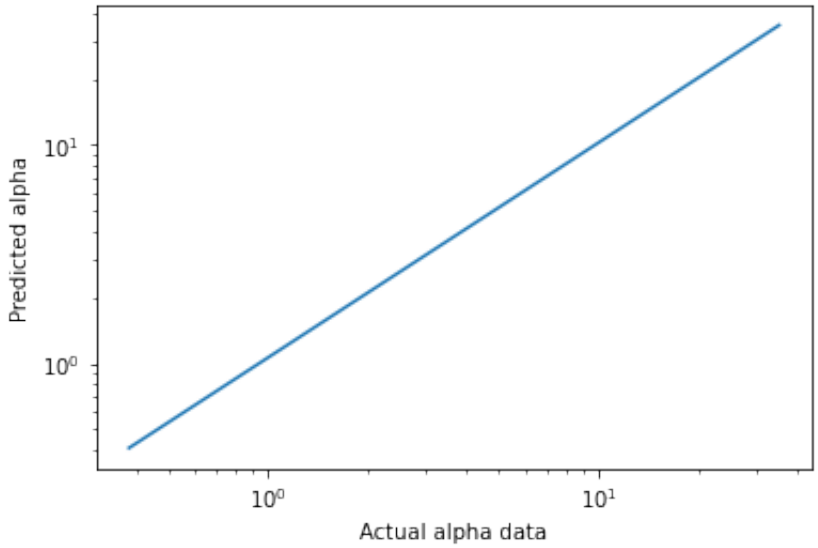
In [45]:

```
#Task 2.3
from sklearn import metrics

test = []
outpt=[]
outptdata=[]
testn = []
outptn = []

test.append([318.0, 0.0, 500.0])
test.append([318.0, 0.0, 1500.0])
test.append([318.0, 0.0, 2500.0])
test.append([318.0, 0.25, 1500.0])
test.append([318.0, 0.5, 500.0])
test.append([318.0, 0.5, 1500.0])
test.append([318.0, 0.5, 2500.0])
test.append([318.0, 0.0, 1000.0])
test.append([318.0, 0.0, 2000.0])
test.append([318.0, 0.25, 1000.0])
test.append([318.0, 0.25, 2000.0])
test.append([318.0, 0.5, 1000.0])
test.append([318.0, 0.5, 2000.0])
test.append([318.0, 0.0, 500.0])
test.append([318.0, 0.0, 2500.0])
test.append([318.0, 0.25, 2500.0])
test.append([318.0, 0.5, 1500.0])
test.append([318.0, 0.0, 1500.0])
test.append([318.0, 0.25, 2000.0])
test.append([318.0, 0.5, 2500.0])

outptdata.append([35.13, 0.3808])
outptdata.append([47.46, 0.3930])
outptdata.append([73.12, 0.4061])
outptdata.append([66.34, 0.4098])
outptdata.append([63.09, 0.4154])
```

```
outptdata.append([85.23, 0.4197])
outptdata.append([131.32, 0.4242])
outptdata.append([38.99, 0.4012])
outptdata.append([53.80, 0.4136])
outptdata.append([54.51, 0.4215])
outptdata.append([75.22, 0.4290])
outptdata.append([70.04, 0.4337])
outptdata.append([96.65, 0.4382])
outptdata.append([33.45, 0.4091])
outptdata.append([60.80, 0.4334])
outptdata.append([85.044, 0.4477])
outptdata.append([77.56, 0.4516])
outptdata.append([40.68, 0.4383])
outptdata.append([65.24, 0.4628])
outptdata.append([98.23, 0.4760])

for x in range(len(test)):
    testn.append([test[x][0]/Tmed, test[x][1]/gamed, test[x][2]/qsmed] )

#first point (row [0])comparison of data and prediction
# put in a loop to print comparion for all data points
for x in range(len(testn)):
    test = [[testn[x][0], testn[x][1], testn[x][2]]]
    testarray = np.array(test)
    outptn = model.predict(testarray)
    outpt.append([outptn[0][0]*almed, outptn[0][1]*efmed])
    print ('row[',x,'] data: T1 = ', testn[x][0]*Tmed, ', gam= ', testn[x][1]
        ', qsol= ', testn[x][2]*qsmed,', alpha= ', outptdata[x][0],\
        ',  predicted alpha = ', outpt[x][0])

plt.figure()
plt.loglog(outptdata[:][0], outpt[:][0])
plt.xlabel("Actual alpha data")
plt.ylabel("Predicted alpha")
plt.show()

#RMS of predicted vs test data
rms_alpha = np.sqrt(metrics.mean_squared_error(outptdata[:][0],outpt[:][0]))
rms_ef = np.sqrt(metrics.mean_squared_error(outptdata[:][1],outpt[:][1]))
print('rms deviation between predictions and the collection of test data: alp
```

```
row[ 0 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  500.0 , alpha=  3
5.13 ,  predicted alpha =  35.35579579508007
row[ 1 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  1500.0 , alpha=
47.46 ,  predicted alpha =  46.10397140096426
row[ 2 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  2500.0 , alpha=
73.12 ,  predicted alpha =  63.713636228460075
row[ 3 ] data: T1 =  317.99999999999994 , gam=  0.25 , qsol=  1500.0 , alpha=
66.34 ,  predicted alpha =  66.66348148511052
row[ 4 ] data: T1 =  317.99999999999994 , gam=  0.5 , qsol=  500.0 , alpha=  6
3.09 ,  predicted alpha =  62.261566764038804
row[ 5 ] data: T1 =  317.99999999999994 , gam=  0.5 , qsol=  1500.0 , alpha=
85.23 ,  predicted alpha =  81.56974759143591
row[ 6 ] data: T1 =  317.99999999999994 , gam=  0.5 , qsol=  2500.0 , alpha=
```

```
131.32 ,  predicted alpha =  106.33833925239445
row[ 7 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  1000.0 , alpha=
38.99 ,  predicted alpha =  40.894876074126365
row[ 8 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  2000.0 , alpha=
53.8 ,  predicted alpha =  54.58968013318778
row[ 9 ] data: T1 =  317.99999999999994 , gam=  0.25 , qsol=  1000.0 , alpha=
54.51 ,  predicted alpha =  55.812112866219884
row[ 10 ] data: T1 =  317.99999999999994 , gam=  0.25 , qsol=  2000.0 , alpha=
75.22 ,  predicted alpha =  76.62401072491409
row[ 11 ] data: T1 =  317.99999999999994 , gam=  0.5 , qsol=  1000.0 , alpha=
70.04 ,  predicted alpha =  71.94912725197078
row[ 12 ] data: T1 =  317.99999999999994 , gam=  0.5 , qsol=  2000.0 , alpha=
96.65 ,  predicted alpha =  93.23908514338733
row[ 13 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  500.0 , alpha=
33.45 ,  predicted alpha =  35.35579579508007
row[ 14 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  2500.0 , alpha=
60.8 ,  predicted alpha =  63.713636228460075
row[ 15 ] data: T1 =  317.99999999999994 , gam=  0.25 , qsol=  2500.0 , alpha=
85.044 ,  predicted alpha =  85.31592312467694
row[ 16 ] data: T1 =  317.99999999999994 , gam=  0.5 , qsol=  1500.0 , alpha=
77.56 ,  predicted alpha =  81.56974759143591
row[ 17 ] data: T1 =  317.99999999999994 , gam=  0.0 , qsol=  1500.0 , alpha=
40.68 ,  predicted alpha =  46.10397140096426
row[ 18 ] data: T1 =  317.99999999999994 , gam=  0.25 , qsol=  2000.0 , alpha=
65.24 ,  predicted alpha =  76.62401072491409
row[ 19 ] data: T1 =  317.99999999999994 , gam=  0.5 , qsol=  2500.0 , alpha=
98.23 ,  predicted alpha =  106.33833925239445
```

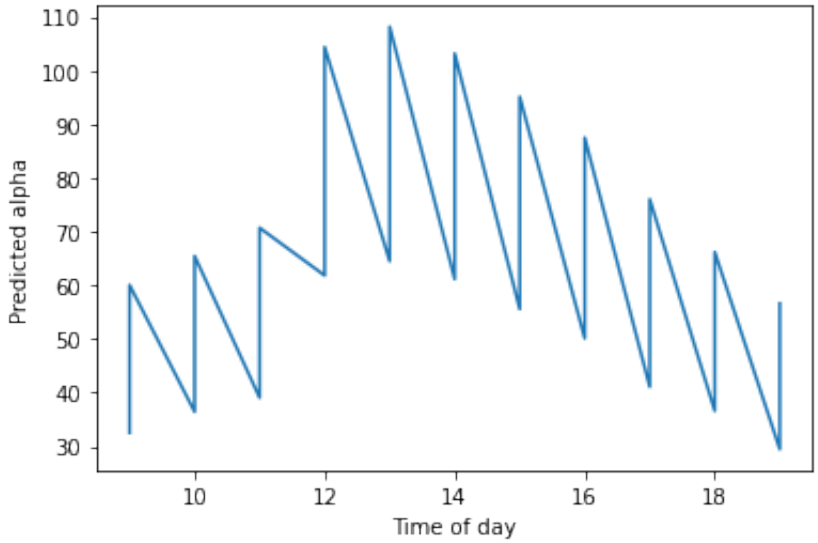



```
rms deviation between predictions and the collection of test data: alpha = 0.1
6097612804647565  ef =  0.958976451567033
```

In [46]:

```
#Task 2.3 Part b
test = []
outpt=[]
testn = []
outptn = []
time = []
pred_alpha = []

test.append([287.0, 0.0, 500.0, 9])
test.append([287.0, 0.5, 500.0, 9])
test.append([295.0, 0.0, 750.0, 10])
test.append([295.0, 0.5, 750.0, 10])
test.append([301.0, 0.0, 1000.0, 11])
test.append([301.0, 0.5, 1000.0, 11])
test.append([305.0, 0.0, 2450.0, 12])
test.append([305.0, 0.5, 2450.0, 12])
test.append([307.0, 0.0, 2600.0, 13])
test.append([307.0, 0.5, 2600.0, 13])
test.append([308.0, 0.0, 2400.0, 14])
test.append([308.0, 0.5, 2400.0, 14])
test.append([308.0, 0.0, 2100.0, 15])
test.append([308.0, 0.5, 2100.0, 15])
test.append([305.0, 0.0, 1800.0, 16])
test.append([305.0, 0.5, 1800.0, 16])
test.append([295.0, 0.0, 1300.0, 17])
test.append([295.0, 0.5, 1300.0, 17])
test.append([292.0, 0.0, 800.0, 18])
test.append([292.0, 0.5, 800.0, 18])
test.append([295.0, 0.0, 250.0, 19])
test.append([295.0, 0.5, 250.0, 19])

for x in range(len(test)):
    testn.append([test[x][0]/Tmed, test[x][1]/gamed, test[x][2]/qsmed] )
    time.append(test[x][3])

#first point (row [0])comparison of data and prediction
# put in a loop to print comparion for all data points
for x in range(len(testn)):
    test = [[testn[x][0], testn[x][1], testn[x][2]]]
    testarray = np.array(test)
    outptn = model.predict(testarray)
    outpt.append([outptn[0][0]*almed, outptn[0][1]*efmed])
    pred_alpha.append(outpt[x][0])
    print ('row[',x,'] data: T1 = ', testn[x][0]*Tmed, ', gam= ', testn[x][1]
        ', qsol= ', testn[x][2]*qsmed, ',  predicted alpha = ', outpt[x][0])

plt.figure()
plt.plot(time, pred_alpha)
plt.xlabel("Time of day")
plt.ylabel("Predicted alpha")
plt.show()
```

```
row[ 0 ] data: T1 =  287.0 , gam=  0.0 , qsol=  500.0 ,  predicted alpha =  32
.51046017961502
row[ 1 ] data: T1 =  287.0 , gam=  0.5 , qsol=  500.0 ,  predicted alpha =  60
.03040354594589
row[ 2 ] data: T1 =  295.0 , gam=  0.0 , qsol=  750.0 ,  predicted alpha =  36
.42781925913692
row[ 3 ] data: T1 =  295.0 , gam=  0.5 , qsol=  750.0 ,  predicted alpha =  65
.44025002196432
row[ 4 ] data: T1 =  301.0 , gam=  0.0 , qsol=  1000.0 ,  predicted alpha =  3
9.04131890002191
row[ 5 ] data: T1 =  301.0 , gam=  0.5 , qsol=  1000.0 ,  predicted alpha =  7
0.69393928992153
row[ 6 ] data: T1 =  305.0 , gam=  0.0 , qsol=  2450.0 ,  predicted alpha =  6
1.81680174141527
row[ 7 ] data: T1 =  305.0 , gam=  0.5 , qsol=  2450.0 ,  predicted alpha =  1
04.37455732254386
row[ 8 ] data: T1 =  307.0 , gam=  0.0 , qsol=  2600.0 ,  predicted alpha =  6
4.48669026948811
row[ 9 ] data: T1 =  307.0 , gam=  0.5 , qsol=  2600.0 ,  predicted alpha =  1
08.1642800592661
row[ 10 ] data: T1 =  308.0 , gam=  0.0 , qsol=  2400.0 ,  predicted alpha =
61.15114225262404
row[ 11 ] data: T1 =  308.0 , gam=  0.5 , qsol=  2400.0 ,  predicted alpha =
103.17117375565768
row[ 12 ] data: T1 =  308.0 , gam=  0.0 , qsol=  2100.0 ,  predicted alpha =
55.55622380897999
row[ 13 ] data: T1 =  308.0 , gam=  0.5 , qsol=  2100.0 ,  predicted alpha =
95.1197553753376
row[ 14 ] data: T1 =  305.0 , gam=  0.0 , qsol=  1800.0 ,  predicted alpha =
50.10198033899367
row[ 15 ] data: T1 =  305.0 , gam=  0.5 , qsol=  1800.0 ,  predicted alpha =
87.49366260436177
row[ 16 ] data: T1 =  295.0 , gam=  0.0 , qsol=  1300.0 ,  predicted alpha =
41.0626166924268
row[ 17 ] data: T1 =  295.0 , gam=  0.5 , qsol=  1300.0 ,  predicted alpha =
76.02330003005862
row[ 18 ] data: T1 =  292.0 , gam=  0.0 , qsol=  800.0 ,  predicted alpha =  3
6.591588109883666
row[ 19 ] data: T1 =  292.0 , gam=  0.5 , qsol=  800.0 ,  predicted alpha =  6
6.18117979429364
row[ 20 ] data: T1 =  295.0 , gam=  0.0 , qsol=  250.0 ,  predicted alpha =  2
9.443648374451698
row[ 21 ] data: T1 =  295.0 , gam=  0.5 , qsol=  250.0 ,  predicted alpha =  5
6.60733440329135
```



In [59]:

```
#Task 2.4

#import useful packages
import keras
import pandas as pd
from keras.models import Sequential
import numpy as np
import keras.backend as kb
import tensorflow as tf
import copy as cp
#the follwoing 2 lines are only needed for Mac OS machines
import os
os.environ['KMP_DUPLICATE_LIB_OK']='True'

#Task 2.1 Normalize Data

#initialize
xdatan=[]
ydatan=[]

T=[]
ga=[]
qs=[]
al=[]
ef=[]

def median(sample):        #function to calculate median
    n = len(sample)
    i = n//2
    if n%2:
        return sorted (sample [i])
    return sum(sorted(sample)[i-1:i+1])/2

#create input data array
#T1(K), gamma, , qsol(kW):
```

```
xdata = []
xdata =  [[ 318.0 , 0.0 , 500.0 ], [ 318.0 , 0.0 , 1000.0 ]]
xdata.append([ 318.0 , 0.0 , 1500.0 ])
xdata.append([ 318.0 , 0.0 , 2000.0 ])
xdata.append([ 318.0 , 0.0 , 2500.0 ])
xdata.append([ 318.0 , 0.25 , 500.0 ])
xdata.append([ 318.0 , 0.25 , 1000.0 ])
xdata.append([ 318.0 , 0.25 , 1500.0 ])
xdata.append([ 318.0 , 0.25 , 2000.0 ])
xdata.append([ 318.0 , 0.25 , 2500.0 ])
xdata.append([ 318.0 , 0.5 , 500.0 ])
xdata.append([ 318.0 , 0.5 , 1000.0 ])
xdata.append([ 318.0 , 0.5 , 1500.0 ])
xdata.append([ 318.0 , 0.5 , 2000.0 ])
xdata.append([ 318.0 , 0.5 , 2500.0 ])

xdata.append([ 303.0 , 0.0 , 500.0 ])
xdata.append([ 303.0 , 0.0 , 1000.0 ])
xdata.append([ 303.0 , 0.0 , 1500.0 ])
xdata.append([ 303.0 , 0.0 , 2000.0 ])
xdata.append([ 303.0 , 0.0 , 2500.0 ])
xdata.append([ 303.0 , 0.25 , 500.0 ])
xdata.append([ 303.0 , 0.25 , 1000.0 ])
xdata.append([ 303.0 , 0.25 , 1500.0 ])
xdata.append([ 303.0 , 0.25 , 2000.0 ])
xdata.append([ 303.0 , 0.25 , 2500.0 ])
xdata.append([ 303.0 , 0.5 , 500.0 ])
xdata.append([ 303.0 , 0.5 , 1000.0 ])
xdata.append([ 303.0 , 0.5 , 1500.0 ])
xdata.append([ 303.0 , 0.5 , 2000.0 ])
xdata.append([ 303.0 , 0.5 , 2500.0 ])

xdata.append([ 288.0 , 0.0 , 500.0 ])
xdata.append([ 288.0 , 0.0 , 1000.0 ])
xdata.append([ 288.0 , 0.0 , 1500.0 ])
xdata.append([ 288.0 , 0.0 , 2000.0 ])
xdata.append([ 288.0 , 0.0 , 2500.0 ])
xdata.append([ 288.0 , 0.25 , 500.0 ])
xdata.append([ 288.0 , 0.25 , 1000.0 ])
xdata.append([ 288.0 , 0.25 , 1500.0 ])
xdata.append([ 288.0 , 0.25 , 2000.0 ])
xdata.append([ 288.0 , 0.25 , 2500.0 ])
xdata.append([ 288.0 , 0.5 , 500.0 ])
xdata.append([ 288.0 , 0.5 , 1000.0 ])
xdata.append([ 288.0 , 0.5 , 1500.0 ])
xdata.append([ 288.0 , 0.5 , 2000.0 ])
xdata.append([ 288.0 , 0.5 , 2500.0 ])

xdata.append([ 268.0 , 0.0 , 500.0 ])
xdata.append([ 268.0 , 0.0 , 1000.0 ])
xdata.append([ 268.0 , 0.0 , 1500.0 ])
xdata.append([ 268.0 , 0.0 , 2000.0 ])
xdata.append([ 268.0 , 0.0 , 2500.0 ])
```

```
xdata.append([ 268.0 , 0.25 , 500.0 ])
xdata.append([ 268.0 , 0.25 , 1000.0 ])
xdata.append([ 268.0 , 0.25 , 1500.0 ])
xdata.append([ 268.0 , 0.25 , 2000.0 ])
xdata.append([ 268.0 , 0.25 , 2500.0 ])
xdata.append([ 268.0 , 0.5 , 500.0 ])
xdata.append([ 268.0 , 0.5 , 1000.0 ])
xdata.append([ 268.0 , 0.5 , 1500.0 ])
xdata.append([ 268.0 , 0.5 , 2000.0 ])
xdata.append([ 268.0 , 0.5 , 2500.0 ])

# alpha, effsys
ydata = []
ydata =  [[ 35.1316 , 0.3808 ],[ 40.3764 , 0.38686 ]]
ydata.append([ 47.4620 , 0.3930 ])
ydata.append([ 57.5639 , 0.39949 ])
ydata.append([ 73.1286 , 0.40612 ])
ydata.append([ 49.1110 , 0.4023 ])
ydata.append([ 56.4428 , 0.40605 ])
ydata.append([ 66.3479 , 0.4098 ])
ydata.append([ 80.4695 , 0.413 ])
ydata.append([ 102.2276 , 0.4175 ])
ydata.append([ 63.0904 , 0.41540 ])
ydata.append([ 72.5092 , 0.4175 ])
ydata.append([ 85.2338, 0.4197 ])
ydata.append([ 103.3750 , 0.42192 ])
ydata.append([ 131.3266 , 0.4242 ])

ydata.append([ 34.273 , 0.3952 ])
ydata.append([ 38.99026 , 0.4012 ])
ydata.append([ 45.2133, 0.4073 ])
ydata.append([ 53.8000 , 0.4136 ])
ydata.append([ 66.4130 , 0.4201 ])
ydata.append([ 47.922 , 0.4178 ])
ydata.append([ 54.518 , 0.4215 ])
ydata.append([ 63.220 , 0.4252 ])
ydata.append([ 75.226 , 0.4290 ])
ydata.append([ 92.862 , 0.4329 ])
ydata.append([ 61.572 , 0.4315 ])
ydata.append([ 70.0468 , 0.43373 ])
ydata.append([ 81.226 , 0.43597 ])
ydata.append([ 96.653 , 0.4382 ])
ydata.append([ 119.3124 , 0.44045 ])

ydata.append([ 33.4521 , 0.40913 ])
ydata.append([ 37.6911, 0.4150 ])
ydata.append([ 43.1602 , 0.4209 ])
ydata.append([ 50.4858 , 0.4271 ])
ydata.append([ 60.8067 , 0.4334 ])
ydata.append([ 46.7865 , 0.4328 ])
ydata.append([ 52.7151 , 0.43646 ])
ydata.append([ 60.36425 , 0.44016 ])
ydata.append([ 70.6099 , 0.443926 ])
```

```
ydata.append([ 85.0447 , 0.4477 ])
ydata.append([ 60.1208 , 0.44721 ])
ydata.append([ 67.7391 , 0.44940 ])
ydata.append([ 77.56830 , 0.4516 ])
ydata.append([ 90.73410 , 0.4538 ])
ydata.append([ 109.2828 , 0.4560 ])

ydata.append([ 32.4123 , 0.42694 ])
ydata.append([ 36.0807 , 0.4325 ])
ydata.append([ 40.6854 , 0.4383 ])
ydata.append([ 46.6374 , 0.4442 ])
ydata.append([ 54.6293 , 0.4503 ])
ydata.append([ 45.3472 , 0.4519 ])
ydata.append([ 50.4796 , 0.4555 ])
ydata.append([ 56.9219 , 0.4591 ])
ydata.append([ 65.2492 , 0.4628 ])
ydata.append([ 76.4304 , 0.4665 ])
ydata.append([ 58.2822 , 0.4672 ])
ydata.append([ 64.8785 , 0.4693 ])
ydata.append([ 73.1584 , 0.4715 ])
ydata.append([ 83.8610 , 0.4738 ])
ydata.append([ 98.2316 , 0.4760 ])

xdatar = np.array(cp.deepcopy(xdata)) #xdata copy
ydatar = np.array(cp.deepcopy(ydata)) #ydata copy

for x in range(len(xdatar)):
    T.append(xdatar[x][0])
    ga.append(xdatar[x][1])
    qs.append(xdatar[x][2])

for y in range(len(ydatar)):
    al.append(ydatar[y][0])
    ef.append(ydatar[y][1])

Tmed = median (T) #find median of the parameters
gamed = median(ga)
qsmed = median(qs)
almed = median(al)
efmed = median(ef)

for x in range(len(xdatar)):
    xdatan.append([xdatar[x][0]/Tmed, xdatar[x][1]/gamed, xdatar[x][2]/qsmed])

for y in range(len(ydatar)):
    ydatan.append([ydatar[y][0]/almed, ydatar[y][1]/efmed])
```

In [67]:
```
from keras import backend as K
#initialize weights with values between -0.2 and 1.2
initializer = tf.keras.initializers.RandomUniform(minval= -0.2, maxval=1.2)

modelv1 = keras.Sequential([
    keras.layers.Dense(16, activation=K.elu, input_shape=[3]),
    keras.layers.Dense(32, activation=K.elu),
    keras.layers.Dense(16, activation=K.elu),
    keras.layers.Dense(2)
  ])

modelv2 = keras.Sequential([
    keras.layers.Dense(16, activation=K.relu, input_shape=[3]),
    keras.layers.Dense(32, activation=K.relu),
    keras.layers.Dense(16, activation=K.relu),
    keras.layers.Dense(16, activation=K.relu),
    keras.layers.Dense(2)
  ])

modelv3 = keras.Sequential([
    keras.layers.Dense(8, activation=K.relu, input_shape=[3]),
    keras.layers.Dense(16, activation=K.relu),
    keras.layers.Dense(8, activation=K.relu),
    keras.layers.Dense(2)
  ])

modelv4 = keras.Sequential([
    keras.layers.Dense(20, activation=K.relu, input_shape=[3]),
    keras.layers.Dense(40, activation=K.relu),
    keras.layers.Dense(20, activation=K.relu),
    keras.layers.Dense(2)
  ])
```

In [68]:
```
sgd = tf.keras.optimizers.RMSprop(0.001) #Original value 0.05
modelv1.compile(loss='mean_absolute_error',optimizer='sgd')
modelv2.compile(loss='mean_absolute_error',optimizer='sgd')
modelv3.compile(loss='mean_absolute_error',optimizer='sgd')
modelv4.compile(loss='mean_absolute_error',optimizer='sgd')
```

In [69]:

```
# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 20,
    restore_best_weights = True,
    verbose=1)
# Add a checkpoint where loss is minimum, and save that model
mc = keras.callbacks.ModelCheckpoint('best_model.SB', monitor='loss',
                     mode='min',  verbose=1, save_best_only=True)

historyDatav1 = modelv1.fit(xarray,yarray,epochs=600,callbacks=[es]) #epoch o
loss_histv1 = historyDatav1.history['loss']

#The above line will return a dictionary, access it's info like this:
best_epochv1 = np.argmin(historyDatav1.history['loss']) + 1
print ('best epoch v1 = ', best_epochv1)
print('smallest loss v1 =', np.min(loss_histv1))
```

```
Epoch 1/600
60/60 [==============================] - 1s 16ms/step - loss: 0.9624
Epoch 2/600
60/60 [==============================] - 0s 354us/step - loss: 0.8003
Epoch 3/600
60/60 [==============================] - 0s 284us/step - loss: 0.6341
Epoch 4/600
60/60 [==============================] - 0s 385us/step - loss: 0.4872
Epoch 5/600
60/60 [==============================] - 0s 389us/step - loss: 0.3649
Epoch 6/600
60/60 [==============================] - 0s 370us/step - loss: 0.2614
Epoch 7/600
60/60 [==============================] - 0s 251us/step - loss: 0.1729
Epoch 8/600
60/60 [==============================] - 0s 211us/step - loss: 0.1330
Epoch 9/600
60/60 [==============================] - 0s 295us/step - loss: 0.1182
Epoch 10/600
60/60 [==============================] - 0s 411us/step - loss: 0.1106
Epoch 11/600
60/60 [==============================] - 0s 232us/step - loss: 0.1060
Epoch 12/600
60/60 [==============================] - 0s 231us/step - loss: 0.1009
Epoch 13/600
60/60 [==============================] - 0s 198us/step - loss: 0.0982
Epoch 14/600
60/60 [==============================] - 0s 250us/step - loss: 0.0973
Epoch 15/600
60/60 [==============================] - 0s 185us/step - loss: 0.0952
Epoch 16/600
60/60 [==============================] - 0s 227us/step - loss: 0.0952
Epoch 17/600
60/60 [==============================] - 0s 124us/step - loss: 0.0939
Epoch 18/600
```

```
60/60 [==============================] - 0s 173us/step - loss: 0.0964
Epoch 19/600
60/60 [==============================] - 0s 143us/step - loss: 0.0930
Epoch 20/600
60/60 [==============================] - 0s 140us/step - loss: 0.0926
Epoch 21/600
60/60 [==============================] - 0s 175us/step - loss: 0.0944
Epoch 22/600
60/60 [==============================] - 0s 229us/step - loss: 0.0937
Epoch 23/600
60/60 [==============================] - 0s 251us/step - loss: 0.0917
Epoch 24/600
60/60 [==============================] - 0s 334us/step - loss: 0.0932
Epoch 25/600
60/60 [==============================] - 0s 258us/step - loss: 0.0943
Epoch 26/600
60/60 [==============================] - 0s 367us/step - loss: 0.0937
Epoch 27/600
60/60 [==============================] - 0s 297us/step - loss: 0.0909
Epoch 28/600
60/60 [==============================] - 0s 216us/step - loss: 0.0921
Epoch 29/600
60/60 [==============================] - 0s 228us/step - loss: 0.0912
Epoch 30/600
60/60 [==============================] - 0s 145us/step - loss: 0.0907
Epoch 31/600
60/60 [==============================] - 0s 149us/step - loss: 0.0906
Epoch 32/600
60/60 [==============================] - 0s 156us/step - loss: 0.0902
Epoch 33/600
60/60 [==============================] - 0s 137us/step - loss: 0.0897
Epoch 34/600
60/60 [==============================] - 0s 153us/step - loss: 0.0901
Epoch 35/600
60/60 [==============================] - 0s 159us/step - loss: 0.0955
Epoch 36/600
60/60 [==============================] - 0s 158us/step - loss: 0.0914
Epoch 37/600
60/60 [==============================] - 0s 185us/step - loss: 0.0905
Epoch 38/600
60/60 [==============================] - ETA: 0s - loss: 0.098 - 0s 163us/step
- loss: 0.0893
Epoch 39/600
60/60 [==============================] - 0s 156us/step - loss: 0.0906
Epoch 40/600
60/60 [==============================] - 0s 161us/step - loss: 0.0885
Epoch 41/600
60/60 [==============================] - 0s 160us/step - loss: 0.0888
Epoch 42/600
60/60 [==============================] - 0s 225us/step - loss: 0.0890
Epoch 43/600
60/60 [==============================] - 0s 188us/step - loss: 0.0880
Epoch 44/600
60/60 [==============================] - 0s 287us/step - loss: 0.0880
Epoch 45/600
60/60 [==============================] - 0s 276us/step - loss: 0.0880
Epoch 46/600
```

```
60/60 [==============================] - 0s 540us/step - loss: 0.0880
Epoch 47/600
60/60 [==============================] - 0s 368us/step - loss: 0.0881
Epoch 48/600
60/60 [==============================] - 0s 286us/step - loss: 0.0880
Epoch 49/600
60/60 [==============================] - 0s 313us/step - loss: 0.0872
Epoch 50/600
60/60 [==============================] - 0s 565us/step - loss: 0.0872
Epoch 51/600
60/60 [==============================] - 0s 276us/step - loss: 0.0861
Epoch 52/600
60/60 [==============================] - 0s 227us/step - loss: 0.0858
Epoch 53/600
60/60 [==============================] - 0s 155us/step - loss: 0.0864
Epoch 54/600
60/60 [==============================] - 0s 196us/step - loss: 0.0861
Epoch 55/600
60/60 [==============================] - 0s 192us/step - loss: 0.0859
Epoch 56/600
60/60 [==============================] - 0s 177us/step - loss: 0.0859
Epoch 57/600
60/60 [==============================] - 0s 167us/step - loss: 0.0881
Epoch 58/600
60/60 [==============================] - 0s 198us/step - loss: 0.0867
Epoch 59/600
60/60 [==============================] - 0s 148us/step - loss: 0.0852
Epoch 60/600
60/60 [==============================] - 0s 167us/step - loss: 0.0897
Epoch 61/600
60/60 [==============================] - 0s 173us/step - loss: 0.0857
Epoch 62/600
60/60 [==============================] - 0s 181us/step - loss: 0.0859
Epoch 63/600
60/60 [==============================] - 0s 175us/step - loss: 0.0866
Epoch 64/600
60/60 [==============================] - 0s 239us/step - loss: 0.0839
Epoch 65/600
60/60 [==============================] - 0s 310us/step - loss: 0.0844
Epoch 66/600
60/60 [==============================] - 0s 637us/step - loss: 0.0860
Epoch 67/600
60/60 [==============================] - 0s 384us/step - loss: 0.0859
Epoch 68/600
60/60 [==============================] - 0s 316us/step - loss: 0.0859
Epoch 69/600
60/60 [==============================] - 0s 200us/step - loss: 0.0860
Epoch 70/600
60/60 [==============================] - 0s 176us/step - loss: 0.0859
Epoch 71/600
60/60 [==============================] - 0s 234us/step - loss: 0.0847
Epoch 72/600
60/60 [==============================] - 0s 341us/step - loss: 0.0834
Epoch 73/600
60/60 [==============================] - 0s 170us/step - loss: 0.0837
Epoch 74/600
60/60 [==============================] - 0s 173us/step - loss: 0.0868
```

```
Epoch 75/600
60/60 [==============================] - 0s 462us/step - loss: 0.0836
Epoch 76/600
60/60 [==============================] - 0s 441us/step - loss: 0.0835
Epoch 77/600
60/60 [==============================] - 0s 304us/step - loss: 0.0833
Epoch 78/600
60/60 [==============================] - 0s 418us/step - loss: 0.0829
Epoch 79/600
60/60 [==============================] - 0s 209us/step - loss: 0.0829
Epoch 80/600
60/60 [==============================] - 0s 162us/step - loss: 0.0819
Epoch 81/600
60/60 [==============================] - 0s 156us/step - loss: 0.0819
Epoch 82/600
60/60 [==============================] - 0s 216us/step - loss: 0.0820
Epoch 83/600
60/60 [==============================] - 0s 209us/step - loss: 0.0841
Epoch 84/600
60/60 [==============================] - 0s 185us/step - loss: 0.0819
Epoch 85/600
60/60 [==============================] - 0s 186us/step - loss: 0.0821
Epoch 86/600
60/60 [==============================] - 0s 231us/step - loss: 0.0830
Epoch 87/600
60/60 [==============================] - 0s 214us/step - loss: 0.0831
Epoch 88/600
60/60 [==============================] - 0s 250us/step - loss: 0.0832
Epoch 89/600
60/60 [==============================] - 0s 273us/step - loss: 0.0851
Epoch 90/600
60/60 [==============================] - 0s 202us/step - loss: 0.0814
Epoch 91/600
60/60 [==============================] - 0s 418us/step - loss: 0.0812
Epoch 92/600
60/60 [==============================] - 0s 295us/step - loss: 0.0829
Epoch 93/600
60/60 [==============================] - 0s 202us/step - loss: 0.0809
Epoch 94/600
60/60 [==============================] - 0s 161us/step - loss: 0.0801
Epoch 95/600
60/60 [==============================] - 0s 176us/step - loss: 0.0817
Epoch 96/600
60/60 [==============================] - 0s 209us/step - loss: 0.0815
Epoch 97/600
60/60 [==============================] - 0s 194us/step - loss: 0.0800
Epoch 98/600
60/60 [==============================] - 0s 243us/step - loss: 0.0800
Epoch 99/600
60/60 [==============================] - 0s 340us/step - loss: 0.0800
Epoch 100/600
60/60 [==============================] - 0s 139us/step - loss: 0.0797
Epoch 101/600
60/60 [==============================] - 0s 163us/step - loss: 0.0800
Epoch 102/600
60/60 [==============================] - 0s 148us/step - loss: 0.0807
Epoch 103/600
```

```
60/60 [==============================] - 0s 224us/step - loss: 0.0811
Epoch 104/600
60/60 [==============================] - 0s 198us/step - loss: 0.0792
Epoch 105/600
60/60 [==============================] - 0s 190us/step - loss: 0.0802
Epoch 106/600
60/60 [==============================] - 0s 189us/step - loss: 0.0796
Epoch 107/600
60/60 [==============================] - 0s 347us/step - loss: 0.0795
Epoch 108/600
60/60 [==============================] - 0s 178us/step - loss: 0.0808
Epoch 109/600
60/60 [==============================] - 0s 207us/step - loss: 0.0802
Epoch 110/600
60/60 [==============================] - 0s 162us/step - loss: 0.0801
Epoch 111/600
60/60 [==============================] - 0s 242us/step - loss: 0.0803
Epoch 112/600
60/60 [==============================] - 0s 230us/step - loss: 0.0787
Epoch 113/600
60/60 [==============================] - 0s 232us/step - loss: 0.0792
Epoch 114/600
60/60 [==============================] - 0s 179us/step - loss: 0.0813
Epoch 115/600
60/60 [==============================] - 0s 224us/step - loss: 0.0788
Epoch 116/600
60/60 [==============================] - 0s 192us/step - loss: 0.0785
Epoch 117/600
60/60 [==============================] - 0s 191us/step - loss: 0.0787
Epoch 118/600
60/60 [==============================] - 0s 165us/step - loss: 0.0790
Epoch 119/600
60/60 [==============================] - 0s 174us/step - loss: 0.0777
Epoch 120/600
60/60 [==============================] - 0s 159us/step - loss: 0.0783
Epoch 121/600
60/60 [==============================] - 0s 187us/step - loss: 0.0772
Epoch 122/600
60/60 [==============================] - 0s 134us/step - loss: 0.0773
Epoch 123/600
60/60 [==============================] - 0s 174us/step - loss: 0.0804
Epoch 124/600
60/60 [==============================] - 0s 165us/step - loss: 0.0775
Epoch 125/600
60/60 [==============================] - 0s 161us/step - loss: 0.0819
Epoch 126/600
60/60 [==============================] - 0s 174us/step - loss: 0.0788
Epoch 127/600
60/60 [==============================] - 0s 181us/step - loss: 0.0772
Epoch 128/600
60/60 [==============================] - 0s 137us/step - loss: 0.0772
Epoch 129/600
60/60 [==============================] - 0s 168us/step - loss: 0.0776
Epoch 130/600
60/60 [==============================] - 0s 199us/step - loss: 0.0759
Epoch 131/600
60/60 [==============================] - 0s 178us/step - loss: 0.0768
```

```
Epoch 132/600
60/60 [==============================] - 0s 160us/step - loss: 0.0773
Epoch 133/600
60/60 [==============================] - 0s 271us/step - loss: 0.0781
Epoch 134/600
60/60 [==============================] - 0s 226us/step - loss: 0.0785
Epoch 135/600
60/60 [==============================] - 0s 162us/step - loss: 0.0763
Epoch 136/600
60/60 [==============================] - 0s 174us/step - loss: 0.0765
Epoch 137/600
60/60 [==============================] - 0s 171us/step - loss: 0.0755
Epoch 138/600
60/60 [==============================] - 0s 192us/step - loss: 0.0750
Epoch 139/600
60/60 [==============================] - 0s 519us/step - loss: 0.0755
Epoch 140/600
60/60 [==============================] - 0s 258us/step - loss: 0.0753
Epoch 141/600
60/60 [==============================] - 0s 205us/step - loss: 0.0752
Epoch 142/600
60/60 [==============================] - 0s 197us/step - loss: 0.0750
Epoch 143/600
60/60 [==============================] - 0s 182us/step - loss: 0.0749
Epoch 144/600
60/60 [==============================] - 0s 168us/step - loss: 0.0743
Epoch 145/600
60/60 [==============================] - 0s 159us/step - loss: 0.0764
Epoch 146/600
60/60 [==============================] - 0s 160us/step - loss: 0.0798
Epoch 147/600
60/60 [==============================] - 0s 178us/step - loss: 0.0765
Epoch 148/600
60/60 [==============================] - 0s 250us/step - loss: 0.0745
Epoch 149/600
60/60 [==============================] - 0s 182us/step - loss: 0.0742
Epoch 150/600
60/60 [==============================] - 0s 238us/step - loss: 0.0746
Epoch 151/600
60/60 [==============================] - 0s 193us/step - loss: 0.0739
Epoch 152/600
60/60 [==============================] - 0s 166us/step - loss: 0.0742
Epoch 153/600
60/60 [==============================] - 0s 147us/step - loss: 0.0742
Epoch 154/600
60/60 [==============================] - 0s 172us/step - loss: 0.0748
Epoch 155/600
60/60 [==============================] - 0s 154us/step - loss: 0.0744
Epoch 156/600
60/60 [==============================] - 0s 216us/step - loss: 0.0741
Epoch 157/600
60/60 [==============================] - 0s 223us/step - loss: 0.0747
Epoch 158/600
60/60 [==============================] - 0s 242us/step - loss: 0.0747
Epoch 159/600
60/60 [==============================] - 0s 290us/step - loss: 0.0756
Epoch 160/600
```

```
60/60 [==============================] - 0s 488us/step - loss: 0.0731
Epoch 161/600
60/60 [==============================] - 0s 204us/step - loss: 0.0756
Epoch 162/600
60/60 [==============================] - 0s 190us/step - loss: 0.0740
Epoch 163/600
60/60 [==============================] - 0s 168us/step - loss: 0.0728
Epoch 164/600
60/60 [==============================] - 0s 170us/step - loss: 0.0728
Epoch 165/600
60/60 [==============================] - 0s 145us/step - loss: 0.0738
Epoch 166/600
60/60 [==============================] - 0s 164us/step - loss: 0.0746
Epoch 167/600
60/60 [==============================] - 0s 216us/step - loss: 0.0744
Epoch 168/600
60/60 [==============================] - 0s 189us/step - loss: 0.0743
Epoch 169/600
60/60 [==============================] - 0s 216us/step - loss: 0.0727
Epoch 170/600
60/60 [==============================] - 0s 336us/step - loss: 0.0720
Epoch 171/600
60/60 [==============================] - 0s 211us/step - loss: 0.0724
Epoch 172/600
60/60 [==============================] - 0s 260us/step - loss: 0.0717
Epoch 173/600
60/60 [==============================] - 0s 209us/step - loss: 0.0715
Epoch 174/600
60/60 [==============================] - 0s 242us/step - loss: 0.0741
Epoch 175/600
60/60 [==============================] - 0s 227us/step - loss: 0.0715
Epoch 176/600
60/60 [==============================] - 0s 202us/step - loss: 0.0719
Epoch 177/600
60/60 [==============================] - 0s 201us/step - loss: 0.0713
Epoch 178/600
60/60 [==============================] - 0s 226us/step - loss: 0.0714
Epoch 179/600
60/60 [==============================] - 0s 314us/step - loss: 0.0715
Epoch 180/600
60/60 [==============================] - 0s 199us/step - loss: 0.0706
Epoch 181/600
60/60 [==============================] - 0s 174us/step - loss: 0.0706
Epoch 182/600
60/60 [==============================] - 0s 236us/step - loss: 0.0709
Epoch 183/600
60/60 [==============================] - 0s 184us/step - loss: 0.0711
Epoch 184/600
60/60 [==============================] - 0s 209us/step - loss: 0.0736
Epoch 185/600
60/60 [==============================] - 0s 248us/step - loss: 0.0726
Epoch 186/600
60/60 [==============================] - 0s 442us/step - loss: 0.0703
Epoch 187/600
60/60 [==============================] - 0s 228us/step - loss: 0.0708
Epoch 188/600
60/60 [==============================] - 0s 260us/step - loss: 0.0713
```

```
Epoch 189/600
60/60 [==============================] - 0s 232us/step - loss: 0.0698
Epoch 190/600
60/60 [==============================] - 0s 181us/step - loss: 0.0704
Epoch 191/600
60/60 [==============================] - 0s 230us/step - loss: 0.0706
Epoch 192/600
60/60 [==============================] - 0s 223us/step - loss: 0.0698
Epoch 193/600
60/60 [==============================] - 0s 234us/step - loss: 0.0699
Epoch 194/600
60/60 [==============================] - 0s 243us/step - loss: 0.0708
Epoch 195/600
60/60 [==============================] - 0s 170us/step - loss: 0.0693
Epoch 196/600
60/60 [==============================] - 0s 194us/step - loss: 0.0693
Epoch 197/600
60/60 [==============================] - 0s 200us/step - loss: 0.0689
Epoch 198/600
60/60 [==============================] - 0s 191us/step - loss: 0.0697
Epoch 199/600
60/60 [==============================] - 0s 214us/step - loss: 0.0693
Epoch 200/600
60/60 [==============================] - 0s 197us/step - loss: 0.0691
Epoch 201/600
60/60 [==============================] - 0s 235us/step - loss: 0.0695
Epoch 202/600
60/60 [==============================] - 0s 185us/step - loss: 0.0695
Epoch 203/600
60/60 [==============================] - 0s 169us/step - loss: 0.0710
Epoch 204/600
60/60 [==============================] - 0s 208us/step - loss: 0.0702
Epoch 205/600
60/60 [==============================] - 0s 201us/step - loss: 0.0688
Epoch 206/600
60/60 [==============================] - 0s 252us/step - loss: 0.0678
Epoch 207/600
60/60 [==============================] - 0s 172us/step - loss: 0.0705
Epoch 208/600
60/60 [==============================] - 0s 169us/step - loss: 0.0695
Epoch 209/600
60/60 [==============================] - 0s 177us/step - loss: 0.0715
Epoch 210/600
60/60 [==============================] - 0s 160us/step - loss: 0.0701
Epoch 211/600
60/60 [==============================] - 0s 167us/step - loss: 0.0678
Epoch 212/600
60/60 [==============================] - 0s 199us/step - loss: 0.0683
Epoch 213/600
60/60 [==============================] - 0s 173us/step - loss: 0.0681
Epoch 214/600
60/60 [==============================] - 0s 188us/step - loss: 0.0674
Epoch 215/600
60/60 [==============================] - 0s 184us/step - loss: 0.0685
Epoch 216/600
60/60 [==============================] - 0s 167us/step - loss: 0.0678
Epoch 217/600
```

```
60/60 [==============================] - 0s 206us/step - loss: 0.0672
Epoch 218/600
60/60 [==============================] - 0s 180us/step - loss: 0.0714
Epoch 219/600
60/60 [==============================] - 0s 187us/step - loss: 0.0675
Epoch 220/600
60/60 [==============================] - 0s 198us/step - loss: 0.0678
Epoch 221/600
60/60 [==============================] - 0s 187us/step - loss: 0.0689
Epoch 222/600
60/60 [==============================] - 0s 178us/step - loss: 0.0669
Epoch 223/600
60/60 [==============================] - 0s 201us/step - loss: 0.0675
Epoch 224/600
60/60 [==============================] - 0s 165us/step - loss: 0.0719
Epoch 225/600
60/60 [==============================] - 0s 175us/step - loss: 0.0674
Epoch 226/600
60/60 [==============================] - 0s 184us/step - loss: 0.0662
Epoch 227/600
60/60 [==============================] - 0s 146us/step - loss: 0.0663
Epoch 228/600
60/60 [==============================] - 0s 168us/step - loss: 0.0710
Epoch 229/600
60/60 [==============================] - 0s 177us/step - loss: 0.0680
Epoch 230/600
60/60 [==============================] - 0s 174us/step - loss: 0.0668
Epoch 231/600
60/60 [==============================] - 0s 162us/step - loss: 0.0656
Epoch 232/600
60/60 [==============================] - 0s 136us/step - loss: 0.0664
Epoch 233/600
60/60 [==============================] - 0s 143us/step - loss: 0.0671
Epoch 234/600
60/60 [==============================] - 0s 175us/step - loss: 0.0678
Epoch 235/600
60/60 [==============================] - 0s 144us/step - loss: 0.0658
Epoch 236/600
60/60 [==============================] - 0s 173us/step - loss: 0.0670
Epoch 237/600
60/60 [==============================] - 0s 181us/step - loss: 0.0676
Epoch 238/600
60/60 [==============================] - 0s 172us/step - loss: 0.0666
Epoch 239/600
60/60 [==============================] - 0s 189us/step - loss: 0.0665
Epoch 240/600
60/60 [==============================] - 0s 153us/step - loss: 0.0652
Epoch 241/600
60/60 [==============================] - 0s 172us/step - loss: 0.0668
Epoch 242/600
60/60 [==============================] - 0s 324us/step - loss: 0.0679
Epoch 243/600
60/60 [==============================] - 0s 175us/step - loss: 0.0671
Epoch 244/600
60/60 [==============================] - 0s 249us/step - loss: 0.0652
Epoch 245/600
60/60 [==============================] - 0s 205us/step - loss: 0.0647
```

```
Epoch 246/600
60/60 [==============================] - 0s 536us/step - loss: 0.0650
Epoch 247/600
60/60 [==============================] - 0s 293us/step - loss: 0.0647
Epoch 248/600
60/60 [==============================] - 0s 384us/step - loss: 0.0669
Epoch 249/600
60/60 [==============================] - 0s 391us/step - loss: 0.0677
Epoch 250/600
60/60 [==============================] - 0s 399us/step - loss: 0.0644
Epoch 251/600
60/60 [==============================] - 0s 285us/step - loss: 0.0648
Epoch 252/600
60/60 [==============================] - 0s 255us/step - loss: 0.0645
Epoch 253/600
60/60 [==============================] - 0s 211us/step - loss: 0.0641
Epoch 254/600
60/60 [==============================] - 0s 226us/step - loss: 0.0649
Epoch 255/600
60/60 [==============================] - 0s 175us/step - loss: 0.0653
Epoch 256/600
60/60 [==============================] - 0s 139us/step - loss: 0.0708
Epoch 257/600
60/60 [==============================] - 0s 199us/step - loss: 0.0668
Epoch 258/600
60/60 [==============================] - 0s 259us/step - loss: 0.0678
Epoch 259/600
60/60 [==============================] - 0s 352us/step - loss: 0.0673
Epoch 260/600
60/60 [==============================] - 0s 302us/step - loss: 0.0642
Epoch 261/600
60/60 [==============================] - 0s 390us/step - loss: 0.0668
Epoch 262/600
60/60 [==============================] - 0s 335us/step - loss: 0.0643
Epoch 263/600
60/60 [==============================] - 0s 309us/step - loss: 0.0634
Epoch 264/600
60/60 [==============================] - 0s 273us/step - loss: 0.0640
Epoch 265/600
60/60 [==============================] - 0s 301us/step - loss: 0.0647
Epoch 266/600
60/60 [==============================] - 0s 150us/step - loss: 0.0626
Epoch 267/600
60/60 [==============================] - 0s 152us/step - loss: 0.0654
Epoch 268/600
60/60 [==============================] - 0s 196us/step - loss: 0.0664
Epoch 269/600
60/60 [==============================] - 0s 200us/step - loss: 0.0644
Epoch 270/600
60/60 [==============================] - 0s 141us/step - loss: 0.0626
Epoch 271/600
60/60 [==============================] - 0s 166us/step - loss: 0.0625
Epoch 272/600
60/60 [==============================] - 0s 164us/step - loss: 0.0631
Epoch 273/600
60/60 [==============================] - 0s 190us/step - loss: 0.0635
Epoch 274/600
```

```
60/60 [==============================] - 0s 233us/step - loss: 0.0675
Epoch 275/600
60/60 [==============================] - 0s 192us/step - loss: 0.0628
Epoch 276/600
60/60 [==============================] - 0s 199us/step - loss: 0.0619
Epoch 277/600
60/60 [==============================] - 0s 215us/step - loss: 0.0625
Epoch 278/600
60/60 [==============================] - 0s 249us/step - loss: 0.0621
Epoch 279/600
60/60 [==============================] - 0s 282us/step - loss: 0.0616
Epoch 280/600
60/60 [==============================] - 0s 183us/step - loss: 0.0625
Epoch 281/600
60/60 [==============================] - 0s 175us/step - loss: 0.0625
Epoch 282/600
60/60 [==============================] - 0s 168us/step - loss: 0.0633
Epoch 283/600
60/60 [==============================] - 0s 163us/step - loss: 0.0634
Epoch 284/600
60/60 [==============================] - 0s 172us/step - loss: 0.0653
Epoch 285/600
60/60 [==============================] - 0s 197us/step - loss: 0.0618
Epoch 286/600
60/60 [==============================] - 0s 156us/step - loss: 0.0665
Epoch 287/600
60/60 [==============================] - 0s 158us/step - loss: 0.0622
Epoch 288/600
60/60 [==============================] - 0s 282us/step - loss: 0.0611
Epoch 289/600
60/60 [==============================] - 0s 205us/step - loss: 0.0628
Epoch 290/600
60/60 [==============================] - 0s 316us/step - loss: 0.0624
Epoch 291/600
60/60 [==============================] - 0s 343us/step - loss: 0.0626
Epoch 292/600
60/60 [==============================] - 0s 284us/step - loss: 0.0622
Epoch 293/600
60/60 [==============================] - 0s 232us/step - loss: 0.0634
Epoch 294/600
60/60 [==============================] - 0s 262us/step - loss: 0.0609
Epoch 295/600
60/60 [==============================] - 0s 225us/step - loss: 0.0602
Epoch 296/600
60/60 [==============================] - 0s 172us/step - loss: 0.0605
Epoch 297/600
60/60 [==============================] - 0s 234us/step - loss: 0.0603
Epoch 298/600
60/60 [==============================] - 0s 226us/step - loss: 0.0610
Epoch 299/600
60/60 [==============================] - 0s 260us/step - loss: 0.0605
Epoch 300/600
60/60 [==============================] - 0s 304us/step - loss: 0.0652
Epoch 301/600
60/60 [==============================] - 0s 286us/step - loss: 0.0632
Epoch 302/600
60/60 [==============================] - 0s 486us/step - loss: 0.0595
```

```
Epoch 303/600
60/60 [==============================] - 0s 397us/step - loss: 0.0599
Epoch 304/600
60/60 [==============================] - 0s 288us/step - loss: 0.0602
Epoch 305/600
60/60 [==============================] - 0s 270us/step - loss: 0.0616
Epoch 306/600
60/60 [==============================] - 0s 227us/step - loss: 0.0608
Epoch 307/600
60/60 [==============================] - 0s 207us/step - loss: 0.0590
Epoch 308/600
60/60 [==============================] - 0s 231us/step - loss: 0.0601
Epoch 309/600
60/60 [==============================] - 0s 251us/step - loss: 0.0597
Epoch 310/600
60/60 [==============================] - 0s 491us/step - loss: 0.0590
Epoch 311/600
60/60 [==============================] - 0s 401us/step - loss: 0.0593
Epoch 312/600
60/60 [==============================] - 0s 297us/step - loss: 0.0594
Epoch 313/600
60/60 [==============================] - 0s 318us/step - loss: 0.0594
Epoch 314/600
60/60 [==============================] - 0s 328us/step - loss: 0.0590
Epoch 315/600
60/60 [==============================] - 0s 205us/step - loss: 0.0598
Epoch 316/600
60/60 [==============================] - 0s 255us/step - loss: 0.0596
Epoch 317/600
60/60 [==============================] - 0s 276us/step - loss: 0.0603
Epoch 318/600
60/60 [==============================] - 0s 276us/step - loss: 0.0583
Epoch 319/600
60/60 [==============================] - 0s 209us/step - loss: 0.0589
Epoch 320/600
60/60 [==============================] - 0s 205us/step - loss: 0.0589
Epoch 321/600
60/60 [==============================] - 0s 271us/step - loss: 0.0604
Epoch 322/600
60/60 [==============================] - 0s 340us/step - loss: 0.0602
Epoch 323/600
60/60 [==============================] - 0s 440us/step - loss: 0.0636
Epoch 324/600
60/60 [==============================] - 0s 275us/step - loss: 0.0605
Epoch 325/600
60/60 [==============================] - 0s 423us/step - loss: 0.0601
Epoch 326/600
60/60 [==============================] - 0s 354us/step - loss: 0.0583
Epoch 327/600
60/60 [==============================] - 0s 290us/step - loss: 0.0600
Epoch 328/600
60/60 [==============================] - 0s 339us/step - loss: 0.0595
Epoch 329/600
60/60 [==============================] - 0s 434us/step - loss: 0.0596
Epoch 330/600
60/60 [==============================] - 0s 291us/step - loss: 0.0606
Epoch 331/600
```

```
60/60 [==============================] - 0s 340us/step - loss: 0.0578
Epoch 332/600
60/60 [==============================] - 0s 350us/step - loss: 0.0589
Epoch 333/600
60/60 [==============================] - 0s 287us/step - loss: 0.0582
Epoch 334/600
60/60 [==============================] - 0s 197us/step - loss: 0.0591
Epoch 335/600
60/60 [==============================] - 0s 190us/step - loss: 0.0571
Epoch 336/600
60/60 [==============================] - 0s 356us/step - loss: 0.0602
Epoch 337/600
60/60 [==============================] - 0s 305us/step - loss: 0.0596
Epoch 338/600
60/60 [==============================] - 0s 303us/step - loss: 0.0612
Epoch 339/600
60/60 [==============================] - 0s 388us/step - loss: 0.0588
Epoch 340/600
60/60 [==============================] - 0s 388us/step - loss: 0.0626
Epoch 341/600
60/60 [==============================] - 0s 327us/step - loss: 0.0578
Epoch 342/600
60/60 [==============================] - 0s 288us/step - loss: 0.0566
Epoch 343/600
60/60 [==============================] - 0s 417us/step - loss: 0.0567
Epoch 344/600
60/60 [==============================] - 0s 202us/step - loss: 0.0597
Epoch 345/600
60/60 [==============================] - 0s 168us/step - loss: 0.0589
Epoch 346/600
60/60 [==============================] - 0s 201us/step - loss: 0.0610
Epoch 347/600
60/60 [==============================] - 0s 161us/step - loss: 0.0561
Epoch 348/600
60/60 [==============================] - 0s 193us/step - loss: 0.0638
Epoch 349/600
60/60 [==============================] - 0s 238us/step - loss: 0.0597
Epoch 350/600
60/60 [==============================] - 0s 214us/step - loss: 0.0559
Epoch 351/600
60/60 [==============================] - 0s 218us/step - loss: 0.0569
Epoch 352/600
60/60 [==============================] - 0s 190us/step - loss: 0.0628
Epoch 353/600
60/60 [==============================] - 0s 155us/step - loss: 0.0564
Epoch 354/600
60/60 [==============================] - 0s 185us/step - loss: 0.0615
Epoch 355/600
60/60 [==============================] - 0s 308us/step - loss: 0.0570
Epoch 356/600
60/60 [==============================] - 0s 225us/step - loss: 0.0578
Epoch 357/600
60/60 [==============================] - 0s 258us/step - loss: 0.0569
Epoch 358/600
60/60 [==============================] - 0s 212us/step - loss: 0.0588
Epoch 359/600
60/60 [==============================] - 0s 253us/step - loss: 0.0573
```

```
Epoch 360/600
60/60 [==============================] - 0s 243us/step - loss: 0.0567
Epoch 361/600
60/60 [==============================] - 0s 215us/step - loss: 0.0610
Epoch 362/600
60/60 [==============================] - 0s 219us/step - loss: 0.0638
Epoch 363/600
60/60 [==============================] - 0s 206us/step - loss: 0.0584
Epoch 364/600
60/60 [==============================] - 0s 307us/step - loss: 0.0595
Epoch 365/600
60/60 [==============================] - 0s 302us/step - loss: 0.0579
Epoch 366/600
60/60 [==============================] - 0s 175us/step - loss: 0.0582
Epoch 367/600
60/60 [==============================] - 0s 224us/step - loss: 0.0620
Epoch 368/600
60/60 [==============================] - 0s 191us/step - loss: 0.0574
Epoch 369/600
60/60 [==============================] - 0s 207us/step - loss: 0.0580
Epoch 370/600
60/60 [==============================] - 0s 168us/step - loss: 0.0573
Restoring model weights from the end of the best epoch
Epoch 00370: early stopping
best epoch v1 =  350
smallest loss v1 = 0.05590683569510778
```

In [70]:

```
historyDatav2 = modelv2.fit(xarray,yarray,epochs=600,callbacks=[es])
loss_histv2 = historyDatav2.history['loss']

best_epochv2 = np.argmin(historyDatav2.history['loss']) + 1
print ('best epoch v2 = ', best_epochv2)
print('smallest loss v2 =', np.min(loss_histv2))
```

```
Epoch 1/600
60/60 [==============================] - 1s 15ms/step - loss: 1.0445
Epoch 2/600
60/60 [==============================] - 0s 220us/step - loss: 1.0140
Epoch 3/600
60/60 [==============================] - 0s 298us/step - loss: 0.9843
Epoch 4/600
60/60 [==============================] - 0s 294us/step - loss: 0.9547
Epoch 5/600
60/60 [==============================] - 0s 404us/step - loss: 0.9250
Epoch 6/600
60/60 [==============================] - 0s 234us/step - loss: 0.8950
Epoch 7/600
60/60 [==============================] - 0s 371us/step - loss: 0.8643
Epoch 8/600
60/60 [==============================] - 0s 339us/step - loss: 0.8327
Epoch 9/600
60/60 [==============================] - 0s 446us/step - loss: 0.7998
Epoch 10/600
60/60 [==============================] - 0s 348us/step - loss: 0.7652
Epoch 11/600
```

```
60/60 [==============================] - 0s 519us/step - loss: 0.7297
Epoch 12/600
60/60 [==============================] - 0s 218us/step - loss: 0.6932
Epoch 13/600
60/60 [==============================] - 0s 170us/step - loss: 0.6548
Epoch 14/600
60/60 [==============================] - 0s 168us/step - loss: 0.6139
Epoch 15/600
60/60 [==============================] - 0s 289us/step - loss: 0.5702
Epoch 16/600
60/60 [==============================] - 0s 150us/step - loss: 0.5228
Epoch 17/600
60/60 [==============================] - 0s 160us/step - loss: 0.4708
Epoch 18/600
60/60 [==============================] - 0s 183us/step - loss: 0.4128
Epoch 19/600
60/60 [==============================] - 0s 385us/step - loss: 0.3476
Epoch 20/600
60/60 [==============================] - 0s 175us/step - loss: 0.2744
Epoch 21/600
60/60 [==============================] - 0s 281us/step - loss: 0.2022
Epoch 22/600
60/60 [==============================] - 0s 153us/step - loss: 0.1520
Epoch 23/600
60/60 [==============================] - 0s 201us/step - loss: 0.1389
Epoch 24/600
60/60 [==============================] - 0s 297us/step - loss: 0.1330
Epoch 25/600
60/60 [==============================] - 0s 185us/step - loss: 0.1310
Epoch 26/600
60/60 [==============================] - 0s 186us/step - loss: 0.1291
Epoch 27/600
60/60 [==============================] - 0s 235us/step - loss: 0.1280
Epoch 28/600
60/60 [==============================] - 0s 283us/step - loss: 0.1265
Epoch 29/600
60/60 [==============================] - 0s 180us/step - loss: 0.1250
Epoch 30/600
60/60 [==============================] - 0s 368us/step - loss: 0.1239
Epoch 31/600
60/60 [==============================] - 0s 589us/step - loss: 0.1229
Epoch 32/600
60/60 [==============================] - 0s 580us/step - loss: 0.1223
Epoch 33/600
60/60 [==============================] - 0s 212us/step - loss: 0.1211
Epoch 34/600
60/60 [==============================] - 0s 239us/step - loss: 0.1198
Epoch 35/600
60/60 [==============================] - 0s 167us/step - loss: 0.1207
Epoch 36/600
60/60 [==============================] - 0s 248us/step - loss: 0.1180
Epoch 37/600
60/60 [==============================] - 0s 472us/step - loss: 0.1169
Epoch 38/600
60/60 [==============================] - 0s 222us/step - loss: 0.1158
Epoch 39/600
60/60 [==============================] - 0s 257us/step - loss: 0.1155
```

```
Epoch 40/600
60/60 [==============================] - 0s 572us/step - loss: 0.1143
Epoch 41/600
60/60 [==============================] - 0s 286us/step - loss: 0.1135
Epoch 42/600
60/60 [==============================] - 0s 487us/step - loss: 0.1128
Epoch 43/600
60/60 [==============================] - 0s 462us/step - loss: 0.1120
Epoch 44/600
60/60 [==============================] - 0s 454us/step - loss: 0.1112
Epoch 45/600
60/60 [==============================] - 0s 207us/step - loss: 0.1109
Epoch 46/600
60/60 [==============================] - 0s 168us/step - loss: 0.1102
Epoch 47/600
60/60 [==============================] - 0s 336us/step - loss: 0.1088
Epoch 48/600
60/60 [==============================] - 0s 460us/step - loss: 0.1079
Epoch 49/600
60/60 [==============================] - 0s 250us/step - loss: 0.1074
Epoch 50/600
60/60 [==============================] - 0s 480us/step - loss: 0.1069
Epoch 51/600
60/60 [==============================] - 0s 393us/step - loss: 0.1071
Epoch 52/600
60/60 [==============================] - 0s 252us/step - loss: 0.1065
Epoch 53/600
60/60 [==============================] - 0s 182us/step - loss: 0.1049
Epoch 54/600
60/60 [==============================] - 0s 179us/step - loss: 0.1046
Epoch 55/600
60/60 [==============================] - 0s 223us/step - loss: 0.1042
Epoch 56/600
60/60 [==============================] - 0s 196us/step - loss: 0.1029
Epoch 57/600
60/60 [==============================] - 0s 356us/step - loss: 0.1033
Epoch 58/600
60/60 [==============================] - 0s 641us/step - loss: 0.1019
Epoch 59/600
60/60 [==============================] - 0s 256us/step - loss: 0.1011
Epoch 60/600
60/60 [==============================] - 0s 1ms/step - loss: 0.1006
Epoch 61/600
60/60 [==============================] - 0s 264us/step - loss: 0.1007
Epoch 62/600
60/60 [==============================] - 0s 266us/step - loss: 0.0994
Epoch 63/600
60/60 [==============================] - 0s 253us/step - loss: 0.0988
Epoch 64/600
60/60 [==============================] - 0s 200us/step - loss: 0.0983
Epoch 65/600
60/60 [==============================] - 0s 240us/step - loss: 0.0978
Epoch 66/600
60/60 [==============================] - 0s 201us/step - loss: 0.0971
Epoch 67/600
60/60 [==============================] - 0s 208us/step - loss: 0.0968
Epoch 68/600
```

```
60/60 [==============================] - 0s 281us/step - loss: 0.0963
Epoch 69/600
60/60 [==============================] - 0s 381us/step - loss: 0.0956
Epoch 70/600
60/60 [==============================] - 0s 172us/step - loss: 0.0952
Epoch 71/600
60/60 [==============================] - 0s 161us/step - loss: 0.0947
Epoch 72/600
60/60 [==============================] - 0s 166us/step - loss: 0.0944
Epoch 73/600
60/60 [==============================] - 0s 185us/step - loss: 0.0935
Epoch 74/600
60/60 [==============================] - 0s 230us/step - loss: 0.0932
Epoch 75/600
60/60 [==============================] - 0s 162us/step - loss: 0.0927
Epoch 76/600
60/60 [==============================] - 0s 188us/step - loss: 0.0920
Epoch 77/600
60/60 [==============================] - 0s 163us/step - loss: 0.0921
Epoch 78/600
60/60 [==============================] - 0s 194us/step - loss: 0.0912
Epoch 79/600
60/60 [==============================] - 0s 192us/step - loss: 0.0911
Epoch 80/600
60/60 [==============================] - 0s 228us/step - loss: 0.0906
Epoch 81/600
60/60 [==============================] - 0s 233us/step - loss: 0.0902
Epoch 82/600
60/60 [==============================] - 0s 195us/step - loss: 0.0894
Epoch 83/600
60/60 [==============================] - 0s 205us/step - loss: 0.0887
Epoch 84/600
60/60 [==============================] - 0s 194us/step - loss: 0.0884
Epoch 85/600
60/60 [==============================] - 0s 248us/step - loss: 0.0884
Epoch 86/600
60/60 [==============================] - 0s 237us/step - loss: 0.0877
Epoch 87/600
60/60 [==============================] - 0s 274us/step - loss: 0.0875
Epoch 88/600
60/60 [==============================] - 0s 168us/step - loss: 0.0866
Epoch 89/600
60/60 [==============================] - 0s 242us/step - loss: 0.0860
Epoch 90/600
60/60 [==============================] - 0s 241us/step - loss: 0.0865
Epoch 91/600
60/60 [==============================] - 0s 238us/step - loss: 0.0872
Epoch 92/600
60/60 [==============================] - 0s 235us/step - loss: 0.0852
Epoch 93/600
60/60 [==============================] - 0s 196us/step - loss: 0.0844
Epoch 94/600
60/60 [==============================] - 0s 253us/step - loss: 0.0845
Epoch 95/600
60/60 [==============================] - 0s 211us/step - loss: 0.0837
Epoch 96/600
60/60 [==============================] - 0s 233us/step - loss: 0.0832
```

```
Epoch 97/600
60/60 [==============================] - 0s 294us/step - loss: 0.0831
Epoch 98/600
60/60 [==============================] - 0s 237us/step - loss: 0.0822
Epoch 99/600
60/60 [==============================] - 0s 186us/step - loss: 0.0819
Epoch 100/600
60/60 [==============================] - 0s 170us/step - loss: 0.0815
Epoch 101/600
60/60 [==============================] - 0s 199us/step - loss: 0.0810
Epoch 102/600
60/60 [==============================] - 0s 181us/step - loss: 0.0814
Epoch 103/600
60/60 [==============================] - 0s 196us/step - loss: 0.0804
Epoch 104/600
60/60 [==============================] - 0s 161us/step - loss: 0.0798
Epoch 105/600
60/60 [==============================] - 0s 279us/step - loss: 0.0804
Epoch 106/600
60/60 [==============================] - 0s 212us/step - loss: 0.0795
Epoch 107/600
60/60 [==============================] - 0s 236us/step - loss: 0.0786
Epoch 108/600
60/60 [==============================] - 0s 208us/step - loss: 0.0782
Epoch 109/600
60/60 [==============================] - 0s 185us/step - loss: 0.0782
Epoch 110/600
60/60 [==============================] - 0s 219us/step - loss: 0.0778
Epoch 111/600
60/60 [==============================] - 0s 247us/step - loss: 0.0788
Epoch 112/600
60/60 [==============================] - 0s 199us/step - loss: 0.0772
Epoch 113/600
60/60 [==============================] - 0s 245us/step - loss: 0.0764
Epoch 114/600
60/60 [==============================] - 0s 199us/step - loss: 0.0771
Epoch 115/600
60/60 [==============================] - 0s 208us/step - loss: 0.0758
Epoch 116/600
60/60 [==============================] - 0s 212us/step - loss: 0.0759
Epoch 117/600
60/60 [==============================] - 0s 229us/step - loss: 0.0761
Epoch 118/600
60/60 [==============================] - 0s 259us/step - loss: 0.0772
Epoch 119/600
60/60 [==============================] - 0s 200us/step - loss: 0.0755
Epoch 120/600
60/60 [==============================] - 0s 226us/step - loss: 0.0749
Epoch 121/600
60/60 [==============================] - 0s 221us/step - loss: 0.0741
Epoch 122/600
60/60 [==============================] - 0s 202us/step - loss: 0.0740
Epoch 123/600
60/60 [==============================] - 0s 196us/step - loss: 0.0743
Epoch 124/600
60/60 [==============================] - 0s 478us/step - loss: 0.0746
Epoch 125/600
```

```
60/60 [==============================] - 0s 332us/step - loss: 0.0730
Epoch 126/600
60/60 [==============================] - 0s 215us/step - loss: 0.0734
Epoch 127/600
60/60 [==============================] - 0s 245us/step - loss: 0.0728
Epoch 128/600
60/60 [==============================] - 0s 179us/step - loss: 0.0722
Epoch 129/600
60/60 [==============================] - 0s 243us/step - loss: 0.0721
Epoch 130/600
60/60 [==============================] - 0s 184us/step - loss: 0.0721
Epoch 131/600
60/60 [==============================] - 0s 240us/step - loss: 0.0720
Epoch 132/600
60/60 [==============================] - 0s 249us/step - loss: 0.0722
Epoch 133/600
60/60 [==============================] - 0s 224us/step - loss: 0.0709
Epoch 134/600
60/60 [==============================] - 0s 226us/step - loss: 0.0713
Epoch 135/600
60/60 [==============================] - 0s 217us/step - loss: 0.0715
Epoch 136/600
60/60 [==============================] - 0s 243us/step - loss: 0.0707
Epoch 137/600
60/60 [==============================] - 0s 281us/step - loss: 0.0706
Epoch 138/600
60/60 [==============================] - 0s 272us/step - loss: 0.0713
Epoch 139/600
60/60 [==============================] - 0s 266us/step - loss: 0.0702
Epoch 140/600
60/60 [==============================] - 0s 512us/step - loss: 0.0702
Epoch 141/600
60/60 [==============================] - 0s 246us/step - loss: 0.0695
Epoch 142/600
60/60 [==============================] - 0s 282us/step - loss: 0.0695
Epoch 143/600
60/60 [==============================] - 0s 213us/step - loss: 0.0698
Epoch 144/600
60/60 [==============================] - 0s 203us/step - loss: 0.0689
Epoch 145/600
60/60 [==============================] - 0s 192us/step - loss: 0.0690
Epoch 146/600
60/60 [==============================] - 0s 201us/step - loss: 0.0688
Epoch 147/600
60/60 [==============================] - 0s 206us/step - loss: 0.0700
Epoch 148/600
60/60 [==============================] - 0s 218us/step - loss: 0.0687
Epoch 149/600
60/60 [==============================] - 0s 214us/step - loss: 0.0685
Epoch 150/600
60/60 [==============================] - 0s 200us/step - loss: 0.0680
Epoch 151/600
60/60 [==============================] - 0s 213us/step - loss: 0.0697
Epoch 152/600
60/60 [==============================] - 0s 395us/step - loss: 0.0681
Epoch 153/600
60/60 [==============================] - 0s 192us/step - loss: 0.0690
```

```
Epoch 154/600
60/60 [==============================] - 0s 247us/step - loss: 0.0678
Epoch 155/600
60/60 [==============================] - 0s 516us/step - loss: 0.0670
Epoch 156/600
60/60 [==============================] - 0s 344us/step - loss: 0.0683
Epoch 157/600
60/60 [==============================] - 0s 354us/step - loss: 0.0675
Epoch 158/600
60/60 [==============================] - 0s 298us/step - loss: 0.0673
Epoch 159/600
60/60 [==============================] - 0s 225us/step - loss: 0.0671
Epoch 160/600
60/60 [==============================] - 0s 203us/step - loss: 0.0672
Epoch 161/600
60/60 [==============================] - 0s 174us/step - loss: 0.0670
Epoch 162/600
60/60 [==============================] - 0s 186us/step - loss: 0.0673
Epoch 163/600
60/60 [==============================] - 0s 188us/step - loss: 0.0663
Epoch 164/600
60/60 [==============================] - 0s 157us/step - loss: 0.0659
Epoch 165/600
60/60 [==============================] - 0s 156us/step - loss: 0.0661
Epoch 166/600
60/60 [==============================] - 0s 171us/step - loss: 0.0660
Epoch 167/600
60/60 [==============================] - 0s 149us/step - loss: 0.0668
Epoch 168/600
60/60 [==============================] - 0s 179us/step - loss: 0.0666
Epoch 169/600
60/60 [==============================] - 0s 390us/step - loss: 0.0657
Epoch 170/600
60/60 [==============================] - 0s 222us/step - loss: 0.0665
Epoch 171/600
60/60 [==============================] - 0s 187us/step - loss: 0.0662
Epoch 172/600
60/60 [==============================] - 0s 197us/step - loss: 0.0653
Epoch 173/600
60/60 [==============================] - 0s 189us/step - loss: 0.0687
Epoch 174/600
60/60 [==============================] - 0s 176us/step - loss: 0.0655
Epoch 175/600
60/60 [==============================] - 0s 192us/step - loss: 0.0656
Epoch 176/600
60/60 [==============================] - 0s 270us/step - loss: 0.0652
Epoch 177/600
60/60 [==============================] - 0s 343us/step - loss: 0.0655
Epoch 178/600
60/60 [==============================] - 0s 426us/step - loss: 0.0649
Epoch 179/600
60/60 [==============================] - 0s 300us/step - loss: 0.0643
Epoch 180/600
60/60 [==============================] - 0s 301us/step - loss: 0.0649
Epoch 181/600
60/60 [==============================] - 0s 249us/step - loss: 0.0644
Epoch 182/600
```

```
60/60 [==============================] - 0s 395us/step - loss: 0.0641
Epoch 183/600
60/60 [==============================] - 0s 296us/step - loss: 0.0652
Epoch 184/600
60/60 [==============================] - 0s 189us/step - loss: 0.0646
Epoch 185/600
60/60 [==============================] - 0s 166us/step - loss: 0.0636
Epoch 186/600
60/60 [==============================] - 0s 238us/step - loss: 0.0637
Epoch 187/600
60/60 [==============================] - 0s 218us/step - loss: 0.0634
Epoch 188/600
60/60 [==============================] - 0s 218us/step - loss: 0.0657
Epoch 189/600
60/60 [==============================] - 0s 258us/step - loss: 0.0651
Epoch 190/600
60/60 [==============================] - 0s 249us/step - loss: 0.0638
Epoch 191/600
60/60 [==============================] - 0s 256us/step - loss: 0.0640
Epoch 192/600
60/60 [==============================] - 0s 340us/step - loss: 0.0632
Epoch 193/600
60/60 [==============================] - 0s 249us/step - loss: 0.0629
Epoch 194/600
60/60 [==============================] - 0s 171us/step - loss: 0.0630
Epoch 195/600
60/60 [==============================] - 0s 178us/step - loss: 0.0627
Epoch 196/600
60/60 [==============================] - 0s 162us/step - loss: 0.0630
Epoch 197/600
60/60 [==============================] - 0s 195us/step - loss: 0.0624
Epoch 198/600
60/60 [==============================] - 0s 173us/step - loss: 0.0623
Epoch 199/600
60/60 [==============================] - 0s 143us/step - loss: 0.0635
Epoch 200/600
60/60 [==============================] - 0s 167us/step - loss: 0.0637
Epoch 201/600
60/60 [==============================] - 0s 167us/step - loss: 0.0628
Epoch 202/600
60/60 [==============================] - 0s 158us/step - loss: 0.0622
Epoch 203/600
60/60 [==============================] - 0s 396us/step - loss: 0.0637
Epoch 204/600
60/60 [==============================] - 0s 302us/step - loss: 0.0623
Epoch 205/600
60/60 [==============================] - 0s 251us/step - loss: 0.0622
Epoch 206/600
60/60 [==============================] - 0s 283us/step - loss: 0.0621
Epoch 207/600
60/60 [==============================] - 0s 287us/step - loss: 0.0617
Epoch 208/600
60/60 [==============================] - 0s 382us/step - loss: 0.0622
Epoch 209/600
60/60 [==============================] - 0s 625us/step - loss: 0.0616
Epoch 210/600
60/60 [==============================] - 0s 220us/step - loss: 0.0617
```

```
Epoch 211/600
60/60 [==============================] - 0s 234us/step - loss: 0.0614
Epoch 212/600
60/60 [==============================] - 0s 131us/step - loss: 0.0617
Epoch 213/600
60/60 [==============================] - 0s 188us/step - loss: 0.0611
Epoch 214/600
60/60 [==============================] - 0s 194us/step - loss: 0.0610
Epoch 215/600
60/60 [==============================] - 0s 178us/step - loss: 0.0611
Epoch 216/600
60/60 [==============================] - 0s 208us/step - loss: 0.0610
Epoch 217/600
60/60 [==============================] - 0s 233us/step - loss: 0.0609
Epoch 218/600
60/60 [==============================] - 0s 261us/step - loss: 0.0610
Epoch 219/600
60/60 [==============================] - 0s 214us/step - loss: 0.0635
Epoch 220/600
60/60 [==============================] - 0s 535us/step - loss: 0.0641
Epoch 221/600
60/60 [==============================] - 0s 537us/step - loss: 0.0618
Epoch 222/600
60/60 [==============================] - 0s 449us/step - loss: 0.0625
Epoch 223/600
60/60 [==============================] - 0s 469us/step - loss: 0.0612
Epoch 224/600
60/60 [==============================] - 0s 314us/step - loss: 0.0619
Epoch 225/600
60/60 [==============================] - 0s 291us/step - loss: 0.0613
Epoch 226/600
60/60 [==============================] - 0s 213us/step - loss: 0.0617
Epoch 227/600
60/60 [==============================] - 0s 227us/step - loss: 0.0609
Epoch 228/600
60/60 [==============================] - 0s 144us/step - loss: 0.0604
Epoch 229/600
60/60 [==============================] - 0s 146us/step - loss: 0.0601
Epoch 230/600
60/60 [==============================] - 0s 173us/step - loss: 0.0600
Epoch 231/600
60/60 [==============================] - 0s 264us/step - loss: 0.0621
Epoch 232/600
60/60 [==============================] - 0s 283us/step - loss: 0.0622
Epoch 233/600
60/60 [==============================] - 0s 465us/step - loss: 0.0627
Epoch 234/600
60/60 [==============================] - 0s 323us/step - loss: 0.0604
Epoch 235/600
60/60 [==============================] - 0s 314us/step - loss: 0.0597
Epoch 236/600
60/60 [==============================] - 0s 411us/step - loss: 0.0599
Epoch 237/600
60/60 [==============================] - 0s 342us/step - loss: 0.0612
Epoch 238/600
60/60 [==============================] - 0s 342us/step - loss: 0.0596
Epoch 239/600
```

```
60/60 [==============================] - 0s 386us/step - loss: 0.0602
Epoch 240/600
60/60 [==============================] - 0s 383us/step - loss: 0.0616
Epoch 241/600
60/60 [==============================] - 0s 226us/step - loss: 0.0614
Epoch 242/600
60/60 [==============================] - 0s 393us/step - loss: 0.0598
Epoch 243/600
60/60 [==============================] - 0s 266us/step - loss: 0.0613
Epoch 244/600
60/60 [==============================] - 0s 164us/step - loss: 0.0606
Epoch 245/600
60/60 [==============================] - 0s 172us/step - loss: 0.0615
Epoch 246/600
60/60 [==============================] - 0s 192us/step - loss: 0.0616
Epoch 247/600
60/60 [==============================] - 0s 167us/step - loss: 0.0610
Epoch 248/600
60/60 [==============================] - 0s 396us/step - loss: 0.0591
Epoch 249/600
60/60 [==============================] - 0s 161us/step - loss: 0.0621
Epoch 250/600
60/60 [==============================] - 0s 219us/step - loss: 0.0595
Epoch 251/600
60/60 [==============================] - 0s 185us/step - loss: 0.0594
Epoch 252/600
60/60 [==============================] - 0s 146us/step - loss: 0.0597
Epoch 253/600
60/60 [==============================] - 0s 156us/step - loss: 0.0594
Epoch 254/600
60/60 [==============================] - 0s 185us/step - loss: 0.0599
Epoch 255/600
60/60 [==============================] - 0s 155us/step - loss: 0.0598
Epoch 256/600
60/60 [==============================] - 0s 161us/step - loss: 0.0592
Epoch 257/600
60/60 [==============================] - 0s 367us/step - loss: 0.0586
Epoch 258/600
60/60 [==============================] - 0s 340us/step - loss: 0.0624
Epoch 259/600
60/60 [==============================] - 0s 322us/step - loss: 0.0643
Epoch 260/600
60/60 [==============================] - 0s 337us/step - loss: 0.0595
Epoch 261/600
60/60 [==============================] - 0s 380us/step - loss: 0.0618
Epoch 262/600
60/60 [==============================] - 0s 307us/step - loss: 0.0587
Epoch 263/600
60/60 [==============================] - 0s 275us/step - loss: 0.0610
Epoch 264/600
60/60 [==============================] - 0s 315us/step - loss: 0.0594
Epoch 265/600
60/60 [==============================] - 0s 208us/step - loss: 0.0584
Epoch 266/600
60/60 [==============================] - 0s 225us/step - loss: 0.0604
Epoch 267/600
60/60 [==============================] - 0s 290us/step - loss: 0.0624
```

```
Epoch 268/600
60/60 [==============================] - 0s 176us/step - loss: 0.0593
Epoch 269/600
60/60 [==============================] - 0s 264us/step - loss: 0.0607
Epoch 270/600
60/60 [==============================] - 0s 205us/step - loss: 0.0594
Epoch 271/600
60/60 [==============================] - 0s 190us/step - loss: 0.0593
Epoch 272/600
60/60 [==============================] - 0s 274us/step - loss: 0.0586
Epoch 273/600
60/60 [==============================] - 0s 334us/step - loss: 0.0584
Epoch 274/600
60/60 [==============================] - 0s 437us/step - loss: 0.0586
Epoch 275/600
60/60 [==============================] - 0s 287us/step - loss: 0.0610
Epoch 276/600
60/60 [==============================] - 0s 298us/step - loss: 0.0591
Epoch 277/600
60/60 [==============================] - 0s 273us/step - loss: 0.0588
Epoch 278/600
60/60 [==============================] - 0s 376us/step - loss: 0.0579
Epoch 279/600
60/60 [==============================] - 0s 382us/step - loss: 0.0579
Epoch 280/600
60/60 [==============================] - 0s 460us/step - loss: 0.0590
Epoch 281/600
60/60 [==============================] - 0s 183us/step - loss: 0.0579
Epoch 282/600
60/60 [==============================] - 0s 175us/step - loss: 0.0595
Epoch 283/600
60/60 [==============================] - 0s 167us/step - loss: 0.0586
Epoch 284/600
60/60 [==============================] - 0s 217us/step - loss: 0.0589
Epoch 285/600
60/60 [==============================] - 0s 168us/step - loss: 0.0579
Epoch 286/600
60/60 [==============================] - 0s 177us/step - loss: 0.0577
Epoch 287/600
60/60 [==============================] - 0s 187us/step - loss: 0.0575
Epoch 288/600
60/60 [==============================] - 0s 224us/step - loss: 0.0610
Epoch 289/600
60/60 [==============================] - 0s 323us/step - loss: 0.0602
Epoch 290/600
60/60 [==============================] - 0s 318us/step - loss: 0.0615
Epoch 291/600
60/60 [==============================] - 0s 302us/step - loss: 0.0593
Epoch 292/600
60/60 [==============================] - 0s 318us/step - loss: 0.0582
Epoch 293/600
60/60 [==============================] - 0s 325us/step - loss: 0.0579
Epoch 294/600
60/60 [==============================] - 0s 386us/step - loss: 0.0574
Epoch 295/600
60/60 [==============================] - 0s 217us/step - loss: 0.0591
Epoch 296/600
```

```
60/60 [==============================] - 0s 290us/step - loss: 0.0610
Epoch 297/600
60/60 [==============================] - 0s 234us/step - loss: 0.0580
Epoch 298/600
60/60 [==============================] - 0s 218us/step - loss: 0.0576
Epoch 299/600
60/60 [==============================] - 0s 272us/step - loss: 0.0582
Epoch 300/600
60/60 [==============================] - 0s 250us/step - loss: 0.0592
Epoch 301/600
60/60 [==============================] - 0s 256us/step - loss: 0.0585
Epoch 302/600
60/60 [==============================] - 0s 218us/step - loss: 0.0581
Epoch 303/600
60/60 [==============================] - 0s 207us/step - loss: 0.0580
Epoch 304/600
60/60 [==============================] - 0s 246us/step - loss: 0.0575
Epoch 305/600
60/60 [==============================] - 0s 231us/step - loss: 0.0594
Epoch 306/600
60/60 [==============================] - 0s 237us/step - loss: 0.0593
Epoch 307/600
60/60 [==============================] - 0s 256us/step - loss: 0.0589
Epoch 308/600
60/60 [==============================] - 0s 253us/step - loss: 0.0577
Epoch 309/600
60/60 [==============================] - 0s 204us/step - loss: 0.0585
Epoch 310/600
60/60 [==============================] - 0s 267us/step - loss: 0.0586
Epoch 311/600
60/60 [==============================] - 0s 185us/step - loss: 0.0574
Epoch 312/600
60/60 [==============================] - 0s 149us/step - loss: 0.0576
Epoch 313/600
60/60 [==============================] - 0s 180us/step - loss: 0.0596
Epoch 314/600
60/60 [==============================] - 0s 183us/step - loss: 0.0580
Epoch 315/600
60/60 [==============================] - 0s 206us/step - loss: 0.0602
Epoch 316/600
60/60 [==============================] - 0s 247us/step - loss: 0.0583
Epoch 317/600
60/60 [==============================] - 0s 170us/step - loss: 0.0596
Epoch 318/600
60/60 [==============================] - 0s 171us/step - loss: 0.0578
Epoch 319/600
60/60 [==============================] - 0s 168us/step - loss: 0.0570
Epoch 320/600
60/60 [==============================] - 0s 160us/step - loss: 0.0569
Epoch 321/600
60/60 [==============================] - 0s 153us/step - loss: 0.0568
Epoch 322/600
60/60 [==============================] - 0s 171us/step - loss: 0.0575
Epoch 323/600
60/60 [==============================] - 0s 201us/step - loss: 0.0571
Epoch 324/600
60/60 [==============================] - 0s 203us/step - loss: 0.0566
```

```
Epoch 325/600
60/60 [==============================] - 0s 370us/step - loss: 0.0573
Epoch 326/600
60/60 [==============================] - 0s 301us/step - loss: 0.0583
Epoch 327/600
60/60 [==============================] - 0s 446us/step - loss: 0.0582
Epoch 328/600
60/60 [==============================] - 0s 332us/step - loss: 0.0603
Epoch 329/600
60/60 [==============================] - 0s 356us/step - loss: 0.0594
Epoch 330/600
60/60 [==============================] - 0s 238us/step - loss: 0.0591
Epoch 331/600
60/60 [==============================] - 0s 193us/step - loss: 0.0572
Epoch 332/600
60/60 [==============================] - 0s 298us/step - loss: 0.0563
Epoch 333/600
60/60 [==============================] - 0s 270us/step - loss: 0.0562
Epoch 334/600
60/60 [==============================] - 0s 316us/step - loss: 0.0577
Epoch 335/600
60/60 [==============================] - 0s 242us/step - loss: 0.0570
Epoch 336/600
60/60 [==============================] - 0s 184us/step - loss: 0.0578
Epoch 337/600
60/60 [==============================] - 0s 171us/step - loss: 0.0561
Epoch 338/600
60/60 [==============================] - 0s 202us/step - loss: 0.0562
Epoch 339/600
60/60 [==============================] - 0s 175us/step - loss: 0.0582
Epoch 340/600
60/60 [==============================] - 0s 213us/step - loss: 0.0563
Epoch 341/600
60/60 [==============================] - 0s 160us/step - loss: 0.0559
Epoch 342/600
60/60 [==============================] - 0s 142us/step - loss: 0.0599
Epoch 343/600
60/60 [==============================] - 0s 155us/step - loss: 0.0564
Epoch 344/600
60/60 [==============================] - 0s 175us/step - loss: 0.0570
Epoch 345/600
60/60 [==============================] - 0s 308us/step - loss: 0.0574
Epoch 346/600
60/60 [==============================] - 0s 316us/step - loss: 0.0574
Epoch 347/600
60/60 [==============================] - 0s 228us/step - loss: 0.0579
Epoch 348/600
60/60 [==============================] - 0s 387us/step - loss: 0.0570
Epoch 349/600
60/60 [==============================] - 0s 213us/step - loss: 0.0569
Epoch 350/600
60/60 [==============================] - 0s 195us/step - loss: 0.0582
Epoch 351/600
60/60 [==============================] - 0s 221us/step - loss: 0.0580
Epoch 352/600
60/60 [==============================] - 0s 348us/step - loss: 0.0557
Epoch 353/600
```

```
60/60 [==============================] - 0s 200us/step - loss: 0.0558
Epoch 354/600
60/60 [==============================] - 0s 247us/step - loss: 0.0561
Epoch 355/600
60/60 [==============================] - 0s 208us/step - loss: 0.0586
Epoch 356/600
60/60 [==============================] - 0s 238us/step - loss: 0.0571
Epoch 357/600
60/60 [==============================] - 0s 291us/step - loss: 0.0564
Epoch 358/600
60/60 [==============================] - 0s 207us/step - loss: 0.0555
Epoch 359/600
60/60 [==============================] - 0s 164us/step - loss: 0.0556
Epoch 360/600
60/60 [==============================] - 0s 181us/step - loss: 0.0563
Epoch 361/600
60/60 [==============================] - 0s 214us/step - loss: 0.0561
Epoch 362/600
60/60 [==============================] - 0s 200us/step - loss: 0.0560
Epoch 363/600
60/60 [==============================] - 0s 201us/step - loss: 0.0582
Epoch 364/600
60/60 [==============================] - 0s 187us/step - loss: 0.0576
Epoch 365/600
60/60 [==============================] - 0s 164us/step - loss: 0.0573
Epoch 366/600
60/60 [==============================] - 0s 162us/step - loss: 0.0556
Epoch 367/600
60/60 [==============================] - 0s 165us/step - loss: 0.0555
Epoch 368/600
60/60 [==============================] - 0s 168us/step - loss: 0.0558
Epoch 369/600
60/60 [==============================] - 0s 202us/step - loss: 0.0556
Epoch 370/600
60/60 [==============================] - 0s 199us/step - loss: 0.0559
Epoch 371/600
60/60 [==============================] - 0s 187us/step - loss: 0.0593
Epoch 372/600
60/60 [==============================] - 0s 161us/step - loss: 0.0555
Epoch 373/600
60/60 [==============================] - 0s 167us/step - loss: 0.0565
Epoch 374/600
60/60 [==============================] - 0s 163us/step - loss: 0.0575
Epoch 375/600
60/60 [==============================] - 0s 153us/step - loss: 0.0564
Epoch 376/600
60/60 [==============================] - 0s 171us/step - loss: 0.0571
Epoch 377/600
60/60 [==============================] - 0s 271us/step - loss: 0.0555
Epoch 378/600
60/60 [==============================] - 0s 504us/step - loss: 0.0552
Epoch 379/600
60/60 [==============================] - 0s 364us/step - loss: 0.0554
Epoch 380/600
60/60 [==============================] - 0s 411us/step - loss: 0.0551
Epoch 381/600
60/60 [==============================] - 0s 342us/step - loss: 0.0565
```

```
Epoch 382/600
60/60 [==============================] - 0s 330us/step - loss: 0.0583
Epoch 383/600
60/60 [==============================] - 0s 205us/step - loss: 0.0573
Epoch 384/600
60/60 [==============================] - 0s 269us/step - loss: 0.0566
Epoch 385/600
60/60 [==============================] - 0s 273us/step - loss: 0.0557
Epoch 386/600
60/60 [==============================] - 0s 198us/step - loss: 0.0589
Epoch 387/600
60/60 [==============================] - 0s 186us/step - loss: 0.0549
Epoch 388/600
60/60 [==============================] - 0s 157us/step - loss: 0.0552
Epoch 389/600
60/60 [==============================] - 0s 168us/step - loss: 0.0570
Epoch 390/600
60/60 [==============================] - 0s 191us/step - loss: 0.0558
Epoch 391/600
60/60 [==============================] - 0s 195us/step - loss: 0.0572
Epoch 392/600
60/60 [==============================] - 0s 178us/step - loss: 0.0550
Epoch 393/600
60/60 [==============================] - 0s 158us/step - loss: 0.0554
Epoch 394/600
60/60 [==============================] - 0s 159us/step - loss: 0.0559
Epoch 395/600
60/60 [==============================] - 0s 326us/step - loss: 0.0567
Epoch 396/600
60/60 [==============================] - 0s 187us/step - loss: 0.0582
Epoch 397/600
60/60 [==============================] - 0s 214us/step - loss: 0.0558
Epoch 398/600
60/60 [==============================] - 0s 197us/step - loss: 0.0573
Epoch 399/600
60/60 [==============================] - 0s 210us/step - loss: 0.0581
Epoch 400/600
60/60 [==============================] - 0s 280us/step - loss: 0.0562
Epoch 401/600
60/60 [==============================] - 0s 150us/step - loss: 0.0564
Epoch 402/600
60/60 [==============================] - 0s 244us/step - loss: 0.0563
Epoch 403/600
60/60 [==============================] - 0s 254us/step - loss: 0.0548
Epoch 404/600
60/60 [==============================] - 0s 219us/step - loss: 0.0549
Epoch 405/600
60/60 [==============================] - 0s 170us/step - loss: 0.0554
Epoch 406/600
60/60 [==============================] - 0s 221us/step - loss: 0.0549
Epoch 407/600
60/60 [==============================] - 0s 157us/step - loss: 0.0548
Epoch 408/600
60/60 [==============================] - 0s 179us/step - loss: 0.0556
Epoch 409/600
60/60 [==============================] - 0s 180us/step - loss: 0.0548
Epoch 410/600
```

```
60/60 [==============================] - 0s 284us/step - loss: 0.0559
Epoch 411/600
60/60 [==============================] - 0s 361us/step - loss: 0.0552
Epoch 412/600
60/60 [==============================] - 0s 219us/step - loss: 0.0579
Epoch 413/600
60/60 [==============================] - 0s 340us/step - loss: 0.0556
Epoch 414/600
60/60 [==============================] - 0s 229us/step - loss: 0.0552
Epoch 415/600
60/60 [==============================] - 0s 310us/step - loss: 0.0578
Epoch 416/600
60/60 [==============================] - 0s 172us/step - loss: 0.0551
Epoch 417/600
60/60 [==============================] - 0s 207us/step - loss: 0.0543
Epoch 418/600
60/60 [==============================] - 0s 236us/step - loss: 0.0545
Epoch 419/600
60/60 [==============================] - 0s 212us/step - loss: 0.0557
Epoch 420/600
60/60 [==============================] - 0s 203us/step - loss: 0.0563
Epoch 421/600
60/60 [==============================] - 0s 265us/step - loss: 0.0562
Epoch 422/600
60/60 [==============================] - 0s 302us/step - loss: 0.0576
Epoch 423/600
60/60 [==============================] - 0s 359us/step - loss: 0.0547
Epoch 424/600
60/60 [==============================] - 0s 427us/step - loss: 0.0566
Epoch 425/600
60/60 [==============================] - 0s 305us/step - loss: 0.0544
Epoch 426/600
60/60 [==============================] - 0s 345us/step - loss: 0.0556
Epoch 427/600
60/60 [==============================] - 0s 431us/step - loss: 0.0573
Epoch 428/600
60/60 [==============================] - 0s 306us/step - loss: 0.0562
Epoch 429/600
60/60 [==============================] - 0s 449us/step - loss: 0.0561
Epoch 430/600
60/60 [==============================] - 0s 301us/step - loss: 0.0548
Epoch 431/600
60/60 [==============================] - 0s 390us/step - loss: 0.0549
Epoch 432/600
60/60 [==============================] - 0s 402us/step - loss: 0.0549
Epoch 433/600
60/60 [==============================] - 0s 416us/step - loss: 0.0572
Epoch 434/600
60/60 [==============================] - 0s 286us/step - loss: 0.0542
Epoch 435/600
60/60 [==============================] - 0s 263us/step - loss: 0.0565
Epoch 436/600
60/60 [==============================] - 0s 235us/step - loss: 0.0543
Epoch 437/600
60/60 [==============================] - 0s 205us/step - loss: 0.0546
Epoch 438/600
60/60 [==============================] - 0s 274us/step - loss: 0.0544
```

```
Epoch 439/600
60/60 [==============================] - 0s 246us/step - loss: 0.0550
Epoch 440/600
60/60 [==============================] - 0s 206us/step - loss: 0.0555
Epoch 441/600
60/60 [==============================] - 0s 279us/step - loss: 0.0542
Epoch 442/600
60/60 [==============================] - 0s 217us/step - loss: 0.0541
Epoch 443/600
60/60 [==============================] - 0s 238us/step - loss: 0.0551
Epoch 444/600
60/60 [==============================] - 0s 262us/step - loss: 0.0543
Epoch 445/600
60/60 [==============================] - 0s 268us/step - loss: 0.0562
Epoch 446/600
60/60 [==============================] - 0s 173us/step - loss: 0.0539
Epoch 447/600
60/60 [==============================] - 0s 141us/step - loss: 0.0539
Epoch 448/600
60/60 [==============================] - 0s 192us/step - loss: 0.0541
Epoch 449/600
60/60 [==============================] - 0s 159us/step - loss: 0.0551
Epoch 450/600
60/60 [==============================] - 0s 260us/step - loss: 0.0559
Epoch 451/600
60/60 [==============================] - 0s 180us/step - loss: 0.0540
Epoch 452/600
60/60 [==============================] - 0s 192us/step - loss: 0.0542
Epoch 453/600
60/60 [==============================] - 0s 153us/step - loss: 0.0543
Epoch 454/600
60/60 [==============================] - 0s 187us/step - loss: 0.0572
Epoch 455/600
60/60 [==============================] - 0s 163us/step - loss: 0.0545
Epoch 456/600
60/60 [==============================] - 0s 163us/step - loss: 0.0581
Epoch 457/600
60/60 [==============================] - 0s 160us/step - loss: 0.0555
Epoch 458/600
60/60 [==============================] - 0s 170us/step - loss: 0.0561
Epoch 459/600
60/60 [==============================] - 0s 202us/step - loss: 0.0546
Epoch 460/600
60/60 [==============================] - 0s 216us/step - loss: 0.0544
Epoch 461/600
60/60 [==============================] - 0s 233us/step - loss: 0.0539
Epoch 462/600
60/60 [==============================] - 0s 150us/step - loss: 0.0568
Epoch 463/600
60/60 [==============================] - 0s 197us/step - loss: 0.0556
Epoch 464/600
60/60 [==============================] - 0s 172us/step - loss: 0.0542
Epoch 465/600
60/60 [==============================] - 0s 209us/step - loss: 0.0538
Epoch 466/600
60/60 [==============================] - 0s 226us/step - loss: 0.0540
Epoch 467/600
```

```
60/60 [==============================] - 0s 197us/step - loss: 0.0538
Epoch 468/600
60/60 [==============================] - 0s 271us/step - loss: 0.0539
Epoch 469/600
60/60 [==============================] - 0s 209us/step - loss: 0.0544
Epoch 470/600
60/60 [==============================] - 0s 167us/step - loss: 0.0539
Epoch 471/600
60/60 [==============================] - 0s 164us/step - loss: 0.0537
Epoch 472/600
60/60 [==============================] - 0s 199us/step - loss: 0.0538
Epoch 473/600
60/60 [==============================] - 0s 230us/step - loss: 0.0537
Epoch 474/600
60/60 [==============================] - 0s 169us/step - loss: 0.0538
Epoch 475/600
60/60 [==============================] - 0s 180us/step - loss: 0.0537
Epoch 476/600
60/60 [==============================] - 0s 152us/step - loss: 0.0531
Epoch 477/600
60/60 [==============================] - 0s 146us/step - loss: 0.0538
Epoch 478/600
60/60 [==============================] - 0s 153us/step - loss: 0.0538
Epoch 479/600
60/60 [==============================] - 0s 167us/step - loss: 0.0547
Epoch 480/600
60/60 [==============================] - 0s 194us/step - loss: 0.0559
Epoch 481/600
60/60 [==============================] - 0s 280us/step - loss: 0.0552
Epoch 482/600
60/60 [==============================] - 0s 281us/step - loss: 0.0545
Epoch 483/600
60/60 [==============================] - 0s 217us/step - loss: 0.0554
Epoch 484/600
60/60 [==============================] - 0s 224us/step - loss: 0.0544
Epoch 485/600
60/60 [==============================] - 0s 219us/step - loss: 0.0533
Epoch 486/600
60/60 [==============================] - 0s 230us/step - loss: 0.0535
Epoch 487/600
60/60 [==============================] - 0s 216us/step - loss: 0.0559
Epoch 488/600
60/60 [==============================] - 0s 207us/step - loss: 0.0554
Epoch 489/600
60/60 [==============================] - 0s 184us/step - loss: 0.0561
Epoch 490/600
60/60 [==============================] - 0s 167us/step - loss: 0.0538
Epoch 491/600
60/60 [==============================] - 0s 185us/step - loss: 0.0566
Epoch 492/600
60/60 [==============================] - 0s 167us/step - loss: 0.0532
Epoch 493/600
60/60 [==============================] - 0s 177us/step - loss: 0.0555
Epoch 494/600
60/60 [==============================] - 0s 198us/step - loss: 0.0555
Epoch 495/600
60/60 [==============================] - 0s 160us/step - loss: 0.0532
```

```
Epoch 496/600
60/60 [==============================] - 0s 263us/step - loss: 0.0540
Restoring model weights from the end of the best epoch
Epoch 00496: early stopping
best epoch v2 =  476
smallest loss v2 = 0.05309077377120654
```

In [71]:

```
historyDatav3 = modelv3.fit(xarray,yarray,epochs=600,callbacks=[es])
loss_histv3 = historyDatav3.history['loss']

best_epochv3 = np.argmin(historyDatav3.history['loss']) + 1
print ('best epoch v3 = ', best_epochv3)
print('smallest loss v3 =', np.min(loss_histv3))
```

```
Epoch 1/600
60/60 [==============================] - 1s 10ms/step - loss: 1.1264
Epoch 2/600
60/60 [==============================] - 0s 187us/step - loss: 1.0720
Epoch 3/600
60/60 [==============================] - 0s 178us/step - loss: 1.0213
Epoch 4/600
60/60 [==============================] - 0s 236us/step - loss: 0.9773
Epoch 5/600
60/60 [==============================] - 0s 304us/step - loss: 0.9433
Epoch 6/600
60/60 [==============================] - 0s 377us/step - loss: 0.9195
Epoch 7/600
60/60 [==============================] - 0s 307us/step - loss: 0.9022
Epoch 8/600
60/60 [==============================] - 0s 261us/step - loss: 0.8852
Epoch 9/600
60/60 [==============================] - 0s 209us/step - loss: 0.8678
Epoch 10/600
60/60 [==============================] - 0s 371us/step - loss: 0.8502
Epoch 11/600
60/60 [==============================] - 0s 262us/step - loss: 0.8322
Epoch 12/600
60/60 [==============================] - 0s 293us/step - loss: 0.8138
Epoch 13/600
60/60 [==============================] - 0s 356us/step - loss: 0.7951
Epoch 14/600
60/60 [==============================] - 0s 165us/step - loss: 0.7758
Epoch 15/600
60/60 [==============================] - 0s 142us/step - loss: 0.7560
Epoch 16/600
60/60 [==============================] - 0s 182us/step - loss: 0.7356
Epoch 17/600
60/60 [==============================] - 0s 289us/step - loss: 0.7146
Epoch 18/600
60/60 [==============================] - 0s 513us/step - loss: 0.6928
Epoch 19/600
60/60 [==============================] - 0s 191us/step - loss: 0.6703
Epoch 20/600
60/60 [==============================] - 0s 211us/step - loss: 0.6470
Epoch 21/600
```

```
60/60 [==============================] - 0s 357us/step - loss: 0.6227
Epoch 22/600
60/60 [==============================] - 0s 228us/step - loss: 0.5974
Epoch 23/600
60/60 [==============================] - 0s 376us/step - loss: 0.5709
Epoch 24/600
60/60 [==============================] - 0s 337us/step - loss: 0.5449
Epoch 25/600
60/60 [==============================] - 0s 332us/step - loss: 0.5219
Epoch 26/600
60/60 [==============================] - 0s 503us/step - loss: 0.5021
Epoch 27/600
60/60 [==============================] - 0s 208us/step - loss: 0.4866
Epoch 28/600
60/60 [==============================] - 0s 213us/step - loss: 0.4729
Epoch 29/600
60/60 [==============================] - 0s 157us/step - loss: 0.4606
Epoch 30/600
60/60 [==============================] - 0s 175us/step - loss: 0.4489
Epoch 31/600
60/60 [==============================] - 0s 161us/step - loss: 0.4375
Epoch 32/600
60/60 [==============================] - 0s 130us/step - loss: 0.4255
Epoch 33/600
60/60 [==============================] - 0s 333us/step - loss: 0.4139
Epoch 34/600
60/60 [==============================] - 0s 327us/step - loss: 0.4022
Epoch 35/600
60/60 [==============================] - 0s 328us/step - loss: 0.3905
Epoch 36/600
60/60 [==============================] - 0s 286us/step - loss: 0.3785
Epoch 37/600
60/60 [==============================] - 0s 370us/step - loss: 0.3666
Epoch 38/600
60/60 [==============================] - 0s 564us/step - loss: 0.3551
Epoch 39/600
60/60 [==============================] - 0s 220us/step - loss: 0.3426
Epoch 40/600
60/60 [==============================] - 0s 152us/step - loss: 0.3306
Epoch 41/600
60/60 [==============================] - 0s 184us/step - loss: 0.3180
Epoch 42/600
60/60 [==============================] - 0s 141us/step - loss: 0.3055
Epoch 43/600
60/60 [==============================] - 0s 246us/step - loss: 0.2928
Epoch 44/600
60/60 [==============================] - 0s 228us/step - loss: 0.2800
Epoch 45/600
60/60 [==============================] - 0s 149us/step - loss: 0.2671
Epoch 46/600
60/60 [==============================] - 0s 229us/step - loss: 0.2550
Epoch 47/600
60/60 [==============================] - 0s 153us/step - loss: 0.2432
Epoch 48/600
60/60 [==============================] - 0s 248us/step - loss: 0.2321
Epoch 49/600
60/60 [==============================] - 0s 145us/step - loss: 0.2211
```

```
Epoch 50/600
60/60 [==============================] - 0s 142us/step - loss: 0.2106
Epoch 51/600
60/60 [==============================] - 0s 118us/step - loss: 0.2010
Epoch 52/600
60/60 [==============================] - 0s 152us/step - loss: 0.1922
Epoch 53/600
60/60 [==============================] - 0s 147us/step - loss: 0.1846
Epoch 54/600
60/60 [==============================] - 0s 228us/step - loss: 0.1781
Epoch 55/600
60/60 [==============================] - 0s 139us/step - loss: 0.1722
Epoch 56/600
60/60 [==============================] - 0s 166us/step - loss: 0.1668
Epoch 57/600
60/60 [==============================] - 0s 129us/step - loss: 0.1619
Epoch 58/600
60/60 [==============================] - 0s 199us/step - loss: 0.1581
Epoch 59/600
60/60 [==============================] - 0s 217us/step - loss: 0.1554
Epoch 60/600
60/60 [==============================] - 0s 319us/step - loss: 0.1533
Epoch 61/600
60/60 [==============================] - 0s 425us/step - loss: 0.1511
Epoch 62/600
60/60 [==============================] - 0s 397us/step - loss: 0.1504
Epoch 63/600
60/60 [==============================] - 0s 264us/step - loss: 0.1484
Epoch 64/600
60/60 [==============================] - 0s 284us/step - loss: 0.1470
Epoch 65/600
60/60 [==============================] - 0s 305us/step - loss: 0.1454
Epoch 66/600
60/60 [==============================] - 0s 212us/step - loss: 0.1444
Epoch 67/600
60/60 [==============================] - 0s 193us/step - loss: 0.1434
Epoch 68/600
60/60 [==============================] - 0s 284us/step - loss: 0.1425
Epoch 69/600
60/60 [==============================] - 0s 156us/step - loss: 0.1414
Epoch 70/600
60/60 [==============================] - 0s 127us/step - loss: 0.1403
Epoch 71/600
60/60 [==============================] - 0s 126us/step - loss: 0.1394
Epoch 72/600
60/60 [==============================] - 0s 130us/step - loss: 0.1391
Epoch 73/600
60/60 [==============================] - 0s 202us/step - loss: 0.1379
Epoch 74/600
60/60 [==============================] - 0s 169us/step - loss: 0.1371
Epoch 75/600
60/60 [==============================] - 0s 168us/step - loss: 0.1364
Epoch 76/600
60/60 [==============================] - 0s 133us/step - loss: 0.1356
Epoch 77/600
60/60 [==============================] - 0s 150us/step - loss: 0.1349
Epoch 78/600
```

```
60/60 [==============================] - 0s 193us/step - loss: 0.1340
Epoch 79/600
60/60 [==============================] - 0s 176us/step - loss: 0.1332
Epoch 80/600
60/60 [==============================] - 0s 234us/step - loss: 0.1326
Epoch 81/600
60/60 [==============================] - 0s 278us/step - loss: 0.1320
Epoch 82/600
60/60 [==============================] - 0s 219us/step - loss: 0.1311
Epoch 83/600
60/60 [==============================] - 0s 430us/step - loss: 0.1305
Epoch 84/600
60/60 [==============================] - 0s 457us/step - loss: 0.1300
Epoch 85/600
60/60 [==============================] - 0s 510us/step - loss: 0.1296
Epoch 86/600
60/60 [==============================] - 0s 336us/step - loss: 0.1289
Epoch 87/600
60/60 [==============================] - 0s 399us/step - loss: 0.1280
Epoch 88/600
60/60 [==============================] - 0s 204us/step - loss: 0.1269
Epoch 89/600
60/60 [==============================] - 0s 218us/step - loss: 0.1263
Epoch 90/600
60/60 [==============================] - 0s 240us/step - loss: 0.1256
Epoch 91/600
60/60 [==============================] - 0s 195us/step - loss: 0.1249
Epoch 92/600
60/60 [==============================] - 0s 247us/step - loss: 0.1242
Epoch 93/600
60/60 [==============================] - 0s 211us/step - loss: 0.1238
Epoch 94/600
60/60 [==============================] - 0s 165us/step - loss: 0.1228
Epoch 95/600
60/60 [==============================] - 0s 164us/step - loss: 0.1222
Epoch 96/600
60/60 [==============================] - 0s 246us/step - loss: 0.1215
Epoch 97/600
60/60 [==============================] - 0s 218us/step - loss: 0.1209
Epoch 98/600
60/60 [==============================] - 0s 194us/step - loss: 0.1201
Epoch 99/600
60/60 [==============================] - 0s 180us/step - loss: 0.1195
Epoch 100/600
60/60 [==============================] - 0s 180us/step - loss: 0.1194
Epoch 101/600
60/60 [==============================] - 0s 221us/step - loss: 0.1185
Epoch 102/600
60/60 [==============================] - 0s 187us/step - loss: 0.1183
Epoch 103/600
60/60 [==============================] - 0s 187us/step - loss: 0.1173
Epoch 104/600
60/60 [==============================] - 0s 163us/step - loss: 0.1166
Epoch 105/600
60/60 [==============================] - 0s 291us/step - loss: 0.1159
Epoch 106/600
60/60 [==============================] - 0s 441us/step - loss: 0.1153
```

```
Epoch 107/600
60/60 [==============================] - 0s 338us/step - loss: 0.1146
Epoch 108/600
60/60 [==============================] - 0s 406us/step - loss: 0.1150
Epoch 109/600
60/60 [==============================] - 0s 191us/step - loss: 0.1143
Epoch 110/600
60/60 [==============================] - 0s 182us/step - loss: 0.1129
Epoch 111/600
60/60 [==============================] - 0s 193us/step - loss: 0.1123
Epoch 112/600
60/60 [==============================] - 0s 175us/step - loss: 0.1120
Epoch 113/600
60/60 [==============================] - 0s 143us/step - loss: 0.1113
Epoch 114/600
60/60 [==============================] - 0s 218us/step - loss: 0.1119
Epoch 115/600
60/60 [==============================] - 0s 200us/step - loss: 0.1099
Epoch 116/600
60/60 [==============================] - 0s 222us/step - loss: 0.1096
Epoch 117/600
60/60 [==============================] - 0s 230us/step - loss: 0.1090
Epoch 118/600
60/60 [==============================] - 0s 258us/step - loss: 0.1082
Epoch 119/600
60/60 [==============================] - 0s 595us/step - loss: 0.1076
Epoch 120/600
60/60 [==============================] - 0s 478us/step - loss: 0.1076
Epoch 121/600
60/60 [==============================] - 0s 516us/step - loss: 0.1064
Epoch 122/600
60/60 [==============================] - 0s 206us/step - loss: 0.1058
Epoch 123/600
60/60 [==============================] - ETA: 0s - loss: 0.114 - 0s 278us/step
- loss: 0.1053
Epoch 124/600
60/60 [==============================] - 0s 271us/step - loss: 0.1047
Epoch 125/600
60/60 [==============================] - 0s 370us/step - loss: 0.1043
Epoch 126/600
60/60 [==============================] - 0s 288us/step - loss: 0.1038
Epoch 127/600
60/60 [==============================] - 0s 733us/step - loss: 0.1032
Epoch 128/600
60/60 [==============================] - 0s 965us/step - loss: 0.1025
Epoch 129/600
60/60 [==============================] - 0s 565us/step - loss: 0.1022
Epoch 130/600
60/60 [==============================] - 0s 316us/step - loss: 0.1016
Epoch 131/600
60/60 [==============================] - 0s 302us/step - loss: 0.1019
Epoch 132/600
60/60 [==============================] - 0s 793us/step - loss: 0.1008
Epoch 133/600
60/60 [==============================] - 0s 163us/step - loss: 0.1002
Epoch 134/600
60/60 [==============================] - 0s 212us/step - loss: 0.1000
```

```
Epoch 135/600
60/60 [==============================] - 0s 159us/step - loss: 0.0995
Epoch 136/600
60/60 [==============================] - 0s 319us/step - loss: 0.0989
Epoch 137/600
60/60 [==============================] - 0s 204us/step - loss: 0.0984
Epoch 138/600
60/60 [==============================] - 0s 183us/step - loss: 0.0978
Epoch 139/600
60/60 [==============================] - 0s 304us/step - loss: 0.0976
Epoch 140/600
60/60 [==============================] - 0s 177us/step - loss: 0.0971
Epoch 141/600
60/60 [==============================] - 0s 269us/step - loss: 0.0964
Epoch 142/600
60/60 [==============================] - 0s 472us/step - loss: 0.0960
Epoch 143/600
60/60 [==============================] - 0s 175us/step - loss: 0.0954
Epoch 144/600
60/60 [==============================] - 0s 332us/step - loss: 0.0950
Epoch 145/600
60/60 [==============================] - 0s 270us/step - loss: 0.0948
Epoch 146/600
60/60 [==============================] - 0s 539us/step - loss: 0.0942
Epoch 147/600
60/60 [==============================] - 0s 269us/step - loss: 0.0941
Epoch 148/600
60/60 [==============================] - 0s 509us/step - loss: 0.0933
Epoch 149/600
60/60 [==============================] - 0s 238us/step - loss: 0.0935
Epoch 150/600
60/60 [==============================] - 0s 210us/step - loss: 0.0925
Epoch 151/600
60/60 [==============================] - 0s 257us/step - loss: 0.0926
Epoch 152/600
60/60 [==============================] - 0s 249us/step - loss: 0.0934
Epoch 153/600
60/60 [==============================] - 0s 276us/step - loss: 0.0914
Epoch 154/600
60/60 [==============================] - 0s 233us/step - loss: 0.0909
Epoch 155/600
60/60 [==============================] - 0s 244us/step - loss: 0.0904
Epoch 156/600
60/60 [==============================] - 0s 181us/step - loss: 0.0907
Epoch 157/600
60/60 [==============================] - 0s 192us/step - loss: 0.0897
Epoch 158/600
60/60 [==============================] - 0s 138us/step - loss: 0.0898
Epoch 159/600
60/60 [==============================] - 0s 179us/step - loss: 0.0891
Epoch 160/600
60/60 [==============================] - 0s 208us/step - loss: 0.0889
Epoch 161/600
60/60 [==============================] - 0s 128us/step - loss: 0.0879
Epoch 162/600
60/60 [==============================] - 0s 170us/step - loss: 0.0878
Epoch 163/600
```

```
60/60 [==============================] - 0s 259us/step - loss: 0.0875
Epoch 164/600
60/60 [==============================] - 0s 271us/step - loss: 0.0884
Epoch 165/600
60/60 [==============================] - 0s 292us/step - loss: 0.0867
Epoch 166/600
60/60 [==============================] - 0s 379us/step - loss: 0.0861
Epoch 167/600
60/60 [==============================] - 0s 504us/step - loss: 0.0857
Epoch 168/600
60/60 [==============================] - 0s 323us/step - loss: 0.0851
Epoch 169/600
60/60 [==============================] - 0s 225us/step - loss: 0.0859
Epoch 170/600
60/60 [==============================] - 0s 200us/step - loss: 0.0842
Epoch 171/600
60/60 [==============================] - 0s 345us/step - loss: 0.0839
Epoch 172/600
60/60 [==============================] - 0s 237us/step - loss: 0.0845
Epoch 173/600
60/60 [==============================] - 0s 311us/step - loss: 0.0832
Epoch 174/600
60/60 [==============================] - 0s 161us/step - loss: 0.0825
Epoch 175/600
60/60 [==============================] - 0s 144us/step - loss: 0.0821
Epoch 176/600
60/60 [==============================] - 0s 156us/step - loss: 0.0818
Epoch 177/600
60/60 [==============================] - 0s 125us/step - loss: 0.0813
Epoch 178/600
60/60 [==============================] - 0s 160us/step - loss: 0.0808
Epoch 179/600
60/60 [==============================] - 0s 249us/step - loss: 0.0806
Epoch 180/600
60/60 [==============================] - 0s 149us/step - loss: 0.0802
Epoch 181/600
60/60 [==============================] - 0s 132us/step - loss: 0.0797
Epoch 182/600
60/60 [==============================] - 0s 227us/step - loss: 0.0798
Epoch 183/600
60/60 [==============================] - 0s 268us/step - loss: 0.0817
Epoch 184/600
60/60 [==============================] - 0s 346us/step - loss: 0.0789
Epoch 185/600
60/60 [==============================] - 0s 319us/step - loss: 0.0780
Epoch 186/600
60/60 [==============================] - 0s 331us/step - loss: 0.0777
Epoch 187/600
60/60 [==============================] - 0s 181us/step - loss: 0.0773
Epoch 188/600
60/60 [==============================] - 0s 192us/step - loss: 0.0770
Epoch 189/600
60/60 [==============================] - 0s 209us/step - loss: 0.0764
Epoch 190/600
60/60 [==============================] - 0s 145us/step - loss: 0.0760
Epoch 191/600
60/60 [==============================] - 0s 164us/step - loss: 0.0758
```

```
Epoch 192/600
60/60 [==============================] - ETA: 0s - loss: 0.076 - 0s 201us/step
- loss: 0.0752
Epoch 193/600
60/60 [==============================] - 0s 165us/step - loss: 0.0749
Epoch 194/600
60/60 [==============================] - 0s 228us/step - loss: 0.0744
Epoch 195/600
60/60 [==============================] - 0s 259us/step - loss: 0.0742
Epoch 196/600
60/60 [==============================] - 0s 135us/step - loss: 0.0739
Epoch 197/600
60/60 [==============================] - 0s 118us/step - loss: 0.0731
Epoch 198/600
60/60 [==============================] - 0s 132us/step - loss: 0.0729
Epoch 199/600
60/60 [==============================] - 0s 159us/step - loss: 0.0723
Epoch 200/600
60/60 [==============================] - 0s 136us/step - loss: 0.0719
Epoch 201/600
60/60 [==============================] - 0s 176us/step - loss: 0.0725
Epoch 202/600
60/60 [==============================] - 0s 171us/step - loss: 0.0716
Epoch 203/600
60/60 [==============================] - 0s 215us/step - loss: 0.0711
Epoch 204/600
60/60 [==============================] - 0s 167us/step - loss: 0.0709
Epoch 205/600
60/60 [==============================] - 0s 219us/step - loss: 0.0703
Epoch 206/600
60/60 [==============================] - 0s 183us/step - loss: 0.0702
Epoch 207/600
60/60 [==============================] - 0s 199us/step - loss: 0.0703
Epoch 208/600
60/60 [==============================] - 0s 171us/step - loss: 0.0697
Epoch 209/600
60/60 [==============================] - 0s 264us/step - loss: 0.0694
Epoch 210/600
60/60 [==============================] - 0s 318us/step - loss: 0.0689
Epoch 211/600
60/60 [==============================] - 0s 287us/step - loss: 0.0687
Epoch 212/600
60/60 [==============================] - 0s 498us/step - loss: 0.0684
Epoch 213/600
60/60 [==============================] - 0s 239us/step - loss: 0.0680
Epoch 214/600
60/60 [==============================] - 0s 362us/step - loss: 0.0679
Epoch 215/600
60/60 [==============================] - 0s 522us/step - loss: 0.0680
Epoch 216/600
60/60 [==============================] - 0s 338us/step - loss: 0.0676
Epoch 217/600
60/60 [==============================] - 0s 338us/step - loss: 0.0673
Epoch 218/600
60/60 [==============================] - 0s 284us/step - loss: 0.0671
Epoch 219/600
60/60 [==============================] - 0s 371us/step - loss: 0.0671
```

```
Epoch 220/600
60/60 [==============================] - 0s 253us/step - loss: 0.0674
Epoch 221/600
60/60 [==============================] - 0s 160us/step - loss: 0.0669
Epoch 222/600
60/60 [==============================] - 0s 140us/step - loss: 0.0665
Epoch 223/600
60/60 [==============================] - 0s 263us/step - loss: 0.0667
Epoch 224/600
60/60 [==============================] - 0s 162us/step - loss: 0.0670
Epoch 225/600
60/60 [==============================] - 0s 263us/step - loss: 0.0666
Epoch 226/600
60/60 [==============================] - 0s 241us/step - loss: 0.0663
Epoch 227/600
60/60 [==============================] - 0s 157us/step - loss: 0.0661
Epoch 228/600
60/60 [==============================] - 0s 153us/step - loss: 0.0662
Epoch 229/600
60/60 [==============================] - 0s 159us/step - loss: 0.0661
Epoch 230/600
60/60 [==============================] - 0s 170us/step - loss: 0.0658
Epoch 231/600
60/60 [==============================] - 0s 213us/step - loss: 0.0658
Epoch 232/600
60/60 [==============================] - 0s 173us/step - loss: 0.0656
Epoch 233/600
60/60 [==============================] - 0s 136us/step - loss: 0.0654
Epoch 234/600
60/60 [==============================] - 0s 155us/step - loss: 0.0655
Epoch 235/600
60/60 [==============================] - 0s 192us/step - loss: 0.0651
Epoch 236/600
60/60 [==============================] - 0s 198us/step - loss: 0.0652
Epoch 237/600
60/60 [==============================] - 0s 170us/step - loss: 0.0656
Epoch 238/600
60/60 [==============================] - 0s 188us/step - loss: 0.0654
Epoch 239/600
60/60 [==============================] - 0s 157us/step - loss: 0.0650
Epoch 240/600
60/60 [==============================] - 0s 159us/step - loss: 0.0648
Epoch 241/600
60/60 [==============================] - 0s 166us/step - loss: 0.0645
Epoch 242/600
60/60 [==============================] - 0s 291us/step - loss: 0.0650
Epoch 243/600
60/60 [==============================] - 0s 254us/step - loss: 0.0645
Epoch 244/600
60/60 [==============================] - 0s 277us/step - loss: 0.0643
Epoch 245/600
60/60 [==============================] - 0s 276us/step - loss: 0.0644
Epoch 246/600
60/60 [==============================] - 0s 385us/step - loss: 0.0640
Epoch 247/600
60/60 [==============================] - 0s 353us/step - loss: 0.0647
Epoch 248/600
```

```
60/60 [==============================] - 0s 355us/step - loss: 0.0640
Epoch 249/600
60/60 [==============================] - 0s 132us/step - loss: 0.0639
Epoch 250/600
60/60 [==============================] - 0s 155us/step - loss: 0.0639
Epoch 251/600
60/60 [==============================] - 0s 142us/step - loss: 0.0636
Epoch 252/600
60/60 [==============================] - 0s 195us/step - loss: 0.0639
Epoch 253/600
60/60 [==============================] - 0s 246us/step - loss: 0.0642
Epoch 254/600
60/60 [==============================] - 0s 173us/step - loss: 0.0636
Epoch 255/600
60/60 [==============================] - 0s 195us/step - loss: 0.0633
Epoch 256/600
60/60 [==============================] - 0s 152us/step - loss: 0.0635
Epoch 257/600
60/60 [==============================] - 0s 201us/step - loss: 0.0637
Epoch 258/600
60/60 [==============================] - 0s 175us/step - loss: 0.0633
Epoch 259/600
60/60 [==============================] - 0s 281us/step - loss: 0.0631
Epoch 260/600
60/60 [==============================] - 0s 126us/step - loss: 0.0635
Epoch 261/600
60/60 [==============================] - 0s 172us/step - loss: 0.0635
Epoch 262/600
60/60 [==============================] - 0s 148us/step - loss: 0.0634
Epoch 263/600
60/60 [==============================] - 0s 150us/step - loss: 0.0630
Epoch 264/600
60/60 [==============================] - 0s 175us/step - loss: 0.0632
Epoch 265/600
60/60 [==============================] - 0s 175us/step - loss: 0.0631
Epoch 266/600
60/60 [==============================] - 0s 240us/step - loss: 0.0636
Epoch 267/600
60/60 [==============================] - 0s 240us/step - loss: 0.0626
Epoch 268/600
60/60 [==============================] - 0s 131us/step - loss: 0.0626
Epoch 269/600
60/60 [==============================] - 0s 129us/step - loss: 0.0628
Epoch 270/600
60/60 [==============================] - 0s 174us/step - loss: 0.0627
Epoch 271/600
60/60 [==============================] - 0s 146us/step - loss: 0.0628
Epoch 272/600
60/60 [==============================] - 0s 216us/step - loss: 0.0626
Epoch 273/600
60/60 [==============================] - 0s 273us/step - loss: 0.0629
Epoch 274/600
60/60 [==============================] - 0s 161us/step - loss: 0.0623
Epoch 275/600
60/60 [==============================] - 0s 152us/step - loss: 0.0621
Epoch 276/600
60/60 [==============================] - 0s 148us/step - loss: 0.0636
```

```
Epoch 277/600
60/60 [==============================] - 0s 166us/step - loss: 0.0630
Epoch 278/600
60/60 [==============================] - 0s 178us/step - loss: 0.0619
Epoch 279/600
60/60 [==============================] - 0s 147us/step - loss: 0.0620
Epoch 280/600
60/60 [==============================] - 0s 205us/step - loss: 0.0621
Epoch 281/600
60/60 [==============================] - 0s 174us/step - loss: 0.0634
Epoch 282/600
60/60 [==============================] - 0s 169us/step - loss: 0.0629
Epoch 283/600
60/60 [==============================] - 0s 263us/step - loss: 0.0621
Epoch 284/600
60/60 [==============================] - 0s 218us/step - loss: 0.0625
Epoch 285/600
60/60 [==============================] - 0s 180us/step - loss: 0.0617
Epoch 286/600
60/60 [==============================] - 0s 178us/step - loss: 0.0618
Epoch 287/600
60/60 [==============================] - 0s 175us/step - loss: 0.0615
Epoch 288/600
60/60 [==============================] - 0s 127us/step - loss: 0.0614
Epoch 289/600
60/60 [==============================] - 0s 157us/step - loss: 0.0646
Epoch 290/600
60/60 [==============================] - 0s 139us/step - loss: 0.0616
Epoch 291/600
60/60 [==============================] - 0s 166us/step - loss: 0.0613
Epoch 292/600
60/60 [==============================] - 0s 157us/step - loss: 0.0622
Epoch 293/600
60/60 [==============================] - 0s 170us/step - loss: 0.0622
Epoch 294/600
60/60 [==============================] - 0s 183us/step - loss: 0.0618
Epoch 295/600
60/60 [==============================] - 0s 180us/step - loss: 0.0612
Epoch 296/600
60/60 [==============================] - 0s 149us/step - loss: 0.0615
Epoch 297/600
60/60 [==============================] - 0s 165us/step - loss: 0.0623
Epoch 298/600
60/60 [==============================] - 0s 165us/step - loss: 0.0616
Epoch 299/600
60/60 [==============================] - 0s 151us/step - loss: 0.0612
Epoch 300/600
60/60 [==============================] - 0s 165us/step - loss: 0.0610
Epoch 301/600
60/60 [==============================] - 0s 160us/step - loss: 0.0625
Epoch 302/600
60/60 [==============================] - 0s 474us/step - loss: 0.0615
Epoch 303/600
60/60 [==============================] - 0s 160us/step - loss: 0.0623
Epoch 304/600
60/60 [==============================] - 0s 169us/step - loss: 0.0621
Epoch 305/600
```

```
60/60 [==============================] - 0s 168us/step - loss: 0.0611
Epoch 306/600
60/60 [==============================] - 0s 145us/step - loss: 0.0610
Epoch 307/600
60/60 [==============================] - 0s 162us/step - loss: 0.0609
Epoch 308/600
60/60 [==============================] - 0s 189us/step - loss: 0.0612
Epoch 309/600
60/60 [==============================] - 0s 193us/step - loss: 0.0610
Epoch 310/600
60/60 [==============================] - 0s 178us/step - loss: 0.0612
Epoch 311/600
60/60 [==============================] - 0s 248us/step - loss: 0.0606
Epoch 312/600
60/60 [==============================] - 0s 201us/step - loss: 0.0611
Epoch 313/600
60/60 [==============================] - 0s 206us/step - loss: 0.0607
Epoch 314/600
60/60 [==============================] - 0s 382us/step - loss: 0.0605
Epoch 315/600
60/60 [==============================] - 0s 132us/step - loss: 0.0612
Epoch 316/600
60/60 [==============================] - 0s 187us/step - loss: 0.0611
Epoch 317/600
60/60 [==============================] - 0s 251us/step - loss: 0.0606
Epoch 318/600
60/60 [==============================] - 0s 312us/step - loss: 0.0619
Epoch 319/600
60/60 [==============================] - 0s 248us/step - loss: 0.0607
Epoch 320/600
60/60 [==============================] - 0s 342us/step - loss: 0.0605
Epoch 321/600
60/60 [==============================] - 0s 203us/step - loss: 0.0614
Epoch 322/600
60/60 [==============================] - 0s 180us/step - loss: 0.0604
Epoch 323/600
60/60 [==============================] - 0s 162us/step - loss: 0.0603
Epoch 324/600
60/60 [==============================] - 0s 131us/step - loss: 0.0610
Epoch 325/600
60/60 [==============================] - 0s 215us/step - loss: 0.0601
Epoch 326/600
60/60 [==============================] - 0s 197us/step - loss: 0.0611
Epoch 327/600
60/60 [==============================] - 0s 184us/step - loss: 0.0601
Epoch 328/600
60/60 [==============================] - 0s 134us/step - loss: 0.0601
Epoch 329/600
60/60 [==============================] - 0s 165us/step - loss: 0.0605
Epoch 330/600
60/60 [==============================] - 0s 222us/step - loss: 0.0606
Epoch 331/600
60/60 [==============================] - 0s 263us/step - loss: 0.0601
Epoch 332/600
60/60 [==============================] - 0s 267us/step - loss: 0.0612
Epoch 333/600
60/60 [==============================] - 0s 291us/step - loss: 0.0619
```

```
Epoch 334/600
60/60 [==============================] - 0s 304us/step - loss: 0.0602
Epoch 335/600
60/60 [==============================] - 0s 324us/step - loss: 0.0610
Epoch 336/600
60/60 [==============================] - 0s 292us/step - loss: 0.0606
Epoch 337/600
60/60 [==============================] - 0s 363us/step - loss: 0.0598
Epoch 338/600
60/60 [==============================] - 0s 316us/step - loss: 0.0598
Epoch 339/600
60/60 [==============================] - 0s 287us/step - loss: 0.0598
Epoch 340/600
60/60 [==============================] - 0s 304us/step - loss: 0.0598
Epoch 341/600
60/60 [==============================] - 0s 357us/step - loss: 0.0603
Epoch 342/600
60/60 [==============================] - 0s 415us/step - loss: 0.0598
Epoch 343/600
60/60 [==============================] - 0s 377us/step - loss: 0.0598
Epoch 344/600
60/60 [==============================] - 0s 267us/step - loss: 0.0601
Epoch 345/600
60/60 [==============================] - 0s 337us/step - loss: 0.0597
Epoch 346/600
60/60 [==============================] - 0s 142us/step - loss: 0.0594
Epoch 347/600
60/60 [==============================] - 0s 149us/step - loss: 0.0595
Epoch 348/600
60/60 [==============================] - 0s 192us/step - loss: 0.0595
Epoch 349/600
60/60 [==============================] - 0s 210us/step - loss: 0.0597
Epoch 350/600
60/60 [==============================] - 0s 147us/step - loss: 0.0596
Epoch 351/600
60/60 [==============================] - 0s 141us/step - loss: 0.0598
Epoch 352/600
60/60 [==============================] - 0s 133us/step - loss: 0.0602
Epoch 353/600
60/60 [==============================] - 0s 155us/step - loss: 0.0601
Epoch 354/600
60/60 [==============================] - 0s 147us/step - loss: 0.0602
Epoch 355/600
60/60 [==============================] - 0s 174us/step - loss: 0.0601
Epoch 356/600
60/60 [==============================] - 0s 200us/step - loss: 0.0601
Epoch 357/600
60/60 [==============================] - 0s 162us/step - loss: 0.0595
Epoch 358/600
60/60 [==============================] - 0s 142us/step - loss: 0.0594
Epoch 359/600
60/60 [==============================] - 0s 145us/step - loss: 0.0591
Epoch 360/600
60/60 [==============================] - 0s 168us/step - loss: 0.0610
Epoch 361/600
60/60 [==============================] - 0s 188us/step - loss: 0.0600
Epoch 362/600
```

```
60/60 [==============================] - 0s 205us/step - loss: 0.0593
Epoch 363/600
60/60 [==============================] - 0s 164us/step - loss: 0.0593
Epoch 364/600
60/60 [==============================] - 0s 200us/step - loss: 0.0591
Epoch 365/600
60/60 [==============================] - 0s 140us/step - loss: 0.0592
Epoch 366/600
60/60 [==============================] - 0s 165us/step - loss: 0.0596
Epoch 367/600
60/60 [==============================] - 0s 198us/step - loss: 0.0591
Epoch 368/600
60/60 [==============================] - 0s 165us/step - loss: 0.0597
Epoch 369/600
60/60 [==============================] - 0s 241us/step - loss: 0.0590
Epoch 370/600
60/60 [==============================] - 0s 266us/step - loss: 0.0596
Epoch 371/600
60/60 [==============================] - 0s 258us/step - loss: 0.0615
Epoch 372/600
60/60 [==============================] - 0s 280us/step - loss: 0.0593
Epoch 373/600
60/60 [==============================] - 0s 739us/step - loss: 0.0589
Epoch 374/600
60/60 [==============================] - 0s 264us/step - loss: 0.0601
Epoch 375/600
60/60 [==============================] - 0s 201us/step - loss: 0.0598
Epoch 376/600
60/60 [==============================] - 0s 342us/step - loss: 0.0589
Epoch 377/600
60/60 [==============================] - 0s 203us/step - loss: 0.0590
Epoch 378/600
60/60 [==============================] - 0s 202us/step - loss: 0.0590
Epoch 379/600
60/60 [==============================] - 0s 273us/step - loss: 0.0587
Epoch 380/600
60/60 [==============================] - 0s 250us/step - loss: 0.0592
Epoch 381/600
60/60 [==============================] - 0s 250us/step - loss: 0.0590
Epoch 382/600
60/60 [==============================] - 0s 166us/step - loss: 0.0587
Epoch 383/600
60/60 [==============================] - 0s 171us/step - loss: 0.0589
Epoch 384/600
60/60 [==============================] - 0s 189us/step - loss: 0.0594
Epoch 385/600
60/60 [==============================] - 0s 199us/step - loss: 0.0589
Epoch 386/600
60/60 [==============================] - 0s 173us/step - loss: 0.0587
Epoch 387/600
60/60 [==============================] - 0s 167us/step - loss: 0.0590
Epoch 388/600
60/60 [==============================] - 0s 169us/step - loss: 0.0588
Epoch 389/600
60/60 [==============================] - 0s 188us/step - loss: 0.0585
Epoch 390/600
60/60 [==============================] - 0s 158us/step - loss: 0.0587
```

```
Epoch 391/600
60/60 [==============================] - 0s 217us/step - loss: 0.0586
Epoch 392/600
60/60 [==============================] - 0s 182us/step - loss: 0.0587
Epoch 393/600
60/60 [==============================] - 0s 181us/step - loss: 0.0589
Epoch 394/600
60/60 [==============================] - 0s 164us/step - loss: 0.0590
Epoch 395/600
60/60 [==============================] - 0s 149us/step - loss: 0.0587
Epoch 396/600
60/60 [==============================] - 0s 143us/step - loss: 0.0587
Epoch 397/600
60/60 [==============================] - 0s 248us/step - loss: 0.0587
Epoch 398/600
60/60 [==============================] - 0s 327us/step - loss: 0.0584
Epoch 399/600
60/60 [==============================] - 0s 307us/step - loss: 0.0584
Epoch 400/600
60/60 [==============================] - 0s 245us/step - loss: 0.0589
Epoch 401/600
60/60 [==============================] - 0s 336us/step - loss: 0.0584
Epoch 402/600
60/60 [==============================] - 0s 399us/step - loss: 0.0587
Epoch 403/600
60/60 [==============================] - 0s 276us/step - loss: 0.0584
Epoch 404/600
60/60 [==============================] - 0s 587us/step - loss: 0.0590
Epoch 405/600
60/60 [==============================] - 0s 222us/step - loss: 0.0597
Epoch 406/600
60/60 [==============================] - ETA: 0s - loss: 0.060 - 0s 156us/step
- loss: 0.0597
Epoch 407/600
60/60 [==============================] - 0s 263us/step - loss: 0.0588
Epoch 408/600
60/60 [==============================] - 0s 185us/step - loss: 0.0583
Epoch 409/600
60/60 [==============================] - 0s 249us/step - loss: 0.0591
Epoch 410/600
60/60 [==============================] - 0s 155us/step - loss: 0.0584
Epoch 411/600
60/60 [==============================] - 0s 180us/step - loss: 0.0589
Epoch 412/600
60/60 [==============================] - 0s 265us/step - loss: 0.0596
Epoch 413/600
60/60 [==============================] - 0s 174us/step - loss: 0.0586
Epoch 414/600
60/60 [==============================] - 0s 163us/step - loss: 0.0584
Epoch 415/600
60/60 [==============================] - 0s 145us/step - loss: 0.0590
Epoch 416/600
60/60 [==============================] - 0s 159us/step - loss: 0.0587
Epoch 417/600
60/60 [==============================] - 0s 153us/step - loss: 0.0582
Epoch 418/600
60/60 [==============================] - 0s 178us/step - loss: 0.0585
```

```
Epoch 419/600
60/60 [==============================] - 0s 181us/step - loss: 0.0582
Epoch 420/600
60/60 [==============================] - 0s 229us/step - loss: 0.0582
Epoch 421/600
60/60 [==============================] - 0s 203us/step - loss: 0.0584
Epoch 422/600
60/60 [==============================] - 0s 201us/step - loss: 0.0580
Epoch 423/600
60/60 [==============================] - 0s 201us/step - loss: 0.0579
Epoch 424/600
60/60 [==============================] - 0s 149us/step - loss: 0.0581
Epoch 425/600
60/60 [==============================] - 0s 170us/step - loss: 0.0581
Epoch 426/600
60/60 [==============================] - 0s 145us/step - loss: 0.0583
Epoch 427/600
60/60 [==============================] - 0s 153us/step - loss: 0.0584
Epoch 428/600
60/60 [==============================] - 0s 168us/step - loss: 0.0591
Epoch 429/600
60/60 [==============================] - 0s 162us/step - loss: 0.0580
Epoch 430/600
60/60 [==============================] - 0s 202us/step - loss: 0.0588
Epoch 431/600
60/60 [==============================] - 0s 171us/step - loss: 0.0582
Epoch 432/600
60/60 [==============================] - 0s 248us/step - loss: 0.0582
Epoch 433/600
60/60 [==============================] - 0s 172us/step - loss: 0.0583
Epoch 434/600
60/60 [==============================] - 0s 215us/step - loss: 0.0579
Epoch 435/600
60/60 [==============================] - 0s 132us/step - loss: 0.0582
Epoch 436/600
60/60 [==============================] - 0s 179us/step - loss: 0.0582
Epoch 437/600
60/60 [==============================] - 0s 143us/step - loss: 0.0584
Epoch 438/600
60/60 [==============================] - ETA: 0s - loss: 0.056 - 0s 174us/step
- loss: 0.0582
Epoch 439/600
60/60 [==============================] - 0s 181us/step - loss: 0.0580
Epoch 440/600
60/60 [==============================] - 0s 208us/step - loss: 0.0579
Epoch 441/600
60/60 [==============================] - 0s 192us/step - loss: 0.0587
Epoch 442/600
60/60 [==============================] - 0s 168us/step - loss: 0.0579
Epoch 443/600
60/60 [==============================] - 0s 178us/step - loss: 0.0578
Epoch 444/600
60/60 [==============================] - 0s 217us/step - loss: 0.0587
Epoch 445/600
60/60 [==============================] - 0s 151us/step - loss: 0.0577
Epoch 446/600
60/60 [==============================] - 0s 152us/step - loss: 0.0581
```

```
Epoch 447/600
60/60 [==============================] - 0s 154us/step - loss: 0.0579
Epoch 448/600
60/60 [==============================] - 0s 169us/step - loss: 0.0577
Epoch 449/600
60/60 [==============================] - 0s 136us/step - loss: 0.0578
Epoch 450/600
60/60 [==============================] - 0s 164us/step - loss: 0.0575
Epoch 451/600
60/60 [==============================] - 0s 184us/step - loss: 0.0578
Epoch 452/600
60/60 [==============================] - 0s 205us/step - loss: 0.0588
Epoch 453/600
60/60 [==============================] - 0s 350us/step - loss: 0.0577
Epoch 454/600
60/60 [==============================] - 0s 345us/step - loss: 0.0576
Epoch 455/600
60/60 [==============================] - 0s 275us/step - loss: 0.0578
Epoch 456/600
60/60 [==============================] - 0s 302us/step - loss: 0.0579
Epoch 457/600
60/60 [==============================] - 0s 352us/step - loss: 0.0578
Epoch 458/600
60/60 [==============================] - 0s 281us/step - loss: 0.0577
Epoch 459/600
60/60 [==============================] - 0s 444us/step - loss: 0.0575
Epoch 460/600
60/60 [==============================] - 0s 221us/step - loss: 0.0582
Epoch 461/600
60/60 [==============================] - 0s 277us/step - loss: 0.0579
Epoch 462/600
60/60 [==============================] - 0s 339us/step - loss: 0.0575
Epoch 463/600
60/60 [==============================] - 0s 272us/step - loss: 0.0577
Epoch 464/600
60/60 [==============================] - 0s 209us/step - loss: 0.0574
Epoch 465/600
60/60 [==============================] - 0s 230us/step - loss: 0.0575
Epoch 466/600
60/60 [==============================] - 0s 273us/step - loss: 0.0583
Epoch 467/600
60/60 [==============================] - 0s 257us/step - loss: 0.0575
Epoch 468/600
60/60 [==============================] - 0s 195us/step - loss: 0.0578
Epoch 469/600
60/60 [==============================] - 0s 268us/step - loss: 0.0576
Epoch 470/600
60/60 [==============================] - 0s 239us/step - loss: 0.0575
Epoch 471/600
60/60 [==============================] - 0s 136us/step - loss: 0.0574
Epoch 472/600
60/60 [==============================] - 0s 146us/step - loss: 0.0576
Epoch 473/600
60/60 [==============================] - 0s 174us/step - loss: 0.0572
Epoch 474/600
60/60 [==============================] - 0s 128us/step - loss: 0.0575
Epoch 475/600
```

```
60/60 [==============================] - 0s 151us/step - loss: 0.0588
Epoch 476/600
60/60 [==============================] - 0s 201us/step - loss: 0.0573
Epoch 477/600
60/60 [==============================] - 0s 209us/step - loss: 0.0573
Epoch 478/600
60/60 [==============================] - 0s 207us/step - loss: 0.0573
Epoch 479/600
60/60 [==============================] - 0s 195us/step - loss: 0.0585
Epoch 480/600
60/60 [==============================] - 0s 181us/step - loss: 0.0573
Epoch 481/600
60/60 [==============================] - 0s 237us/step - loss: 0.0575
Epoch 482/600
60/60 [==============================] - 0s 338us/step - loss: 0.0574
Epoch 483/600
60/60 [==============================] - 0s 258us/step - loss: 0.0573
Epoch 484/600
60/60 [==============================] - 0s 274us/step - loss: 0.0574
Epoch 485/600
60/60 [==============================] - 0s 347us/step - loss: 0.0573
Epoch 486/600
60/60 [==============================] - 0s 346us/step - loss: 0.0574
Epoch 487/600
60/60 [==============================] - 0s 173us/step - loss: 0.0578
Epoch 488/600
60/60 [==============================] - 0s 345us/step - loss: 0.0572
Epoch 489/600
60/60 [==============================] - 0s 236us/step - loss: 0.0576
Epoch 490/600
60/60 [==============================] - 0s 174us/step - loss: 0.0571
Epoch 491/600
60/60 [==============================] - 0s 240us/step - loss: 0.0571
Epoch 492/600
60/60 [==============================] - 0s 177us/step - loss: 0.0576
Epoch 493/600
60/60 [==============================] - 0s 334us/step - loss: 0.0576
Epoch 494/600
60/60 [==============================] - 0s 305us/step - loss: 0.0571
Epoch 495/600
60/60 [==============================] - 0s 354us/step - loss: 0.0585
Epoch 496/600
60/60 [==============================] - 0s 196us/step - loss: 0.0577
Epoch 497/600
60/60 [==============================] - 0s 366us/step - loss: 0.0571
Epoch 498/600
60/60 [==============================] - 0s 258us/step - loss: 0.0570
Epoch 499/600
60/60 [==============================] - 0s 179us/step - loss: 0.0572
Epoch 500/600
60/60 [==============================] - 0s 182us/step - loss: 0.0581
Epoch 501/600
60/60 [==============================] - 0s 273us/step - loss: 0.0570
Epoch 502/600
60/60 [==============================] - 0s 256us/step - loss: 0.0572
Epoch 503/600
60/60 [==============================] - 0s 313us/step - loss: 0.0569
```

```
Epoch 504/600
60/60 [==============================] - 0s 356us/step - loss: 0.0569
Epoch 505/600
60/60 [==============================] - 0s 288us/step - loss: 0.0570
Epoch 506/600
60/60 [==============================] - 0s 316us/step - loss: 0.0568
Epoch 507/600
60/60 [==============================] - 0s 345us/step - loss: 0.0574
Epoch 508/600
60/60 [==============================] - 0s 421us/step - loss: 0.0569
Epoch 509/600
60/60 [==============================] - 0s 293us/step - loss: 0.0569
Epoch 510/600
60/60 [==============================] - 0s 558us/step - loss: 0.0568
Epoch 511/600
60/60 [==============================] - 0s 574us/step - loss: 0.0572
Epoch 512/600
60/60 [==============================] - 0s 353us/step - loss: 0.0573
Epoch 513/600
60/60 [==============================] - 0s 244us/step - loss: 0.0566
Epoch 514/600
60/60 [==============================] - ETA: 0s - loss: 0.055 - 0s 234us/step
- loss: 0.0569
Epoch 515/600
60/60 [==============================] - 0s 173us/step - loss: 0.0576
Epoch 516/600
60/60 [==============================] - 0s 195us/step - loss: 0.0568
Epoch 517/600
60/60 [==============================] - 0s 202us/step - loss: 0.0579
Epoch 518/600
60/60 [==============================] - 0s 133us/step - loss: 0.0569
Epoch 519/600
60/60 [==============================] - 0s 231us/step - loss: 0.0566
Epoch 520/600
60/60 [==============================] - 0s 159us/step - loss: 0.0569
Epoch 521/600
60/60 [==============================] - 0s 191us/step - loss: 0.0570
Epoch 522/600
60/60 [==============================] - 0s 152us/step - loss: 0.0570
Epoch 523/600
60/60 [==============================] - 0s 157us/step - loss: 0.0567
Epoch 524/600
60/60 [==============================] - 0s 215us/step - loss: 0.0566
Epoch 525/600
60/60 [==============================] - 0s 159us/step - loss: 0.0582
Epoch 526/600
60/60 [==============================] - 0s 170us/step - loss: 0.0566
Epoch 527/600
60/60 [==============================] - 0s 187us/step - loss: 0.0566
Epoch 528/600
60/60 [==============================] - 0s 140us/step - loss: 0.0573
Epoch 529/600
60/60 [==============================] - 0s 220us/step - loss: 0.0569
Epoch 530/600
60/60 [==============================] - 0s 165us/step - loss: 0.0573
Epoch 531/600
60/60 [==============================] - 0s 188us/step - loss: 0.0568
```

```
Epoch 532/600
60/60 [==============================] - 0s 152us/step - loss: 0.0566
Epoch 533/600
60/60 [==============================] - 0s 198us/step - loss: 0.0575
Epoch 534/600
60/60 [==============================] - 0s 171us/step - loss: 0.0568
Epoch 535/600
60/60 [==============================] - 0s 150us/step - loss: 0.0566
Epoch 536/600
60/60 [==============================] - 0s 161us/step - loss: 0.0566
Epoch 537/600
60/60 [==============================] - 0s 163us/step - loss: 0.0570
Epoch 538/600
60/60 [==============================] - 0s 180us/step - loss: 0.0565
Epoch 539/600
60/60 [==============================] - 0s 171us/step - loss: 0.0565
Epoch 540/600
60/60 [==============================] - 0s 186us/step - loss: 0.0566
Epoch 541/600
60/60 [==============================] - 0s 189us/step - loss: 0.0564
Epoch 542/600
60/60 [==============================] - 0s 201us/step - loss: 0.0564
Epoch 543/600
60/60 [==============================] - 0s 202us/step - loss: 0.0565
Epoch 544/600
60/60 [==============================] - 0s 207us/step - loss: 0.0570
Epoch 545/600
60/60 [==============================] - 0s 171us/step - loss: 0.0566
Epoch 546/600
60/60 [==============================] - 0s 243us/step - loss: 0.0564
Epoch 547/600
60/60 [==============================] - 0s 239us/step - loss: 0.0565
Epoch 548/600
60/60 [==============================] - 0s 178us/step - loss: 0.0568
Epoch 549/600
60/60 [==============================] - 0s 187us/step - loss: 0.0567
Epoch 550/600
60/60 [==============================] - 0s 217us/step - loss: 0.0566
Epoch 551/600
60/60 [==============================] - 0s 229us/step - loss: 0.0564
Epoch 552/600
60/60 [==============================] - 0s 211us/step - loss: 0.0578
Epoch 553/600
60/60 [==============================] - 0s 182us/step - loss: 0.0569
Epoch 554/600
60/60 [==============================] - 0s 339us/step - loss: 0.0564
Epoch 555/600
60/60 [==============================] - 0s 211us/step - loss: 0.0564
Epoch 556/600
60/60 [==============================] - 0s 239us/step - loss: 0.0566
Epoch 557/600
60/60 [==============================] - 0s 277us/step - loss: 0.0564
Epoch 558/600
60/60 [==============================] - 0s 204us/step - loss: 0.0570
Epoch 559/600
60/60 [==============================] - 0s 145us/step - loss: 0.0564
Epoch 560/600
```

```
60/60 [==============================] - 0s 156us/step - loss: 0.0562
Epoch 561/600
60/60 [==============================] - 0s 145us/step - loss: 0.0566
Epoch 562/600
60/60 [==============================] - 0s 169us/step - loss: 0.0563
Epoch 563/600
60/60 [==============================] - 0s 157us/step - loss: 0.0563
Epoch 564/600
60/60 [==============================] - 0s 152us/step - loss: 0.0573
Epoch 565/600
60/60 [==============================] - 0s 150us/step - loss: 0.0563
Epoch 566/600
60/60 [==============================] - 0s 199us/step - loss: 0.0563
Epoch 567/600
60/60 [==============================] - 0s 188us/step - loss: 0.0563
Epoch 568/600
60/60 [==============================] - 0s 295us/step - loss: 0.0562
Epoch 569/600
60/60 [==============================] - 0s 267us/step - loss: 0.0561
Epoch 570/600
60/60 [==============================] - 0s 330us/step - loss: 0.0561
Epoch 571/600
60/60 [==============================] - 0s 342us/step - loss: 0.0562
Epoch 572/600
60/60 [==============================] - 0s 333us/step - loss: 0.0565
Epoch 573/600
60/60 [==============================] - 0s 320us/step - loss: 0.0564
Epoch 574/600
60/60 [==============================] - 0s 200us/step - loss: 0.0562
Epoch 575/600
60/60 [==============================] - 0s 261us/step - loss: 0.0562
Epoch 576/600
60/60 [==============================] - 0s 230us/step - loss: 0.0561
Epoch 577/600
60/60 [==============================] - 0s 217us/step - loss: 0.0563
Epoch 578/600
60/60 [==============================] - 0s 162us/step - loss: 0.0564
Epoch 579/600
60/60 [==============================] - 0s 259us/step - loss: 0.0563
Epoch 580/600
60/60 [==============================] - 0s 169us/step - loss: 0.0561
Epoch 581/600
60/60 [==============================] - 0s 166us/step - loss: 0.0561
Epoch 582/600
60/60 [==============================] - 0s 154us/step - loss: 0.0561
Epoch 583/600
60/60 [==============================] - 0s 160us/step - loss: 0.0562
Epoch 584/600
60/60 [==============================] - 0s 165us/step - loss: 0.0564
Epoch 585/600
60/60 [==============================] - 0s 228us/step - loss: 0.0564
Epoch 586/600
60/60 [==============================] - 0s 189us/step - loss: 0.0560
Epoch 587/600
60/60 [==============================] - 0s 138us/step - loss: 0.0560
Epoch 588/600
60/60 [==============================] - 0s 137us/step - loss: 0.0559
```

```
Epoch 589/600
60/60 [==============================] - 0s 147us/step - loss: 0.0561
Epoch 590/600
60/60 [==============================] - 0s 158us/step - loss: 0.0564
Epoch 591/600
60/60 [==============================] - 0s 171us/step - loss: 0.0560
Epoch 592/600
60/60 [==============================] - 0s 182us/step - loss: 0.0560
Epoch 593/600
60/60 [==============================] - 0s 221us/step - loss: 0.0562
Epoch 594/600
60/60 [==============================] - 0s 281us/step - loss: 0.0561
Epoch 595/600
60/60 [==============================] - 0s 238us/step - loss: 0.0567
Epoch 596/600
60/60 [==============================] - 0s 201us/step - loss: 0.0561
Epoch 597/600
60/60 [==============================] - 0s 216us/step - loss: 0.0562
Epoch 598/600
60/60 [==============================] - 0s 249us/step - loss: 0.0560
Epoch 599/600
60/60 [==============================] - 0s 383us/step - loss: 0.0562
Epoch 600/600
60/60 [==============================] - 0s 221us/step - loss: 0.0561
best epoch v3 =  588
smallest loss v3 = 0.05589737569292386
```

In [72]:

```
historyDatav4 = modelv4.fit(xarray,yarray,epochs=600,callbacks=[es])
loss_histv4 = historyDatav4.history['loss']

best_epochv4 = np.argmin(historyDatav4.history['loss']) + 1
print ('best epoch v4 = ', best_epochv4)
print('smallest loss v4 =', np.min(loss_histv4))
```

```
Epoch 1/600
60/60 [==============================] - 1s 14ms/step - loss: 0.9858
Epoch 2/600
60/60 [==============================] - 0s 231us/step - loss: 0.9451
Epoch 3/600
60/60 [==============================] - 0s 278us/step - loss: 0.9036
Epoch 4/600
60/60 [==============================] - 0s 765us/step - loss: 0.8610
Epoch 5/600
60/60 [==============================] - 0s 429us/step - loss: 0.8169
Epoch 6/600
60/60 [==============================] - 0s 396us/step - loss: 0.7709
Epoch 7/600
60/60 [==============================] - 0s 274us/step - loss: 0.7238
Epoch 8/600
60/60 [==============================] - 0s 340us/step - loss: 0.6768
Epoch 9/600
60/60 [==============================] - 0s 207us/step - loss: 0.6291
Epoch 10/600
60/60 [==============================] - 0s 199us/step - loss: 0.5792
Epoch 11/600
```

```
60/60 [==============================] - 0s 174us/step - loss: 0.5267
Epoch 12/600
60/60 [==============================] - 0s 249us/step - loss: 0.4696
Epoch 13/600
60/60 [==============================] - 0s 200us/step - loss: 0.4112
Epoch 14/600
60/60 [==============================] - 0s 202us/step - loss: 0.3576
Epoch 15/600
60/60 [==============================] - 0s 271us/step - loss: 0.3063
Epoch 16/600
60/60 [==============================] - 0s 231us/step - loss: 0.2592
Epoch 17/600
60/60 [==============================] - 0s 343us/step - loss: 0.2207
Epoch 18/600
60/60 [==============================] - 0s 312us/step - loss: 0.1882
Epoch 19/600
60/60 [==============================] - 0s 268us/step - loss: 0.1661
Epoch 20/600
60/60 [==============================] - 0s 259us/step - loss: 0.1526
Epoch 21/600
60/60 [==============================] - 0s 225us/step - loss: 0.1436
Epoch 22/600
60/60 [==============================] - 0s 161us/step - loss: 0.1410
Epoch 23/600
60/60 [==============================] - 0s 137us/step - loss: 0.1359
Epoch 24/600
60/60 [==============================] - 0s 143us/step - loss: 0.1350
Epoch 25/600
60/60 [==============================] - 0s 145us/step - loss: 0.1289
Epoch 26/600
60/60 [==============================] - 0s 149us/step - loss: 0.1264
Epoch 27/600
60/60 [==============================] - 0s 237us/step - loss: 0.1239
Epoch 28/600
60/60 [==============================] - 0s 161us/step - loss: 0.1210
Epoch 29/600
60/60 [==============================] - 0s 163us/step - loss: 0.1197
Epoch 30/600
60/60 [==============================] - 0s 133us/step - loss: 0.1197
Epoch 31/600
60/60 [==============================] - 0s 137us/step - loss: 0.1143
Epoch 32/600
60/60 [==============================] - 0s 148us/step - loss: 0.1122
Epoch 33/600
60/60 [==============================] - 0s 155us/step - loss: 0.1117
Epoch 34/600
60/60 [==============================] - 0s 154us/step - loss: 0.1082
Epoch 35/600
60/60 [==============================] - 0s 141us/step - loss: 0.1072
Epoch 36/600
60/60 [==============================] - 0s 173us/step - loss: 0.1063
Epoch 37/600
60/60 [==============================] - 0s 261us/step - loss: 0.1025
Epoch 38/600
60/60 [==============================] - 0s 188us/step - loss: 0.1012
Epoch 39/600
60/60 [==============================] - 0s 299us/step - loss: 0.0994
```

```
Epoch 40/600
60/60 [==============================] - 0s 178us/step - loss: 0.0968
Epoch 41/600
60/60 [==============================] - 0s 195us/step - loss: 0.0964
Epoch 42/600
60/60 [==============================] - 0s 175us/step - loss: 0.0932
Epoch 43/600
60/60 [==============================] - 0s 259us/step - loss: 0.0909
Epoch 44/600
60/60 [==============================] - 0s 526us/step - loss: 0.0913
Epoch 45/600
60/60 [==============================] - 0s 190us/step - loss: 0.0896
Epoch 46/600
60/60 [==============================] - 0s 163us/step - loss: 0.0866
Epoch 47/600
60/60 [==============================] - 0s 183us/step - loss: 0.0869
Epoch 48/600
60/60 [==============================] - 0s 181us/step - loss: 0.0843
Epoch 49/600
60/60 [==============================] - 0s 135us/step - loss: 0.0817
Epoch 50/600
60/60 [==============================] - 0s 154us/step - loss: 0.0807
Epoch 51/600
60/60 [==============================] - 0s 158us/step - loss: 0.0788
Epoch 52/600
60/60 [==============================] - 0s 131us/step - loss: 0.0789
Epoch 53/600
60/60 [==============================] - 0s 169us/step - loss: 0.0779
Epoch 54/600
60/60 [==============================] - 0s 127us/step - loss: 0.0759
Epoch 55/600
60/60 [==============================] - 0s 191us/step - loss: 0.0753
Epoch 56/600
60/60 [==============================] - 0s 268us/step - loss: 0.0743
Epoch 57/600
60/60 [==============================] - 0s 151us/step - loss: 0.0763
Epoch 58/600
60/60 [==============================] - 0s 166us/step - loss: 0.0731
Epoch 59/600
60/60 [==============================] - 0s 228us/step - loss: 0.0721
Epoch 60/600
60/60 [==============================] - 0s 655us/step - loss: 0.0714
Epoch 61/600
60/60 [==============================] - 0s 799us/step - loss: 0.0713
Epoch 62/600
60/60 [==============================] - 0s 447us/step - loss: 0.0706
Epoch 63/600
60/60 [==============================] - 0s 380us/step - loss: 0.0696
Epoch 64/600
60/60 [==============================] - 0s 404us/step - loss: 0.0700
Epoch 65/600
60/60 [==============================] - 0s 283us/step - loss: 0.0686
Epoch 66/600
60/60 [==============================] - 0s 369us/step - loss: 0.0684
Epoch 67/600
60/60 [==============================] - 0s 230us/step - loss: 0.0677
Epoch 68/600
```

```
60/60 [==============================] - 0s 199us/step - loss: 0.0679
Epoch 69/600
60/60 [==============================] - 0s 346us/step - loss: 0.0678
Epoch 70/600
60/60 [==============================] - 0s 1ms/step - loss: 0.0686
Epoch 71/600
60/60 [==============================] - 0s 608us/step - loss: 0.0671
Epoch 72/600
60/60 [==============================] - 0s 362us/step - loss: 0.0666
Epoch 73/600
60/60 [==============================] - 0s 190us/step - loss: 0.0656
Epoch 74/600
60/60 [==============================] - 0s 165us/step - loss: 0.0666
Epoch 75/600
60/60 [==============================] - 0s 181us/step - loss: 0.0650
Epoch 76/600
60/60 [==============================] - 0s 207us/step - loss: 0.0678
Epoch 77/600
60/60 [==============================] - 0s 165us/step - loss: 0.0657
Epoch 78/600
60/60 [==============================] - 0s 187us/step - loss: 0.0655
Epoch 79/600
60/60 [==============================] - 0s 255us/step - loss: 0.0644
Epoch 80/600
60/60 [==============================] - 0s 207us/step - loss: 0.0636
Epoch 81/600
60/60 [==============================] - 0s 713us/step - loss: 0.0633
Epoch 82/600
60/60 [==============================] - 0s 676us/step - loss: 0.0639
Epoch 83/600
60/60 [==============================] - 0s 251us/step - loss: 0.0629
Epoch 84/600
60/60 [==============================] - 0s 162us/step - loss: 0.0624
Epoch 85/600
60/60 [==============================] - 0s 236us/step - loss: 0.0626
Epoch 86/600
60/60 [==============================] - 0s 242us/step - loss: 0.0632
Epoch 87/600
60/60 [==============================] - 0s 472us/step - loss: 0.0631
Epoch 88/600
60/60 [==============================] - 0s 1ms/step - loss: 0.0620
Epoch 89/600
60/60 [==============================] - 0s 218us/step - loss: 0.0622
Epoch 90/600
60/60 [==============================] - 0s 225us/step - loss: 0.0633
Epoch 91/600
60/60 [==============================] - 0s 185us/step - loss: 0.0621
Epoch 92/600
60/60 [==============================] - 0s 199us/step - loss: 0.0672
Epoch 93/600
60/60 [==============================] - 0s 275us/step - loss: 0.0616
Epoch 94/600
60/60 [==============================] - 0s 244us/step - loss: 0.0602
Epoch 95/600
60/60 [==============================] - 0s 217us/step - loss: 0.0614
Epoch 96/600
60/60 [==============================] - 0s 183us/step - loss: 0.0605
```

```
Epoch 97/600
60/60 [==============================] - 0s 300us/step - loss: 0.0620
Epoch 98/600
60/60 [==============================] - 0s 274us/step - loss: 0.0653
Epoch 99/600
60/60 [==============================] - 0s 244us/step - loss: 0.0610
Epoch 100/600
60/60 [==============================] - 0s 194us/step - loss: 0.0592
Epoch 101/600
60/60 [==============================] - 0s 285us/step - loss: 0.0612
Epoch 102/600
60/60 [==============================] - 0s 204us/step - loss: 0.0632
Epoch 103/600
60/60 [==============================] - 0s 195us/step - loss: 0.0609
Epoch 104/600
60/60 [==============================] - 0s 173us/step - loss: 0.0604
Epoch 105/600
60/60 [==============================] - 0s 196us/step - loss: 0.0595
Epoch 106/600
60/60 [==============================] - 0s 185us/step - loss: 0.0623
Epoch 107/600
60/60 [==============================] - 0s 160us/step - loss: 0.0625
Epoch 108/600
60/60 [==============================] - 0s 167us/step - loss: 0.0587
Epoch 109/600
60/60 [==============================] - 0s 211us/step - loss: 0.0592
Epoch 110/600
60/60 [==============================] - 0s 314us/step - loss: 0.0592
Epoch 111/600
60/60 [==============================] - 0s 171us/step - loss: 0.0587
Epoch 112/600
60/60 [==============================] - 0s 250us/step - loss: 0.0582
Epoch 113/600
60/60 [==============================] - 0s 276us/step - loss: 0.0582
Epoch 114/600
60/60 [==============================] - 0s 452us/step - loss: 0.0583
Epoch 115/600
60/60 [==============================] - 0s 300us/step - loss: 0.0604
Epoch 116/600
60/60 [==============================] - 0s 432us/step - loss: 0.0585
Epoch 117/600
60/60 [==============================] - 0s 439us/step - loss: 0.0581
Epoch 118/600
60/60 [==============================] - 0s 197us/step - loss: 0.0617
Epoch 119/600
60/60 [==============================] - 0s 241us/step - loss: 0.0594
Epoch 120/600
60/60 [==============================] - 0s 283us/step - loss: 0.0572
Epoch 121/600
60/60 [==============================] - 0s 302us/step - loss: 0.0572
Epoch 122/600
60/60 [==============================] - 0s 247us/step - loss: 0.0572
Epoch 123/600
60/60 [==============================] - 0s 372us/step - loss: 0.0574
Epoch 124/600
60/60 [==============================] - 0s 252us/step - loss: 0.0573
Epoch 125/600
```

```
60/60 [==============================] - 0s 335us/step - loss: 0.0581
Epoch 126/600
60/60 [==============================] - 0s 223us/step - loss: 0.0572
Epoch 127/600
60/60 [==============================] - 0s 212us/step - loss: 0.0572
Epoch 128/600
60/60 [==============================] - 0s 207us/step - loss: 0.0565
Epoch 129/600
60/60 [==============================] - 0s 202us/step - loss: 0.0571
Epoch 130/600
60/60 [==============================] - 0s 229us/step - loss: 0.0566
Epoch 131/600
60/60 [==============================] - 0s 316us/step - loss: 0.0577
Epoch 132/600
60/60 [==============================] - 0s 256us/step - loss: 0.0619
Epoch 133/600
60/60 [==============================] - 0s 535us/step - loss: 0.0569
Epoch 134/600
60/60 [==============================] - 0s 269us/step - loss: 0.0567
Epoch 135/600
60/60 [==============================] - 0s 387us/step - loss: 0.0573
Epoch 136/600
60/60 [==============================] - 0s 314us/step - loss: 0.0573
Epoch 137/600
60/60 [==============================] - 0s 230us/step - loss: 0.0574
Epoch 138/600
60/60 [==============================] - 0s 200us/step - loss: 0.0571
Epoch 139/600
60/60 [==============================] - 0s 288us/step - loss: 0.0599
Epoch 140/600
60/60 [==============================] - 0s 296us/step - loss: 0.0568
Epoch 141/600
60/60 [==============================] - 0s 342us/step - loss: 0.0560
Epoch 142/600
60/60 [==============================] - 0s 182us/step - loss: 0.0560
Epoch 143/600
60/60 [==============================] - 0s 219us/step - loss: 0.0564
Epoch 144/600
60/60 [==============================] - 0s 260us/step - loss: 0.0588
Epoch 145/600
60/60 [==============================] - 0s 344us/step - loss: 0.0567
Epoch 146/600
60/60 [==============================] - 0s 291us/step - loss: 0.0556
Epoch 147/600
60/60 [==============================] - 0s 257us/step - loss: 0.0556
Epoch 148/600
60/60 [==============================] - 0s 198us/step - loss: 0.0555
Epoch 149/600
60/60 [==============================] - 0s 187us/step - loss: 0.0573
Epoch 150/600
60/60 [==============================] - 0s 190us/step - loss: 0.0578
Epoch 151/600
60/60 [==============================] - 0s 171us/step - loss: 0.0571
Epoch 152/600
60/60 [==============================] - 0s 176us/step - loss: 0.0572
Epoch 153/600
60/60 [==============================] - 0s 242us/step - loss: 0.0555
```

```
Epoch 154/600
60/60 [==============================] - 0s 137us/step - loss: 0.0551
Epoch 155/600
60/60 [==============================] - 0s 152us/step - loss: 0.0554
Epoch 156/600
60/60 [==============================] - 0s 168us/step - loss: 0.0588
Epoch 157/600
60/60 [==============================] - 0s 171us/step - loss: 0.0588
Epoch 158/600
60/60 [==============================] - 0s 182us/step - loss: 0.0552
Epoch 159/600
60/60 [==============================] - 0s 212us/step - loss: 0.0578
Epoch 160/600
60/60 [==============================] - 0s 204us/step - loss: 0.0574
Epoch 161/600
60/60 [==============================] - 0s 191us/step - loss: 0.0567
Epoch 162/600
60/60 [==============================] - 0s 229us/step - loss: 0.0550
Epoch 163/600
60/60 [==============================] - 0s 255us/step - loss: 0.0561
Epoch 164/600
60/60 [==============================] - 0s 226us/step - loss: 0.0590
Epoch 165/600
60/60 [==============================] - 0s 344us/step - loss: 0.0550
Epoch 166/600
60/60 [==============================] - 0s 298us/step - loss: 0.0561
Epoch 167/600
60/60 [==============================] - 0s 321us/step - loss: 0.0559
Epoch 168/600
60/60 [==============================] - 0s 323us/step - loss: 0.0570
Epoch 169/600
60/60 [==============================] - 0s 218us/step - loss: 0.0543
Epoch 170/600
60/60 [==============================] - 0s 182us/step - loss: 0.0544
Epoch 171/600
60/60 [==============================] - 0s 211us/step - loss: 0.0545
Epoch 172/600
60/60 [==============================] - 0s 187us/step - loss: 0.0575
Epoch 173/600
60/60 [==============================] - 0s 320us/step - loss: 0.0595
Epoch 174/600
60/60 [==============================] - 0s 242us/step - loss: 0.0547
Epoch 175/600
60/60 [==============================] - 0s 210us/step - loss: 0.0549
Epoch 176/600
60/60 [==============================] - 0s 200us/step - loss: 0.0546
Epoch 177/600
60/60 [==============================] - 0s 181us/step - loss: 0.0549
Epoch 178/600
60/60 [==============================] - 0s 154us/step - loss: 0.0558
Epoch 179/600
60/60 [==============================] - 0s 156us/step - loss: 0.0542
Epoch 180/600
60/60 [==============================] - 0s 136us/step - loss: 0.0552
Epoch 181/600
60/60 [==============================] - 0s 165us/step - loss: 0.0543
Epoch 182/600
```

```
60/60 [==============================] - 0s 170us/step - loss: 0.0537
Epoch 183/600
60/60 [==============================] - 0s 154us/step - loss: 0.0537
Epoch 184/600
60/60 [==============================] - 0s 187us/step - loss: 0.0549
Epoch 185/600
60/60 [==============================] - 0s 173us/step - loss: 0.0541
Epoch 186/600
60/60 [==============================] - 0s 195us/step - loss: 0.0554
Epoch 187/600
60/60 [==============================] - 0s 217us/step - loss: 0.0544
Epoch 188/600
60/60 [==============================] - 0s 173us/step - loss: 0.0601
Epoch 189/600
60/60 [==============================] - 0s 160us/step - loss: 0.0548
Epoch 190/600
60/60 [==============================] - 0s 180us/step - loss: 0.0558
Epoch 191/600
60/60 [==============================] - 0s 199us/step - loss: 0.0555
Epoch 192/600
60/60 [==============================] - 0s 219us/step - loss: 0.0567
Epoch 193/600
60/60 [==============================] - 0s 205us/step - loss: 0.0558
Epoch 194/600
60/60 [==============================] - 0s 304us/step - loss: 0.0533
Epoch 195/600
60/60 [==============================] - 0s 170us/step - loss: 0.0541
Epoch 196/600
60/60 [==============================] - 0s 235us/step - loss: 0.0534
Epoch 197/600
60/60 [==============================] - 0s 302us/step - loss: 0.0531
Epoch 198/600
60/60 [==============================] - 0s 191us/step - loss: 0.0527
Epoch 199/600
60/60 [==============================] - 0s 206us/step - loss: 0.0553
Epoch 200/600
60/60 [==============================] - 0s 234us/step - loss: 0.0537
Epoch 201/600
60/60 [==============================] - 0s 188us/step - loss: 0.0528
Epoch 202/600
60/60 [==============================] - 0s 189us/step - loss: 0.0533
Epoch 203/600
60/60 [==============================] - 0s 202us/step - loss: 0.0533
Epoch 204/600
60/60 [==============================] - 0s 212us/step - loss: 0.0535
Epoch 205/600
60/60 [==============================] - 0s 202us/step - loss: 0.0535
Epoch 206/600
60/60 [==============================] - 0s 271us/step - loss: 0.0538
Epoch 207/600
60/60 [==============================] - 0s 151us/step - loss: 0.0580
Epoch 208/600
60/60 [==============================] - 0s 290us/step - loss: 0.0558
Epoch 209/600
60/60 [==============================] - 0s 271us/step - loss: 0.0532
Epoch 210/600
60/60 [==============================] - 0s 152us/step - loss: 0.0579
```

```
Epoch 211/600
60/60 [==============================] - 0s 148us/step - loss: 0.0537
Epoch 212/600
60/60 [==============================] - 0s 157us/step - loss: 0.0522
Epoch 213/600
60/60 [==============================] - 0s 141us/step - loss: 0.0521
Epoch 214/600
60/60 [==============================] - 0s 193us/step - loss: 0.0530
Epoch 215/600
60/60 [==============================] - 0s 242us/step - loss: 0.0521
Epoch 216/600
60/60 [==============================] - 0s 172us/step - loss: 0.0518
Epoch 217/600
60/60 [==============================] - 0s 155us/step - loss: 0.0524
Epoch 218/600
60/60 [==============================] - 0s 169us/step - loss: 0.0546
Epoch 219/600
60/60 [==============================] - 0s 176us/step - loss: 0.0521
Epoch 220/600
60/60 [==============================] - 0s 237us/step - loss: 0.0517
Epoch 221/600
60/60 [==============================] - 0s 155us/step - loss: 0.0531
Epoch 222/600
60/60 [==============================] - 0s 200us/step - loss: 0.0516
Epoch 223/600
60/60 [==============================] - 0s 166us/step - loss: 0.0516
Epoch 224/600
60/60 [==============================] - 0s 231us/step - loss: 0.0522
Epoch 225/600
60/60 [==============================] - 0s 359us/step - loss: 0.0526
Epoch 226/600
60/60 [==============================] - 0s 274us/step - loss: 0.0525
Epoch 227/600
60/60 [==============================] - 0s 199us/step - loss: 0.0515
Epoch 228/600
60/60 [==============================] - 0s 225us/step - loss: 0.0540
Epoch 229/600
60/60 [==============================] - 0s 193us/step - loss: 0.0541
Epoch 230/600
60/60 [==============================] - 0s 207us/step - loss: 0.0521
Epoch 231/600
60/60 [==============================] - 0s 192us/step - loss: 0.0520
Epoch 232/600
60/60 [==============================] - 0s 207us/step - loss: 0.0522
Epoch 233/600
60/60 [==============================] - 0s 217us/step - loss: 0.0520
Epoch 234/600
60/60 [==============================] - 0s 188us/step - loss: 0.0509
Epoch 235/600
60/60 [==============================] - 0s 232us/step - loss: 0.0509
Epoch 236/600
60/60 [==============================] - 0s 173us/step - loss: 0.0509
Epoch 237/600
60/60 [==============================] - 0s 218us/step - loss: 0.0516
Epoch 238/600
60/60 [==============================] - 0s 227us/step - loss: 0.0513
Epoch 239/600
```

```
60/60 [==============================] - 0s 223us/step - loss: 0.0511
Epoch 240/600
60/60 [==============================] - 0s 314us/step - loss: 0.0517
Epoch 241/600
60/60 [==============================] - 0s 252us/step - loss: 0.0507
Epoch 242/600
60/60 [==============================] - 0s 179us/step - loss: 0.0516
Epoch 243/600
60/60 [==============================] - 0s 164us/step - loss: 0.0502
Epoch 244/600
60/60 [==============================] - 0s 141us/step - loss: 0.0501
Epoch 245/600
60/60 [==============================] - 0s 192us/step - loss: 0.0519
Epoch 246/600
60/60 [==============================] - 0s 180us/step - loss: 0.0558
Epoch 247/600
60/60 [==============================] - 0s 178us/step - loss: 0.0532
Epoch 248/600
60/60 [==============================] - 0s 198us/step - loss: 0.0522
Epoch 249/600
60/60 [==============================] - 0s 191us/step - loss: 0.0544
Epoch 250/600
60/60 [==============================] - 0s 225us/step - loss: 0.0515
Epoch 251/600
60/60 [==============================] - 0s 418us/step - loss: 0.0501
Epoch 252/600
60/60 [==============================] - 0s 309us/step - loss: 0.0516
Epoch 253/600
60/60 [==============================] - 0s 518us/step - loss: 0.0508
Epoch 254/600
60/60 [==============================] - 0s 272us/step - loss: 0.0505
Epoch 255/600
60/60 [==============================] - 0s 190us/step - loss: 0.0512
Epoch 256/600
60/60 [==============================] - 0s 226us/step - loss: 0.0522
Epoch 257/600
60/60 [==============================] - 0s 206us/step - loss: 0.0532
Epoch 258/600
60/60 [==============================] - 0s 184us/step - loss: 0.0531
Epoch 259/600
60/60 [==============================] - 0s 166us/step - loss: 0.0523
Epoch 260/600
60/60 [==============================] - 0s 182us/step - loss: 0.0520
Epoch 261/600
60/60 [==============================] - 0s 162us/step - loss: 0.0518
Epoch 262/600
60/60 [==============================] - 0s 146us/step - loss: 0.0500
Epoch 263/600
60/60 [==============================] - 0s 160us/step - loss: 0.0522
Epoch 264/600
60/60 [==============================] - 0s 174us/step - loss: 0.0493
Epoch 265/600
60/60 [==============================] - 0s 214us/step - loss: 0.0505
Epoch 266/600
60/60 [==============================] - 0s 187us/step - loss: 0.0497
Epoch 267/600
60/60 [==============================] - 0s 163us/step - loss: 0.0511
```

```
Epoch 268/600
60/60 [==============================] - 0s 196us/step - loss: 0.0582
Epoch 269/600
60/60 [==============================] - 0s 185us/step - loss: 0.0530
Epoch 270/600
60/60 [==============================] - 0s 168us/step - loss: 0.0531
Epoch 271/600
60/60 [==============================] - 0s 184us/step - loss: 0.0529
Epoch 272/600
60/60 [==============================] - 0s 223us/step - loss: 0.0549
Epoch 273/600
60/60 [==============================] - 0s 178us/step - loss: 0.0499
Epoch 274/600
60/60 [==============================] - 0s 217us/step - loss: 0.0498
Epoch 275/600
60/60 [==============================] - 0s 270us/step - loss: 0.0563
Epoch 276/600
60/60 [==============================] - 0s 322us/step - loss: 0.0532
Epoch 277/600
60/60 [==============================] - 0s 287us/step - loss: 0.0498
Epoch 278/600
60/60 [==============================] - 0s 278us/step - loss: 0.0512
Epoch 279/600
60/60 [==============================] - 0s 277us/step - loss: 0.0487
Epoch 280/600
60/60 [==============================] - 0s 277us/step - loss: 0.0487
Epoch 281/600
60/60 [==============================] - 0s 264us/step - loss: 0.0500
Epoch 282/600
60/60 [==============================] - 0s 199us/step - loss: 0.0516
Epoch 283/600
60/60 [==============================] - 0s 166us/step - loss: 0.0491
Epoch 284/600
60/60 [==============================] - 0s 220us/step - loss: 0.0490
Epoch 285/600
60/60 [==============================] - 0s 156us/step - loss: 0.0488
Epoch 286/600
60/60 [==============================] - 0s 195us/step - loss: 0.0483
Epoch 287/600
60/60 [==============================] - 0s 188us/step - loss: 0.0516
Epoch 288/600
60/60 [==============================] - 0s 211us/step - loss: 0.0511
Epoch 289/600
60/60 [==============================] - 0s 188us/step - loss: 0.0494
Epoch 290/600
60/60 [==============================] - 0s 205us/step - loss: 0.0494
Epoch 291/600
60/60 [==============================] - 0s 179us/step - loss: 0.0496
Epoch 292/600
60/60 [==============================] - 0s 333us/step - loss: 0.0487
Epoch 293/600
60/60 [==============================] - 0s 192us/step - loss: 0.0552
Epoch 294/600
60/60 [==============================] - 0s 161us/step - loss: 0.0545
Epoch 295/600
60/60 [==============================] - 0s 172us/step - loss: 0.0527
Epoch 296/600
```

```
60/60 [==============================] - 0s 158us/step - loss: 0.0498
Epoch 297/600
60/60 [==============================] - 0s 196us/step - loss: 0.0526
Epoch 298/600
60/60 [==============================] - 0s 199us/step - loss: 0.0524
Epoch 299/600
60/60 [==============================] - 0s 160us/step - loss: 0.0492
Epoch 300/600
60/60 [==============================] - 0s 153us/step - loss: 0.0482
Epoch 301/600
60/60 [==============================] - 0s 136us/step - loss: 0.0483
Epoch 302/600
60/60 [==============================] - 0s 190us/step - loss: 0.0482
Epoch 303/600
60/60 [==============================] - 0s 159us/step - loss: 0.0500
Epoch 304/600
60/60 [==============================] - 0s 178us/step - loss: 0.0503
Epoch 305/600
60/60 [==============================] - 0s 226us/step - loss: 0.0475
Epoch 306/600
60/60 [==============================] - 0s 352us/step - loss: 0.0528
Epoch 307/600
60/60 [==============================] - 0s 228us/step - loss: 0.0519
Epoch 308/600
60/60 [==============================] - 0s 187us/step - loss: 0.0490
Epoch 309/600
60/60 [==============================] - 0s 176us/step - loss: 0.0485
Epoch 310/600
60/60 [==============================] - 0s 210us/step - loss: 0.0487
Epoch 311/600
60/60 [==============================] - 0s 198us/step - loss: 0.0494
Epoch 312/600
60/60 [==============================] - 0s 177us/step - loss: 0.0479
Epoch 313/600
60/60 [==============================] - 0s 220us/step - loss: 0.0475
Epoch 314/600
60/60 [==============================] - 0s 357us/step - loss: 0.0501
Epoch 315/600
60/60 [==============================] - 0s 191us/step - loss: 0.0526
Epoch 316/600
60/60 [==============================] - 0s 170us/step - loss: 0.0481
Epoch 317/600
60/60 [==============================] - 0s 184us/step - loss: 0.0491
Epoch 318/600
60/60 [==============================] - 0s 190us/step - loss: 0.0500
Epoch 319/600
60/60 [==============================] - 0s 205us/step - loss: 0.0559
Epoch 320/600
60/60 [==============================] - 0s 192us/step - loss: 0.0605
Epoch 321/600
60/60 [==============================] - 0s 174us/step - loss: 0.0517
Epoch 322/600
60/60 [==============================] - 0s 221us/step - loss: 0.0478
Epoch 323/600
60/60 [==============================] - 0s 216us/step - loss: 0.0507
Epoch 324/600
60/60 [==============================] - 0s 186us/step - loss: 0.0643
```

```
Epoch 325/600
60/60 [==============================] - 0s 174us/step - loss: 0.0474
Epoch 326/600
60/60 [==============================] - 0s 182us/step - loss: 0.0542
Epoch 327/600
60/60 [==============================] - 0s 310us/step - loss: 0.0493
Epoch 328/600
60/60 [==============================] - 0s 188us/step - loss: 0.0479
Epoch 329/600
60/60 [==============================] - 0s 171us/step - loss: 0.0468
Epoch 330/600
60/60 [==============================] - 0s 151us/step - loss: 0.0475
Epoch 331/600
60/60 [==============================] - 0s 245us/step - loss: 0.0502
Epoch 332/600
60/60 [==============================] - 0s 215us/step - loss: 0.0570
Epoch 333/600
60/60 [==============================] - 0s 170us/step - loss: 0.0484
Epoch 334/600
60/60 [==============================] - 0s 180us/step - loss: 0.0479
Epoch 335/600
60/60 [==============================] - 0s 195us/step - loss: 0.0489
Epoch 336/600
60/60 [==============================] - 0s 201us/step - loss: 0.0461
Epoch 337/600
60/60 [==============================] - 0s 179us/step - loss: 0.0469
Epoch 338/600
60/60 [==============================] - 0s 164us/step - loss: 0.0481
Epoch 339/600
60/60 [==============================] - 0s 257us/step - loss: 0.0497
Epoch 340/600
60/60 [==============================] - 0s 300us/step - loss: 0.0551
Epoch 341/600
60/60 [==============================] - 0s 297us/step - loss: 0.0469
Epoch 342/600
60/60 [==============================] - 0s 222us/step - loss: 0.0469
Epoch 343/600
60/60 [==============================] - 0s 210us/step - loss: 0.0484
Epoch 344/600
60/60 [==============================] - 0s 226us/step - loss: 0.0463
Epoch 345/600
60/60 [==============================] - 0s 232us/step - loss: 0.0487
Epoch 346/600
60/60 [==============================] - 0s 206us/step - loss: 0.0461
Epoch 347/600
60/60 [==============================] - 0s 236us/step - loss: 0.0460
Epoch 348/600
60/60 [==============================] - 0s 257us/step - loss: 0.0480
Epoch 349/600
60/60 [==============================] - 0s 299us/step - loss: 0.0505
Epoch 350/600
60/60 [==============================] - 0s 250us/step - loss: 0.0500
Epoch 351/600
60/60 [==============================] - 0s 237us/step - loss: 0.0617
Epoch 352/600
60/60 [==============================] - 0s 171us/step - loss: 0.0474
Epoch 353/600
```

```
60/60 [==============================] - 0s 258us/step - loss: 0.0457
Epoch 354/600
60/60 [==============================] - 0s 133us/step - loss: 0.0453
Epoch 355/600
60/60 [==============================] - 0s 144us/step - loss: 0.0454
Epoch 356/600
60/60 [==============================] - 0s 201us/step - loss: 0.0451
Epoch 357/600
60/60 [==============================] - 0s 207us/step - loss: 0.0484
Epoch 358/600
60/60 [==============================] - 0s 188us/step - loss: 0.0474
Epoch 359/600
60/60 [==============================] - 0s 163us/step - loss: 0.0468
Epoch 360/600
60/60 [==============================] - 0s 169us/step - loss: 0.0488
Epoch 361/600
60/60 [==============================] - 0s 185us/step - loss: 0.0472
Epoch 362/600
60/60 [==============================] - 0s 156us/step - loss: 0.0457
Epoch 363/600
60/60 [==============================] - 0s 165us/step - loss: 0.0491
Epoch 364/600
60/60 [==============================] - 0s 205us/step - loss: 0.0523
Epoch 365/600
60/60 [==============================] - 0s 175us/step - loss: 0.0503
Epoch 366/600
60/60 [==============================] - 0s 262us/step - loss: 0.0487
Epoch 367/600
60/60 [==============================] - 0s 191us/step - loss: 0.0452
Epoch 368/600
60/60 [==============================] - 0s 224us/step - loss: 0.0450
Epoch 369/600
60/60 [==============================] - 0s 223us/step - loss: 0.0448
Epoch 370/600
60/60 [==============================] - 0s 216us/step - loss: 0.0471
Epoch 371/600
60/60 [==============================] - 0s 202us/step - loss: 0.0470
Epoch 372/600
60/60 [==============================] - 0s 172us/step - loss: 0.0486
Epoch 373/600
60/60 [==============================] - 0s 153us/step - loss: 0.0542
Epoch 374/600
60/60 [==============================] - 0s 170us/step - loss: 0.0485
Epoch 375/600
60/60 [==============================] - 0s 187us/step - loss: 0.0460
Epoch 376/600
60/60 [==============================] - 0s 197us/step - loss: 0.0457
Epoch 377/600
60/60 [==============================] - 0s 211us/step - loss: 0.0446
Epoch 378/600
60/60 [==============================] - 0s 188us/step - loss: 0.0462
Epoch 379/600
60/60 [==============================] - 0s 175us/step - loss: 0.0481
Epoch 380/600
60/60 [==============================] - 0s 178us/step - loss: 0.0445
Epoch 381/600
60/60 [==============================] - 0s 179us/step - loss: 0.0448
```

```
Epoch 382/600
60/60 [==============================] - 0s 155us/step - loss: 0.0456
Epoch 383/600
60/60 [==============================] - 0s 148us/step - loss: 0.0446
Epoch 384/600
60/60 [==============================] - 0s 190us/step - loss: 0.0491
Epoch 385/600
60/60 [==============================] - 0s 179us/step - loss: 0.0478
Epoch 386/600
60/60 [==============================] - 0s 171us/step - loss: 0.0491
Epoch 387/600
60/60 [==============================] - 0s 184us/step - loss: 0.0540
Epoch 388/600
60/60 [==============================] - 0s 161us/step - loss: 0.0481
Epoch 389/600
60/60 [==============================] - 0s 171us/step - loss: 0.0482
Epoch 390/600
60/60 [==============================] - 0s 185us/step - loss: 0.0441
Epoch 391/600
60/60 [==============================] - 0s 152us/step - loss: 0.0446
Epoch 392/600
60/60 [==============================] - 0s 164us/step - loss: 0.0448
Epoch 393/600
60/60 [==============================] - 0s 176us/step - loss: 0.0441
Epoch 394/600
60/60 [==============================] - 0s 164us/step - loss: 0.0442
Epoch 395/600
60/60 [==============================] - 0s 151us/step - loss: 0.0452
Epoch 396/600
60/60 [==============================] - 0s 168us/step - loss: 0.0441
Epoch 397/600
60/60 [==============================] - 0s 160us/step - loss: 0.0481
Epoch 398/600
60/60 [==============================] - 0s 164us/step - loss: 0.0530
Epoch 399/600
60/60 [==============================] - 0s 145us/step - loss: 0.0436
Epoch 400/600
60/60 [==============================] - 0s 152us/step - loss: 0.0435
Epoch 401/600
60/60 [==============================] - 0s 168us/step - loss: 0.0447
Epoch 402/600
60/60 [==============================] - 0s 191us/step - loss: 0.0457
Epoch 403/600
60/60 [==============================] - 0s 166us/step - loss: 0.0465
Epoch 404/600
60/60 [==============================] - 0s 178us/step - loss: 0.0594
Epoch 405/600
60/60 [==============================] - 0s 203us/step - loss: 0.0472
Epoch 406/600
60/60 [==============================] - 0s 147us/step - loss: 0.0631
Epoch 407/600
60/60 [==============================] - 0s 173us/step - loss: 0.0481
Epoch 408/600
60/60 [==============================] - 0s 217us/step - loss: 0.0515
Epoch 409/600
60/60 [==============================] - 0s 158us/step - loss: 0.0504
Epoch 410/600
```

```
60/60 [==============================] - 0s 260us/step - loss: 0.0525
Epoch 411/600
60/60 [==============================] - 0s 226us/step - loss: 0.0535
Epoch 412/600
60/60 [==============================] - 0s 186us/step - loss: 0.0482
Epoch 413/600
60/60 [==============================] - 0s 171us/step - loss: 0.0458
Epoch 414/600
60/60 [==============================] - 0s 166us/step - loss: 0.0433
Epoch 415/600
60/60 [==============================] - 0s 167us/step - loss: 0.0452
Epoch 416/600
60/60 [==============================] - 0s 224us/step - loss: 0.0469
Epoch 417/600
60/60 [==============================] - 0s 169us/step - loss: 0.0467
Epoch 418/600
60/60 [==============================] - 0s 223us/step - loss: 0.0470
Epoch 419/600
60/60 [==============================] - 0s 161us/step - loss: 0.0504
Epoch 420/600
60/60 [==============================] - 0s 249us/step - loss: 0.0597
Epoch 421/600
60/60 [==============================] - 0s 216us/step - loss: 0.0542
Epoch 422/600
60/60 [==============================] - 0s 183us/step - loss: 0.0534
Epoch 423/600
60/60 [==============================] - 0s 164us/step - loss: 0.0542
Epoch 424/600
60/60 [==============================] - 0s 163us/step - loss: 0.0460
Epoch 425/600
60/60 [==============================] - 0s 196us/step - loss: 0.0452
Epoch 426/600
60/60 [==============================] - 0s 159us/step - loss: 0.0500
Epoch 427/600
60/60 [==============================] - 0s 178us/step - loss: 0.0631
Epoch 428/600
60/60 [==============================] - 0s 188us/step - loss: 0.0568
Epoch 429/600
60/60 [==============================] - 0s 175us/step - loss: 0.0487
Epoch 430/600
60/60 [==============================] - 0s 201us/step - loss: 0.0437
Epoch 431/600
60/60 [==============================] - 0s 172us/step - loss: 0.0434
Epoch 432/600
60/60 [==============================] - 0s 182us/step - loss: 0.0433
Epoch 433/600
60/60 [==============================] - 0s 168us/step - loss: 0.0423
Epoch 434/600
60/60 [==============================] - 0s 137us/step - loss: 0.0439
Epoch 435/600
60/60 [==============================] - 0s 192us/step - loss: 0.0481
Epoch 436/600
60/60 [==============================] - 0s 165us/step - loss: 0.0432
Epoch 437/600
60/60 [==============================] - 0s 170us/step - loss: 0.0424
Epoch 438/600
60/60 [==============================] - 0s 181us/step - loss: 0.0434
```

```
Epoch 439/600
60/60 [==============================] - 0s 182us/step - loss: 0.0444
Epoch 440/600
60/60 [==============================] - 0s 238us/step - loss: 0.0451
Epoch 441/600
60/60 [==============================] - 0s 208us/step - loss: 0.0487
Epoch 442/600
60/60 [==============================] - 0s 156us/step - loss: 0.0457
Epoch 443/600
60/60 [==============================] - 0s 228us/step - loss: 0.0438
Epoch 444/600
60/60 [==============================] - 0s 185us/step - loss: 0.0443
Epoch 445/600
60/60 [==============================] - 0s 180us/step - loss: 0.0483
Epoch 446/600
60/60 [==============================] - 0s 158us/step - loss: 0.0454
Epoch 447/600
60/60 [==============================] - 0s 188us/step - loss: 0.0465
Epoch 448/600
60/60 [==============================] - 0s 159us/step - loss: 0.0493
Epoch 449/600
60/60 [==============================] - 0s 184us/step - loss: 0.0447
Epoch 450/600
60/60 [==============================] - 0s 270us/step - loss: 0.0432
Epoch 451/600
60/60 [==============================] - 0s 286us/step - loss: 0.0439
Epoch 452/600
60/60 [==============================] - 0s 379us/step - loss: 0.0430
Epoch 453/600
60/60 [==============================] - 0s 459us/step - loss: 0.0494
Restoring model weights from the end of the best epoch
Epoch 00453: early stopping
best epoch v4 =  433
smallest loss v4 = 0.04233019823829333
```

In [83]:

```
#Task2.4 Table
from tabulate import tabulate
table = [['Original Model', np.min(loss_hist), best_epoch, 'baseline'], ['Mod
print(tabulate(table,headers=['Model Name', 'minimum loss value', '# of epoch
```

```
Model Name        minimum loss value    # of epoch  compared to baseline
--------------  --------------------  ------------  ----------------------
Original Model              0.0543997           598  baseline
Model v1                    0.0559068           350  smaller
Model v2                    0.0530908           476  smaller
Model v3                    0.0558974           588  similar
Model v4                    0.0423302           433  smaller
```