For Project 3, I worked on all of the tasks by myself. This project looked at the performance of the solar panel designs connected 72 cells in series (Task 1), and 4 cells in series and/or parallel (Task 2).

Task 1

In task 1.1, I was given operating and performance parameter data for the solar panel design as DS3.1.1Lowflux data array. Each of the three input parameters— T_{air} , I_D , R_L —were standardized by subtracting the mean and dividing by the standard deviation. Modifying the given P3pcaExample code, I determined the eigenvalues and eigenvectors of the input variable array, summarized in table 1 below. The scatter plots of the standardized data and PCA data are included in Figure 1 as well. Based on the scatter plots as well as the eigenvectors and eigenvalues, most important value is I_D , and then R_L . It seems that T_{air} does not have as much of an importance.

Table 1. Eigenvalues and Eigenvectors of the input variable matrix $[T_{air}, I_D, R_L]$.

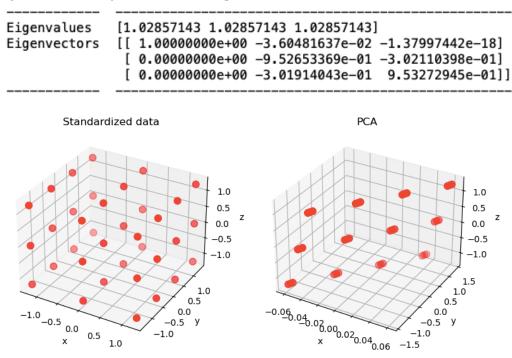


Figure 1. Scatter plots of the standardized data (left) and PCA data (right). X represents T_{air} , y is I_D , and z is R_L . Based on the scatter plots as well as the eigenvectors and eigenvalues, most important value is I_D and then R_L . It seems that T_{air} does not have as much of an importance.

In task 1.2, I was given CodeP3.1.2 from class that contains the basic Keras neural network model structure. First, I normalized the DS3.1.1Lowflux data via dividing data by the median value for each parameter. The given data was randomly separated to create a training set (2/3 the size of the data) and a validation set (1/3 the size of the data). Then, I created the keras.sequential network model with the following specs—1) RandomUniform initializer, 2)

inlet layer with 6 neurons (with 3 inputs) with K.elu activation function, 3) 3 hidden layers with 8, 16, and 8 neurons all with K.elu activation function, 4) outlet layer with 2 neurons without an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0001. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.0256122 with best epoch at 775). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 2), and second between the prediction vs real data from the normalized validation data set (Figure 3). The mean absolute error between the prediction and the training set was 0.0023915 while the mean absolute error between the prediction and the normalized validation set was 0.002488. Therefore, both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

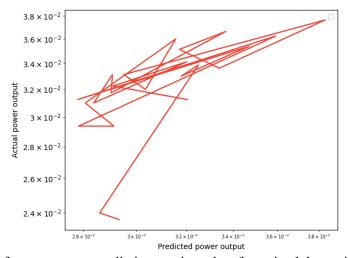


Figure 2. Log-log plot of power output prediction vs given data for trained data using the keras model. It makes a fairly good prediction as can be seen on the graph. The MAE was 0.0023915.

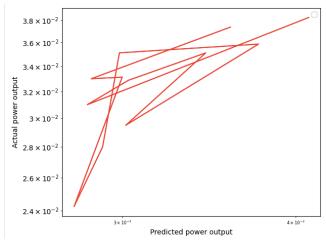


Figure 3. Log-log plot of power output prediction vs given data from the validation set using the trained keras model. It makes a fairly good prediction, but worse compared to the trained set (Figure 2) as can be seen on the graph. The MAE was 0.002483.

The keras model from above was also used to test the normalized Hiflux data given in DS3.1.2Hiflux. The Hiflux data contains data with $I_D > 1300~W/m^2$, and each of the parameters were normalized via dividing each value based on the median of each parameter. The results of the prediction from Hiflux data (based on the keras model) compared to the real data is shown in Figure 4—the mean absolute error between the prediction and the given was 0.969615, which is worse than the Lowflux data by factor of 100. This phenomenon is expected since I_D varies significantly from the data the model was trained based on. Usually, solar radiation intensities max at $1300W/m^2$, so the Hiflux data is simply for validation purposes at higher flux levels.

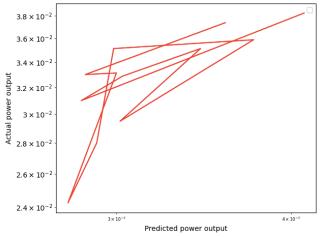


Figure 4. Log-log plot of power output prediction vs given data from the high flux data set using low flux trained keras model. It makes an acceptable prediction, but worse compared to the trained set (Figure 2) as can be seen on the graph. The MAE was 0.969615.

The trained model was used to create a surface plot (Figure 5) of solar power output prediction based on the function of R_L and I_D . Air temperature was fixed at 20 °C while 4 Ω < R_L < 8 Ω and 500 < I_D < 1800 W/m^2 .

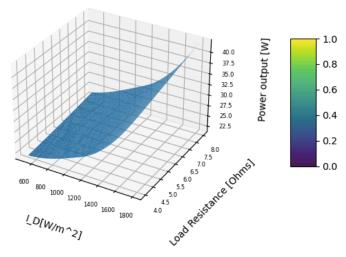


Figure 5. A surface plot for predicted \dot{W} values for $4 \Omega < R_L < 8 \Omega$ and $500 < I_D < 1800 W/m^2$ with $T_{air} = 20$ °C. As predicted from the eigenvalue, eigenvectors, and scatter plot results in Task 1.1, I_D and R_L influence power output. Also, it can be seen that I_D influences the power output more than R_L .

In task 1.3, I repeated task 1.2 with a new neural network model. The neural network model now has the following specs—1) RandomUniform initializer, 2) inlet layer with 6 neurons (with 3 inputs) with K.elu activation function, 3) 4 hidden layers with 8, 12, 16, and 8 neurons all with K.elu activation function, 4) outlet layer with 2 neurons without an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0003. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.013608 with best epoch at 767). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 6), and second between the prediction vs real data from the normalized validation data set (Figure 7). The mean absolute error between the prediction and the training set was 0.004687 while the mean absolute error between the prediction and the normalized validation set was 0.004788. Therefore, both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

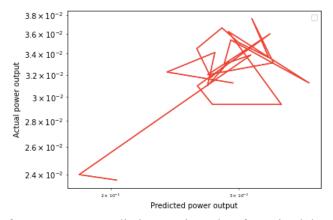


Figure 6. Log-log plot of power output prediction vs given data for trained data using the modified keras model. It makes a fairly good prediction as can be seen on the graph. The MAE was 0.004687.

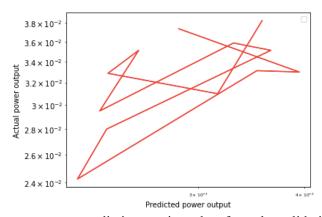


Figure 7. Log-log plot of power output prediction vs given data from the validation set using the modified keras model. It makes a fairly good prediction, but worse compared to the trained set (Figure 6) as can be seen on the graph. The MAE was 0.004788.

The modified keras model from above was also used to test the normalized Hiflux data given in DS3.1.2Hiflux. The Hiflux data contains data with $I_D > 1300 \text{ W/m}^2$, and each of the parameters were normalized via dividing each value based on the median of each parameter. The results of the prediction from Hiflux data (based on the keras model) compared to the real data is shown in Figure 8—the mean absolute error between the prediction and the given was 0.97004, which is worse than the Lowflux data by factor of 100. This phenomenon is expected since I_D varies significantly from the data the model was trained based on.

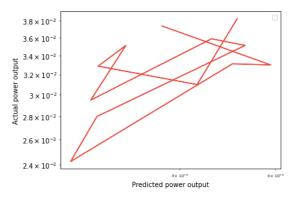


Figure 8. Log-log plot of power output prediction vs given data from the high flux data set using low flux modified keras model. It makes an acceptable prediction, but worse compared to the trained set (Figure 2) as can be seen on the graph. The MAE was 0.97004.

Based on the figures 6-8, it is clear that graphically the modified 4 hidden layers model is a better match of the real data. The one-to-one linear trend is more visible in all of the graphs generated from Task 1.3 compared to those from Task 1.2. However, MAE is statistically comparable for both tasks. Since the loss started to increase although the predictions are more one-to-one with the real data, this is a sign of overfitting of the model. The validation metrics, in this case, mean absolute error loss has improved until a point where it is now getting worse. The trained model was used to create a surface plot (Figure 9) of solar power output prediction based on the function of R_L and I_D . Air temperature was fixed at 20 °C while $4 \Omega < R_L < 8 \Omega$ and $500 < I_D < 1800 \ W/m^2$.

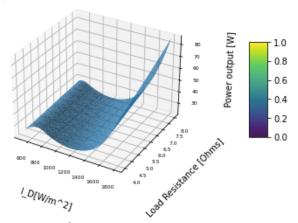


Figure 9. A surface plot for predicted \dot{W} values for $4\Omega < R_L < 8\Omega$ and $500 < I_D < 1800$ W/m^2 with $T_{air} = 20$ °C. As predicted from the eigenvalue, eigenvectors, and scatter plot results in Task 1.1, it can be seen that I_D influences the power output more than R_L . This is a more specified surface plot compared to the one generated from Task 1.2.

Task 2

In task 2, I am looking at a solar PV system comprised of 4 solar panels in 3 different modes—1) 4 in parallel, 2) 2x2 in series/parallel, and 3) 4 in series as shown in Figure 10. Performance data of the system is given as DS3.2.1maxMode with the input data [T_{air} , I_D , R_L] and the output parameters [M_{max} , V_L , \dot{W}_{max}].

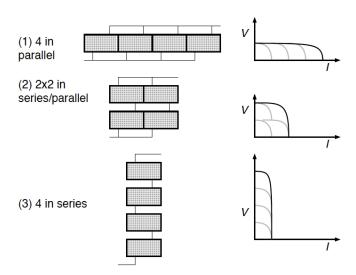


Figure 10. Schematics of solar cell layouts for the different 4 PV panel system modes.

In task 2.1, I built a NN model for predicting the mode that will produce most power for a specified set of operating conditions. First, I normalized the DS3.2.1maxMode data via dividing data by the median value for each parameter. The given data was randomly separated to create a training set (3/4 the size of the data) and a validation set (1/4 the size of the data). Then, I created the keras.sequential network model with the following specs—1) RandomUniform initializer, 2) inlet layer with 16 neurons (with 3 inputs) with K.elu activation function, 3) 3 hidden layers with 32, 16, and 16 neurons all with K.elu activation function, 4) outlet layer with 3 neurons without an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0001. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.025821 with best epoch at 688). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 11), and second between the prediction vs real data from the normalized validation data set (Figure 12). The mean absolute error between the prediction and the training set was 0.007073 for M_{max} and 0.0173438 for \dot{W}_{max} , while the mean absolute error between the prediction and the normalized validation set was 0.0388 for M_{max} and 0.06592 for \dot{W}_{max} . Therefore, both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

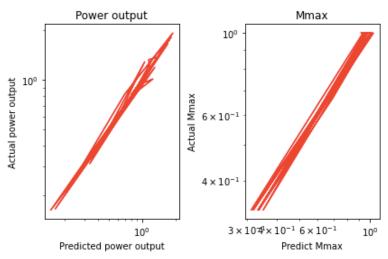


Figure 11. Log-log plot of power output and M_{max} predictions vs given data for trained data using the keras model. As can be seen on the graph, it made pretty great accurate predictions (one-to-one trend) for both power outputs and M_{max} . The MAE was 0.007073 for M_{max} and 0.0173438 for \dot{W}_{max} .

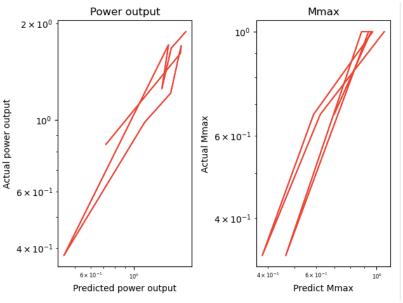


Figure 12. Log-log plot of power output and M_{max} predictions vs given data from the validation set using the keras model. It makes a fairly good prediction (one-to-one trend), but worse compared to the trained set (Figure 11) as can be seen on the graph. The MAE was 0.0388 for M_{max} and 0.06592 for \dot{W}_{max} .

In task 2.2, I built a new NN model for predicting the most power output generated for a specified set of operating conditions and mode given. Performance data of the system is given as DS3.2.2multiModePerf with the input data [M, T_{air} , I_D , R_L] and the output parameters [V_L , \dot{W}_{max}] for the 4 panel systems. First, I normalized the DS3.2.2multiModePerf data via dividing data by the median value for each parameter. The given data was randomly separated to create a training set (3/4 the size of the data) and a validation set (1/4 the size of the data). Then, I created the keras.sequential network model with the following specs—1) RandomUniform initializer, 2) inlet layer with 16 neurons (with 4 inputs) with K.elu activation function, 3) 3 hidden layers with 32, 16, and 16 neurons all with K.elu activation function, 4) outlet layer with 2 neurons without

an activation function, 5) RMSprop optimizer, 6) initialized weights to -0.2 and 0.7, 7) epochs of 800, and 8) learning rate of 0.0001. The resulting NN model was trained to get the mean absolute error of 0.025 or below (ended up getting MAE = 0.0242132 with best epoch at 311). After the training is complete, I ran two comparisons sets—first between the prediction vs real data from the training data set (Figure 13), and second between the prediction vs real data from the normalized validation data set (Figure 14). The mean absolute error between the prediction and the training set was 0.13747 for \dot{W}_{max} , while the mean absolute error between the prediction and the normalized validation set was 0.20073 for \dot{W}_{max} . Since M is now an input parameter, only the \dot{W}_{max} was compared with MAE. Both predictions were fairly good using the trained model, but it was visible that trained set predictions were much better than the validation set predictions. It makes sense since the model was actually trained based on the training set—the model has seen these values before, so it should be better at predicting the power outputs given the training set.

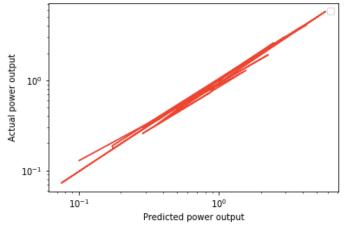


Figure 13. Log-log plot of power output predictions vs given data for trained data using the keras model. As can be seen on the graph, it made pretty great accurate predictions (one-to-one trend) for power outputs. The MAE was 0.13747 for \dot{W}_{max} .

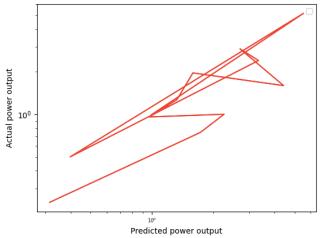


Figure 14. Log-log plot of power output predictions vs given data from the validation set using the keras model. It makes a fairly good prediction (one-to-one trend), but worse compared to the trained set (Figure 13) as can be seen on the graph. The MAE was 0.20073 for \dot{W}_{max} .

The keras model generated in Task 2.1 was used to predict M_{max} for the combinations of operating conditions in Table 2. The resulting predictions of M_{max} and \dot{W}_{max} are documented in Table 3.

Table 2. Combinations of operating conditions to be run through the keras model from Task 2.1 [T_{air} , I_D , R_L].

T_{air} (deg, C)	I_D (W/m ²)	R_{L} (Ohms)
10.0	200	50.
20.0	200	130.
10.0	500	40.
20.0	500	80.
20.0	700	30.
20.	700	55.
10.0	1000	12.
20.0	1000	25.
20.0	1000	39.

Table 3. Combinations of operating conditions [T_{air} , I_D , R_L] and the resulting predictions [M_{max} , V_L , \dot{W}_{max}] using keras model generated in Task 2.1.

Tair	I_D	R_L	Mmax	V_L	Wdot	
10.0	200	50	1.9602212	290588379 89.	.8546043753624	9.899569237232209
20.0	200	130	3.122393	488883972 147	7.6177656412124	6 10.749907332658767
10.0	500	140	2.738590	8365249634 12	23.951601147651	67 22.106579428911207
20.0	500	80	3.0291666	6984558105 19	96.109809589385	97 27.262160074710845
20.0	700	30	2.7685380	0578041077 13	39.982870268821	7 33.15414147377014
20.0	700	55	3.1750450	609474182 199	9.3540021657943	6 36.27611528635025
10.0	1000	12	1.889492	5117492676 95	5.9185514092445	3 46.14515111446381
20.0	1000	25	2.859831	5119743347 15	56.905422306060	79 51.35843331813812
20.0	1000	j39	3.335097	312927246 203	3.7794769525527	8 53.72723318338394

Then, the M_{max} predictions from the first model was rounded to the nearest integer to be put through the keras model generated in Task 2.2. Thus, the input parameters were $[[M_{max}]_{rounded}, T_{air}, I_D, R_L]$, which was input to the NN model to generate predictions for $[V_L, \dot{W}_{max}]$. All of the data was normalized to the median used to train the data for the respective NN models. The prediction results are shown in Table 4.

Table 4. Combinations of operating conditions [[M_{max}]_{round}, T_{air} , I_D , R_L] and the resulting predictions [V_L , \dot{W}_{max}] using keras model generated in Task 2.2. The power output predictions are much larger compared to those generated from NN model in Task 2.1.

Mmax_round	Tair	I_D	R_L	V_L Wdot
2.0	10.0	 200	 50	91.62284830808639 27.14180871248245
3.0	20.0	j200	j130	161.88119632005692 23.520206040143965
3.0	10.0	j500	j40	114.02570812702179 54.815417718887325
3.0	20.0	j500	j80	148.4456235408783 32.26498575210571
3.0	20.0	j700	j30	67.31403270959854 21.857767286896706
3.0	20.0	j700	55	137.04444386959076 47.840831798315044
2.0	10.0	1000	12	105.40879675149917 151.831032371521
3.0	20.0	1000	25	116.42981876134873 69.384532392025
3.0	20.0	1000	j39	180.83092231750487 102.59218779802322
mean absolu	te error be	tween predict:	ions from fi	irst and second model: Wdot = 29.240247532725334

The power output predictions are much greater than the respective values from the NN model predictions from Task 2.1 generated model. The mean absolute error between the \dot{W}_{max} values from the first model vs the second model is 29.24, which is fairly big. The Task 2.1 model is viable for predicting M_{max} , but it is not a viable model for accurately controlling the switch setting in the multi-mode 4 PV panel system described in Figure 10. The difference is due to the second model taking M_{max} into account while the first model does not as an input parameter.

*All neural networks were designed to be K.elu and 3 hidden layers—with respective neurons in each layers mentioned above—to avoid overfitting and to create faster convergence (based on the experimental data from project 2).

Appendix

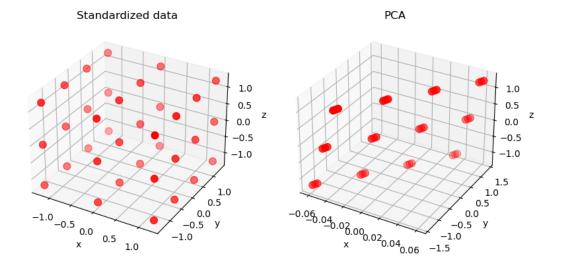
```
In [11]:
          #Task 1.1
          import math
          import numpy as np
          #Part 1 input data: Air temp (degC), ID (W/sqm), load resistance (ohms)
          # - split into training set and a randomly slected small validation set
          xdata = [[-10.0, 350, 4.464],
            [-10.0, 650, 4.464],
            [-10.0, 950, 4.464],
            [-10.0, 1250, 4.464],
            [10.0, 350, 4.464],
            [10.0, 650, 4.464],
            [10.0, 950, 4.464],
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            [30.0, 650, 8.928],
            [30.0, 950, 8.928],
            [30.0, 1250, 8.928]]
          #Part 1 output data: VL (V) and Power out (W)
          ydata = [[18.9, 80.3],
           [23.5, 124.6],
           [24.8, 138.6],
           [25.6, 146.9],
           [19.2, 83.1],
           [25.0, 140.5],
```

```
[26.5, 157.6],
 [27.3, 167.5],
 [19.4, 84.7],
 [26.4, 156.7],
 [28.1, 177.7],
 [29.0, 189.4],
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 [25.8, 99.7],
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 [23.6, 83.7],
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 [27.6, 113.8],
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 [24.8, 92.0],
 [28.1, 118.2],
 [29.3, 128.8],
 [30.1, 135.5],
 [23.5, 62.2],
 [25.4, 72.5],
 [26.3, 77.6],
 [26.9, 81.1],
 [25.0, 70.3],
 [27.1, 82.7],
 [28.1, 88.7],
 [28.7, 92.8],
 [26.5, 78.6],
 [28.8, 93.5],
 [29.9, 100.5],
 [30.6, 105.2]]
xarray= np.array(xdata)
yarray= np.array(ydata)
```

```
In [12]:
          #Task 1.1a
          import statistics as s
          Tair =[]
          Id =[]
          Rl =[]
          Tairn =[]
          Idn =[]
          Rln =[]
          xarrayn = []
          for x in range(len(xarray)):
              Tair.append(xarray[x][0])
              Id.append(xarray[x][1])
              Rl.append(xarray[x][2])
          avgTair = s.mean(Tair)
          avgId = s.mean(Id)
          avgRl = s.mean(Rl)
          sdTair = s.pstdev(Tair)
          sdId = s.pstdev(Id)
          sdRl = s.pstdev(Rl)
          Tairn = (Tair-avgTair)/sdTair
          Idn = (Id-avgId)/sdId
          Rln = (Rl-avgRl)/sdRl
          xarrayn = np.column_stack((Tairn, Idn, Rln))
          print(xarrayn)
```

```
[[-1.22474487e+00 -1.34164079e+00 -1.22474487e+00]
          [-1.22474487e+00 -4.47213595e-01 -1.22474487e+00]
          [-1.22474487e+00 4.47213595e-01 -1.22474487e+00]
          [-1.22474487e+00 1.34164079e+00 -1.22474487e+00]
          [ 0.00000000e+00 -1.34164079e+00 -1.22474487e+00]
          [ 0.00000000e+00 -4.47213595e-01 -1.22474487e+00]
           0.00000000e+00 4.47213595e-01 -1.22474487e+00]
           0.00000000e+00 1.34164079e+00 -1.22474487e+00]
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           1.22474487e+00 -4.47213595e-01 -1.22474487e+00]
          [ 1.22474487e+00 4.47213595e-01 -1.22474487e+00]
          [ 1.22474487e+00 1.34164079e+00 -1.22474487e+00]
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           1.22474487e+00 -4.47213595e-01 -4.87361991e-16]
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          [-1.22474487e+00 -1.34164079e+00 1.22474487e+00]
          [-1.22474487e+00 -4.47213595e-01 1.22474487e+00]
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          [1.22474487e+00 -4.47213595e-01 1.22474487e+00]
          [ 1.22474487e+00 4.47213595e-01 1.22474487e+00]
          In [67]:
         #Task 1.1b&c - PCA example
         import numpy as np
         from numpy import linalg as LA
         import tensorflow as tf
         from tabulate import tabulate
         X = xarrayn #define array
         C = np.cov(X.T) #transpose is matrix we want to work with - compute covarian
         w, v = LA.eig(C) # get the eigenvalues w and the eigenvectors v
         table = [['Eigenvalues', w],['Eigenvectors',v]]
         print(tabulate(table))
```

```
In [81]:
          # libraries
          %matplotlib notebook
          from mpl toolkits.mplot3d import Axes3D
          import matplotlib.pyplot as plt
          import numpy as np
          import pandas as pd
          fig = plt.figure(figsize=plt.figaspect(0.5))
          x=X[:,0]
          y=X[:,1]
          z=X[:,2]
          A = np.array([v[:,2],v[:,1]])
          Xmean = np.mean(X,0)
          Y = np.matmul(A, (X-Xmean).T)
          xhat = np.matmul(A.T,Y).T + Xmean
          xh=xhat[:,0]
          yh=xhat[:,1]
          zh=xhat[:,2]
          ax = fig.add subplot(1, 2, 1, projection='3d')
          ax.scatter(x,y,z, c='red', s=60)
          ax.set_xlabel('x')
          ax.set_ylabel('y')
          ax.set_zlabel('z')
          ax.title.set_text('Standardized data');
          ax = fig.add_subplot(1, 2, 2, projection='3d')
          ax.scatter(xh,yh,zh, c='red', s=60)
          ax.set_xlabel('x')
          ax.set ylabel('y')
          ax.set zlabel('z')
          ax.title.set text('PCA');
          plt.show()
```



```
In [13]:
          #Task 1.2 Part a
          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'
          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
          V1 = []
          Wdot = []
          for y in range(len(yarray)):
              Vl.append(xarray[y][0])
              Wdot.append(xarray[y][1])
          medTair = median(Tair)
          medId = median(Id)
          medRl = median(Rl)
          medVl = median(Vl)
          medWdot = median(Wdot)
          Tairn2 = Tair/medTair
          Idn2 = Id/medId
          Rln2 = Rl/medRl
          Vln2 = Vl/medVl
          Wdotn2 = Wdot/medWdot
          xarrayn2 = np.column stack((Tairn2, Idn2, Rln2))
          yarrayn2 = np.column stack((Vln2, Wdotn2))
          print(xarrayn2)
          print(yarrayn2)
         [[-1.
                        0.4375
                                     0.666666671
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[3.

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           [ 3.
                     1.1875]
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                     1.5625]]
In [15]:
          #Task 1.2 Part b
          from sklearn.model_selection import train_test_split
          X_train, X_test, y_train, y_test = train_test_split(xarray, yarray, test_size
          print(X train)
          print(y_train)
          print(X_test)
          print(y_test)
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                  62.2]
           [ 24.8 138.6]
           [ 28.8 93.5]
           [ 25.6 146.9]
           [ 26.5 78.6]
```

[30.1 135.5]

```
[ 26.9 81.1]
 [ 28.1 177.7]
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         83.71
 [ 28.7
        92.8]
 [ 28.1 118.2]
 [ 22.4 75.2]
 [ 19.4 84.7]
 [ 26.5 104.9]
 [ 26.4 156.7]
 [ 29.9 100.5]]
```

```
In [16]:
          #normalized data
          Tairtrainn = []
          Idtrainn = []
          Rltrainn = []
          Vltrainn = []
          Wdottrainn = []
          Tairtestn = []
          Idtestn = []
          Rltestn = []
          Vltestn = []
          Wdottestn = []
          for x in range(len(X_train)):
              Tairtrainn.append(X train[x][0]/medTair)
              Idtrainn.append(X_train[x][1]/medId)
              Rltrainn.append(X_train[x][2]/medRl)
              Vltrainn.append(y train[x][0]/medVl)
              Wdottrainn.append(y_train[x][0]/medWdot)
          for y in range(len(X test)):
              Tairtestn.append(X test[y][0]/medTair)
              Idtestn.append(X_test[y][1]/medId)
              Rltestn.append(X test[y][2]/medRl)
              Vltestn.append(y test[y][0]/medVl)
              Wdottestn.append(y_test[y][0]/medWdot)
          X trainn = np.column stack((Tairtrainn, Idtrainn, Rltrainn))
          y_trainn = np.column_stack((Vltrainn, Wdottrainn))
          X_testn = np.column_stack((Tairtestn, Idtestn, Rltestn))
          y_testn = np.column_stack((Vltestn, Wdottestn))
```

```
from keras import backend as K
#initialize weights
initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)

model = keras.Sequential([
    keras.layers.Dense(6, activation=K.elu, input_shape=[3], kernel_initiali keras.layers.Dense(8, activation=K.elu, kernel_initializer=initializer), keras.layers.Dense(16, activation=K.elu, kernel_initializer=initializer), keras.layers.Dense(8, activation=K.elu, kernel_initializer=initializer), keras.layers.Dense(8, activation=K.elu, kernel_initializer=initializer), keras.layers.Dense(2, kernel_initializer=initializer)
])
```

```
In [384... #from tf.keras import optimizers
    rms = keras.optimizers.RMSprop(0.0001)
    model.compile(loss='mean_absolute_error',optimizer=rms)
In [386... # Add as a surface state of the state of the
```

```
# Add an early stopping callback
es = keras.callbacks.EarlyStopping(
    monitor='loss',
    mode='min',
    patience = 80,
    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(X trainn, y trainn, epochs=800, callbacks=[es])
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))
model.save('./best model')
```

```
Epoch 1/800
Epoch 2/800
Epoch 3/800
Epoch 4/800
Epoch 5/800
Epoch 6/800
Epoch 7/800
Epoch 8/800
Epoch 9/800
Epoch 10/800
Epoch 11/800
Epoch 12/800
Epoch 13/800
Epoch 14/800
```

24/24	[======]	_	0s	243us/step - loss: 0.02	75
	15/800				
	[=========]	-	0s	278us/step - loss: 0.02	78
	16/800 [======]	_	0 s	340us/sten = loss: 0.02	84
	17/800		O D	510db, 500p 10bb. 0.02	0 1
	[======]	_	0s	362us/step - loss: 0.02	74
	18/800				
	[======] 19/800	-	0s	362us/step - loss: 0.02	78
	[=========]	_	0s	361us/step - loss: 0.02	79
Epoch	20/800			<u>-</u>	
	[======]	-	0s	311us/step - loss: 0.02	75
	21/800 [======]		٥٠	202::2/2+07]022: 0.02	72
	22/800	_	US	202us/step - 10ss: 0.02	13
	[========]	_	0s	177us/step - loss: 0.02	74
	23/800				
	[========]	-	0s	226us/step - loss: 0.02	75
	24/800 [======]	_	0s	262us/step - loss: 0.02	76
Epoch	25/800			<u>-</u>	
	[=====]	-	0s	343us/step - loss: 0.02	76
	26/800 [=======]		٥٥	200ug/g+op logg• 0 02	0 1
	27/800	_	US	200ds/scep - 10ss. 0.02	01
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	28/800		0	0.57 / 1	- -
	[======] 29/800	-	US	25/us/step - loss: 0.02	/5
	[=======]	_	0s	229us/step - loss: 0.02	81
	30/800				
	[======] 31/800	-	0s	244us/step - loss: 0.02	77
	[========]	_	0s	376us/step - loss: 0.02	74
Epoch	32/800			<u>-</u>	
	[=========]	-	0s	229us/step - loss: 0.02	79
	33/800 [==========]	_	0s	260us/step - loss: 0.02	75
Epoch	34/800				
	[=========]	-	0s	272us/step - loss: 0.02	75
	35/800 [=======]	_	0s	255us/step - loss: 0.02	75
Epoch	36/800				
	[======]	-	0s	274us/step - loss: 0.02	78
	37/800 [=======]	_	۸e	226us/sten _ loss• 0 02	72
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	41/800		•	010 / 1 3 3 3 3	-
	[======] 42/800	-	0s	219us/step - loss: 0.02	/5
	[========]	_	0s	213us/step - loss: 0.02	77
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Epoch	43/800				
	[========]	_	0s	199us/step - loss: 0.0279)
Epoch	44/800				
	[=======]	-	0s	306us/step - loss: 0.0274	Ė
	45/800		0 -	100/	_
	[======] 46/800	_	0s	190us/step - loss: 0.02/6)
	[========]	_	0s	227us/step = loss: 0.0280)
	47/800		٥٥		
	[======]	_	0s	218us/step - loss: 0.0274	ŀ
	48/800				
	[======] 49/800	-	0s	184us/step - loss: 0.0275)
	[=========]	_	0s	238us/step = loss: 0.0278	₹
	50/800		٥٥	10000,000	
	[======]	-	0s	254us/step - loss: 0.0274	Ŀ
	51/800				
	[======] 52/800	-	0s	190us/step - loss: 0.0275)
	[=========]	_	0s	232us/step - loss: 0.0277	7
Epoch	53/800			_	
	[======]	-	0s	226us/step - loss: 0.0274	Ŀ
	54/800		0 -	225/	
	[======] 55/800	-	US	225us/step - loss: 0.02/3	5
	[=======]	_	0s	309us/step - loss: 0.0273	3
Epoch	56/800			_	
	[======]	-	0s	388us/step - loss: 0.0275)
	57/800 [======]		٥٥	424ug/gton logg. 0 0272	,
	58/800	-	US	424us/step - 10ss: 0:02/3)
	[========]	_	0s	177us/step - loss: 0.0273	3
	59/800				
	[======] 60/800	-	0s	232us/step - loss: 0.0273	3
	[=========]	_	٥q	314us/sten - loss: 0.0278	₹
	61/800		0 D	311d5/5ccp 1055. 0.02/6	•
	[======]	-	0s	243us/step - loss: 0.0280)
	62/800		^	546 / 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	_
	[======] 63/800	-	US	546us/step - loss: 0.02/6)
	[========]	_	0s	332us/step - loss: 0.0277	7
Epoch	64/800				
	[=======]	-	0s	293us/step - loss: 0.0280)
	65/800 [=======]		٥٥	170ug/gton logg. 0 0274	1
	66/800	-	US	17ous/step - 10ss: 0.0274	t
	[========]	_	0s	205us/step - loss: 0.0276	5
	67/800				
	[======================================	-	0s	205us/step - loss: 0.0277	1
	68/800 [=======]	_	۸e	218us/sten = loss 0 0273	₹
	69/800	_	va	210ab/bccp - 10bb. 0.02/3	•
24/24	[======]	_	0s	201us/step - loss: 0.0275	5
	70/800		•	0.15	
	[======] 71/800	-	υs	215us/step - loss: 0.0280)
ъЪоси	11/000				

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Epoch 72/800
24/24 [============== ] - 0s 244us/step - loss: 0.0273
Epoch 73/800
Epoch 74/800
Epoch 75/800
Epoch 76/800
Epoch 77/800
Epoch 78/800
24/24 [============== ] - 0s 203us/step - loss: 0.0275
Epoch 79/800
Epoch 80/800
24/24 [=============== ] - 0s 182us/step - loss: 0.0278
Epoch 81/800
24/24 [=============== ] - 0s 182us/step - loss: 0.0274
Epoch 82/800
Epoch 83/800
24/24 [============== ] - 0s 204us/step - loss: 0.0279
Epoch 84/800
Epoch 85/800
24/24 [=============== ] - 0s 182us/step - loss: 0.0275
Epoch 86/800
24/24 [=============== ] - 0s 186us/step - loss: 0.0280
Epoch 87/800
Epoch 88/800
Epoch 89/800
24/24 [============= ] - 0s 221us/step - loss: 0.0277
Epoch 90/800
Epoch 91/800
24/24 [=============== ] - 0s 241us/step - loss: 0.0272
Epoch 92/800
Epoch 93/800
Epoch 94/800
Epoch 95/800
Epoch 96/800
Epoch 97/800
Epoch 98/800
Epoch 99/800
```

Epoch	100/800			
	[========]	_	0s	225us/step - loss: 0.0273
	101/800			
	[======] 102/800	-	0s	183us/step - loss: 0.0275
	[==========]	_	0s	181us/step - loss: 0.0279
Epoch	103/800			
	[=======]	-	0s	214us/step - loss: 0.0273
	104/800	_	۸e	219us/sten = loss. 0 0274
	105/800		V D	21343/3669 - 1033: 0:02/4
	[=======]	-	0s	173us/step - loss: 0.0278
	106/800 [======]		٥٥	201ug/gton logg. 0 0273
	107/800	_	US	201us/scep - 10ss. 0.02/3
24/24	[=======]	-	0s	231us/step - loss: 0.0273
	108/800 [=======]		0~	101, 101, 101, 101, 101, 101, 101, 101,
	109/800	_	US	181us/step - 10ss: 0.02/6
24/24	[=======]	_	0s	172us/step - loss: 0.0273
	110/800		•	006 / 1 0 0074
	[======] 111/800	-	0s	226us/step - loss: 0.02/4
	[=========]	_	0s	238us/step - loss: 0.0273
	112/800			
	[======] 113/800	-	0s	213us/step - loss: 0.0276
	[==========]	_	0s	221us/step - loss: 0.0271
Epoch	114/800			
	[======] 115/800	-	0s	229us/step - loss: 0.0272
	[===========]	_	0s	230us/step - loss: 0.0272
Epoch	116/800			
	[======================================	-	0s	268us/step - loss: 0.0276
	117/800 [======]	_	0s	249us/step - loss: 0.0277
Epoch	118/800			-
	[======================================	-	0s	250us/step - loss: 0.0273
	119/800 [======]	_	0 s	238us/sten = loss: 0.0274
	120/800		0 D	23045/2009 1055: 0.02/1
	[=====]	-	0s	189us/step - loss: 0.0279
	121/800 [======]		۸c	215ug/gton logg. 0 0274
	122/800	_	US	213us/scep - 10ss. 0.02/4
	[=======]	_	0s	314us/step - loss: 0.0277
	123/800 [=======]		٥a	20799/9+09 1099 0 0272
	124/800	_	US	30/us/scep - 10ss: 0.02/2
24/24	[=======]	_	0s	287us/step - loss: 0.0273
	125/800		0 -	4000-7-1
	[======] 126/800	-	US	450us/scep - 10SS: 0.02//
24/24	[=======]	_	0s	239us/step - loss: 0.0273
	127/800		•	101/
	[======] 128/800	-	υs	191us/step - loss: 0.0273
просп	120,000			

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Epoch 129/800
Epoch 130/800
Epoch 131/800
Epoch 132/800
Epoch 133/800
Epoch 134/800
24/24 [============== ] - 0s 217us/step - loss: 0.0277
Epoch 135/800
24/24 [============== ] - 0s 186us/step - loss: 0.0273
Epoch 136/800
Epoch 137/800
Epoch 138/800
24/24 [=============== ] - 0s 215us/step - loss: 0.0272
Epoch 139/800
Epoch 140/800
Epoch 141/800
Epoch 142/800
24/24 [=============== ] - 0s 208us/step - loss: 0.0273
Epoch 143/800
Epoch 144/800
Epoch 145/800
24/24 [================ ] - 0s 342us/step - loss: 0.0274
Epoch 146/800
24/24 [============== ] - 0s 266us/step - loss: 0.0277
Epoch 147/800
Epoch 148/800
Epoch 149/800
Epoch 150/800
Epoch 151/800
Epoch 152/800
Epoch 153/800
Epoch 154/800
Epoch 155/800
Epoch 156/800
```

Epoch	157/800				
	[========]	_	0s	249us/step - loss: 0.027	6
	158/800				
	[======================================	-	0s	195us/step - loss: 0.027	3
	159/800 [=======]	_	۸e	194us/sten _ loss. 0 027	7 1
	160/800	_	VS	194us/scep - 10ss. 0.02/	1
	[========]	_	0s	201us/step - loss: 0.027	3
	161/800				
	[======================================	-	0s	241us/step - loss: 0.027	4
	162/800 [=======]	_	۸e	183us/sten = loss. 0 027	79
	163/800		0 D	10345, 5005	
	[======]	-	0s	197us/step - loss: 0.027	3
	164/800				
	[======] 165/800	-	0s	204us/step - loss: 0.027	4
	[=========]	_	0s	207us/step - loss: 0.027	7
Epoch	166/800			_	
	[======]	-	0s	183us/step - loss: 0.027	3
	167/800		0 -	102 /	7.0
	[======] 168/800	-	US	183us/step - loss: 0.02/	3
	[========]	_	0s	228us/step - loss: 0.027	8
Epoch	169/800			_	
	[======]	-	0s	196us/step - loss: 0.027	2
	170/800 [======]		٥٥	2/11/2/2+02 1022 0 027	1 2
	171/800	-	US	241us/scep - 10ss: 0.02/	3
	[========]	_	0s	242us/step - loss: 0.027	75
	172/800				
	[=========]	-	0s	220us/step - loss: 0.027	1
	173/800 [======]	_	0s	184us/step - loss: 0.027	7 1
	174/800		Ů.	10145, 500p 1055, 0102,	_
	[======]	-	0s	225us/step - loss: 0.027	3
_	175/800		0 -	217/	7 1
	[======] 176/800	-	US	31/us/step - loss: 0.02/	1
	[========]	_	0s	278us/step - loss: 0.027	2
Epoch	177/800				
	[========]	-	0s	298us/step - loss: 0.027	4
	178/800 [=======]		٥٥	321ug/g+on logg: 0 027	16
	179/800	_	VS	321us/scep - 10ss. 0.02/	U
	[========]	_	0s	330us/step - loss: 0.027	1
	180/800				
	[======================================	-	0s	637us/step - loss: 0.027	4
	181/800 [=======]	_	٥q	369us/sten = loss: 0.027	16
	182/800		Ů.	10001 0101	Ū
24/24	[======]	-	0s	598us/step - loss: 0.027	4
	183/800		0	41000/0465	7 ~
	[======] 184/800	-	US	419us/step - 10ss: 0.027	2
	[=========]	_	0s	317us/step - loss: 0.027	75
	185/800			-	

24/24	[======]	_	0s	329us/step - loss: 0.03	271
	186/800				
	[=======]	-	0s	563us/step - loss: 0.03	272
	187/800		•	435 / 1 3 0 0	276
	[======] 188/800	-	US	435us/step - loss: 0.0	2/6
	[========]	_	0 s	323us/sten = loss: 0.0	274
	189/800		0 D	223db/ beep 10bb. 0.0	_ , _
	[=======]	_	0s	448us/step - loss: 0.0	271
	190/800				
	[=======]	-	0s	495us/step - loss: 0.03	274
	191/800		•	262 / 1	
	[======] 192/800	-	0s	368us/step - loss: 0.03	270
	[========]	_	0 s	397115/sten = loss: 0.0	271
	193/800		OB	337 db/ bccp 10bb. 0.0	_ , _
	[=======]	_	0s	579us/step - loss: 0.02	272
Epoch	194/800				
	[======]	-	0s	333us/step - loss: 0.03	277
	195/800		•		
	[======================================	-	0s	299us/step - loss: 0.03	271
	196/800	_	۸e	35211g/g+an _ logg. 0 0	271
	197/800		V.S	332us/scep - 10ss. 0.0.	2/1
	[=========]	_	0s	273us/step - loss: 0.03	272
Epoch	198/800				
	[======]	-	0s	565us/step - loss: 0.03	276
	199/800				
	[=========]	-	0s	304us/step - loss: 0.03	275
_	200/800		٥٥	317ug/g+on logg. 0 0	771
	201/800		V.S	317ds/scep - 10ss. 0.0.	2/1
_	[=======]	_	0s	253us/step - loss: 0.03	272
	202/800			-	
	[======]	-	0s	357us/step - loss: 0.03	275
	203/800		•		271
	[======] 204/800	-	US	223us/step - loss: 0.0	2/1
-	[=======]	_	0s	289us/step = loss: 0.0	272
	205/800		0 D	20745/5005 1055. 0.07	- , -
	[======]	_	0s	225us/step - loss: 0.03	275
	206/800				
	[======]	-	0s	240us/step - loss: 0.03	272
	207/800		0 -	226/	272
	[======] 208/800	-	US	236us/step - loss: 0.0.	2/3
	[======]	_	0s	271us/step - loss: 0.0	276
	209/800		0.0		_, _
24/24	[======]	_	0s	321us/step - loss: 0.03	270
	210/800				
	[======]	-	0s	313us/step - loss: 0.03	270
	211/800		0~	27/115/5+05 1055 0 0	771
	[======] 212/800	-	US	2/4us/scep - 10ss: 0.0.	2 / I
	[=======]	_	0s	254us/step - loss: 0.03	274
	213/800				
	[======]	_	0s	308us/step - loss: 0.03	270

Epoch	214/800			
	[========]	_	0s	553us/step - loss: 0.0271
	215/800			
	[======================================	-	0s	342us/step - loss: 0.0272
	216/800 [======]		۸e	546us/sten _ loss• 0 0277
	217/800	_	US	340us/scep - 10ss. 0.02//
	[=========]	_	0s	343us/step - loss: 0.0275
	218/800			
	[=========]	-	0s	294us/step - loss: 0.0270
	219/800 [======]	_	۸e	255us/sten = loss. 0 0270
	220/800		0.D	23343/3669 - 1033: 0:02/0
	[=======]	_	0s	428us/step - loss: 0.0271
	221/800			
	[=========]	-	0s	312us/step - loss: 0.0273
	222/800 [======]	_	Λς	239us/sten = loss: 0.0277
	223/800		O D	203us, 200p 10551 0102, 7
	[======]	_	0s	361us/step - loss: 0.0270
	224/800		•	440 /
	[======] 225/800	-	0s	440us/step - loss: 0.02/2
	[========]	_	0s	270us/step - loss: 0.0274
Epoch	226/800			_
	[]	_	0s	406us/step - loss: 0.0271
	227/800 [======]		0~	204/
	228/800	_	US	204us/step - loss: 0.02/2
	[========]	_	0s	285us/step - loss: 0.0276
	229/800			
	[=======]	-	0s	539us/step - loss: 0.0269
	230/800 [======]	_	Λq	256us/sten = loss: 0.0269
	231/800		0 D	23045/2005
	[======]	_	0s	217us/step - loss: 0.0270
	232/800		•	000 / 1 0 000 4
	[=======] 233/800	_	US	2//us/step - loss: 0.02/4
	[========]	_	0s	280us/step - loss: 0.0271
Epoch	234/800			
	[=======]	_	0s	288us/step - loss: 0.0275
	235/800 [=======]		٥٥	201112/2+02 1022 0 0270
	236/800	_	US	201us/step - 10ss: 0.02/0
	[========]	_	0s	229us/step - loss: 0.0273
	237/800			
	[======================================	-	0s	208us/step - loss: 0.0275
	238/800 [=======]	_	۸e	171us/sten - loss 0 0269
	239/800		V.S	1/1d5/5ccp = 1055. 0.0207
24/24	[======]	_	0s	311us/step - loss: 0.0269
	240/800		_	
	[=======] 241/800	-	υs	238us/step - loss: 0.0270
	[===========]	_	0s	246us/step - loss: 0.0273
	242/800			

24/24	[=====]	_	0s	583us/step -	loss:	0.0278
	243/800		•	100 / 1	-	
	[======] 244/800	-	0s	490us/step -	loss:	0.0270
	[========]	_	0s	246us/step -	loss:	0.0271
Epoch	245/800			_		
	[=======]	-	0s	418us/step -	loss:	0.0274
	246/800 [=======]	_	۸e	661ug/gten _	1000	0 0271
	247/800		05	oolub/sccp -	1055.	0.0271
	[======]	-	0s	381us/step -	loss:	0.0271
	248/800 [=======]		0 -	620/	1	0 0070
	249/800	_	US	629us/step -	loss:	0.02/3
	[=======]	_	0s	291us/step -	loss:	0.0268
	250/800					
	[======] 251/800	-	0s	309us/step -	loss:	0.0269
	[===========]	_	0s	270us/step -	loss:	0.0269
Epoch	252/800			_		
	[======]	-	0s	259us/step -	loss:	0.0271
	253/800 [=======]		٥٥	2/911g/g+on	logg.	0 0273
	254/800	_	05	24ous/step -	1055:	0.02/3
	[=======]	_	0s	224us/step -	loss:	0.0279
	255/800				_	
	[======] 256/800	-	0s	293us/step -	loss:	0.0274
	[========]	_	0s	207us/step -	loss:	0.0269
Epoch	257/800					
	[======]	-	0s	196us/step -	loss:	0.0268
	258/800 [=======]	_	۸e	194119/sten -	1088.	0 0270
	259/800		0.5	174d5/500p -	1055.	0.0270
	[======]	-	0s	190us/step -	loss:	0.0272
	260/800 [=======]		٥٠	200119/9405	1000.	0 0270
	261/800	_	US	288us/step -	TOSS:	0.02/8
	[=======]	_	0s	223us/step -	loss:	0.0270
	262/800				-	
	[======] 263/800	-	0s	294us/step -	loss:	0.0271
	[=======]	_	0s	262us/step -	loss:	0.0274
Epoch	264/800					
	[========]	-	0s	265us/step -	loss:	0.0270
	265/800 [=======]	_	0s	252us/sten -	loss:	0.0271
	266/800		Ů.	23245, 5005	1000.	0.0271
	[=====]	-	0s	217us/step -	loss:	0.0273
	267/800 [=======]		٥٥	195118/8+05	logge	0 0260
	268/800	_	US	193us/step -	TO22;	0.0209
24/24	[======]	_	0s	195us/step -	loss:	0.0270
	269/800		0	0.21 / :	,	0 0071
	[======] 270/800	-	US	231us/step -	TOSS:	0.0271
	[========]	_	0s	206us/step -	loss:	0.0272
-				-		

Epoch	271/800			
	[=========]	_	0s	283us/step - loss: 0.0271
	272/800			
	[========]	-	0s	240us/step - loss: 0.0269
	273/800 [======]	_	۸e	213us/sten _ loss• 0 0269
	274/800	_	US	213us/scep - 10ss. 0.0209
	[=========]	_	0s	211us/step - loss: 0.0271
	275/800			
	[======]	-	0s	223us/step - loss: 0.0274
	276/800 [======]		۸c	238us/sten loss: 0 0270
	277/800	_	US	230us/scep - 10ss. 0.02/0
	[=========]	_	0s	240us/step - loss: 0.0272
	278/800			
	[=======]	-	0s	204us/step - loss: 0.0275
	279/800 [======]	_	۸e	285115/sten _ loss. 0 0270
	280/800		0.5	203us/step = 10ss. 0.02/0
	[======]	_	0s	269us/step - loss: 0.0271
	281/800			
	[======] 282/800	_	0s	195us/step - loss: 0.02/3
	[==========]	_	0s	220us/step - loss: 0.0269
	283/800		• •	
	[======]	_	0s	209us/step - loss: 0.0270
	284/800		•	004 / 1 0 0070
	[======] 285/800	_	US	234us/step - loss: 0.02/3
	[========]	_	0s	248us/step - loss: 0.0270
Epoch	286/800			
	[======]	_	0s	250us/step - loss: 0.0273
	287/800 [=======]		٥٥	230us/ston loss: 0.0270
	288/800	_	US	239us/scep - 10ss. 0.02/0
	[=========]	_	0s	276us/step - loss: 0.0270
	289/800			
	[=======] 290/800	-	0s	233us/step - loss: 0.0268
	[==========]	_	0s	240us/step = loss: 0.0269
	291/800		0.5	21005, 5005 10551 010203
	[=======]	_	0s	295us/step - loss: 0.0271
	292/800		•	056 / 1 2 0 0055
	[======] 293/800	-	0s	256us/step - loss: 0.02/5
	[=========]	_	0s	296us/step - loss: 0.0269
Epoch	294/800			
	[======]	-	0s	241us/step - loss: 0.0271
	295/800 [========]		٥٩	19799/9409 1099 0 0274
	[=====================================	_	US	18/us/step - 10ss: 0.02/4
	[========]	_	0s	210us/step - loss: 0.0271
Epoch	297/800			
	[=========]	-	0s	391us/step - loss: 0.0268
	298/800 [=======]	_	0 =	262us/sten = loss. 0 0272
	299/800	_	U D	20245/500p - 1055. 0.02/2
-				

	[======]	_	0s	330us/step	_	loss:	0.0267
	300/800	_	0s	219us/step	_	loss:	0.0268
Epoch	301/800						
	[======] 302/800	-	0s	279us/step	-	loss:	0.0268
24/24	[======]	-	0s	217us/step	-	loss:	0.0269
	303/800	_	0s	25911s/step	_	loss:	0.0270
Epoch	304/800			_			
	[======] 305/800	-	0s	245us/step	-	loss:	0.0275
24/24	[======]	_	0s	243us/step	_	loss:	0.0269
	306/800		۸c	268ug/gton		loss.	0 0270
Epoch	307/800						
	[==========]	-	0s	261us/step	-	loss:	0.0274
	308/800 [==========]	_	0s	208us/step	_	loss:	0.0270
Epoch	309/800						
	[======] 310/800	_	0s	182us/step	_	loss:	0.0269
24/24	[======]	_	0s	202us/step	-	loss:	0.0271
	311/800 [=========]	_	0s	217us/step	_	loss:	0.0270
Epoch	312/800			_			
	[======] 313/800	-	0s	321us/step	-	loss:	0.0273
24/24	[======]	_	0s	260us/step	_	loss:	0.0269
	314/800 [=========]		۸c	200ug/g+op		logge	0 0271
Epoch	315/800						
	[======] 316/800	-	0s	278us/step	-	loss:	0.0274
	[==========]	_	0s	291us/step	_	loss:	0.0270
Epoch	317/800						
	[======] 318/800	_	US	255us/step	_	loss:	0.02/1
	[======]	-	0s	239us/step	-	loss:	0.0274
	319/800 [=========]	_	0s	220us/step	_	loss:	0.0269
Epoch	320/800						
	[======] 321/800	_	0s	198us/step	-	loss:	0.0270
24/24	[======]	_	0s	275us/step	-	loss:	0.0272
	322/800 [=======]	_	0s	190us/step	_	loss:	0.0268
Epoch	323/800						
	[======] 324/800	-	0s	255us/step	-	loss:	0.0268
24/24	[======]	_	0s	255us/step	_	loss:	0.0272
	325/800 [======]		Ωc	220112/2+05		logg•	0 0260
Epoch	326/800						
	[======================================	-	0s	252us/step	-	loss:	0.0272
	327/800 [=======]	_	0s	265us/step	_	loss:	0.0268
	•			-			

Epoch	328/800				
	[======]	-	0s	244us/step - loss:	0.0270
_	329/800 [======]		٥٩	276 yg /gtop logg.	0 0271
	330/800	_	US	2/ous/step - loss:	0.02/1
	[========]	_	0s	212us/step - loss:	0.0268
	331/800				
	[======] 332/800	_	0s	188us/step - loss:	0.0269
	[=========]	_	0s	213us/step - loss:	0.0274
Epoch	333/800				
	[======================================	-	0s	249us/step - loss:	0.0267
	334/800 [=======]	_	0s	291us/step - loss:	0.0268
Epoch	335/800				
	[======]	-	0s	271us/step - loss:	0.0270
	336/800 [======]		۸c	407us/sten loss.	0 0268
	337/800	_	US	40/us/scep - 10ss.	0.0200
24/24	[======]	-	0s	288us/step - loss:	0.0267
	338/800		0 ~	202/=+ 1	0 0072
	[======] 339/800	-	US	303us/step - loss:	0.02/3
	[========]	_	0s	292us/step - loss:	0.0268
	340/800				
	[======] 341/800	-	0s	222us/step - loss:	0.0270
	[==========]	_	0s	220us/step - loss:	0.0267
Epoch	342/800				
	[======================================	-	0s	287us/step - loss:	0.0269
	343/800 [=======]	_	0s	261us/step - loss:	0.0273
Epoch	344/800				
	[======================================	-	0s	252us/step - loss:	0.0269
-	345/800 [=======]	_	0s	187us/step = loss:	0.0269
	346/800			10, us, stop 1022 t	000203
	[======================================	-	0s	256us/step - loss:	0.0273
	347/800 [=======]	_	۸e	215us/sten - loss.	0 0268
	348/800		05	213u3/3ccp - 1033.	0.0200
	[=======]	-	0s	224us/step - loss:	0.0275
	349/800 [========]		٥٥	207ug/g+on logg.	0 0273
	350/800	_	US	20/us/step - 10ss:	0.0273
24/24	[======]	-	0s	261us/step - loss:	0.0268
	351/800		0 ~	274	0 0067
	[======] 352/800	-	US	2/4us/step - loss:	0.0267
	[=======]	-	0s	206us/step - loss:	0.0270
	353/800		•	265 / 1	0 0067
	[======] 354/800	-	US	265us/step - loss:	0.0267
	[=========]	_	0s	219us/step - loss:	0.0269
Epoch	355/800				
	[======] 356/800	-	0s	243us/step - loss:	0.0268
просп	330,000				

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Epoch 357/800
24/24 [=============== ] - 0s 176us/step - loss: 0.0268
Epoch 358/800
Epoch 359/800
Epoch 360/800
Epoch 361/800
Epoch 362/800
24/24 [============== ] - 0s 317us/step - loss: 0.0269
Epoch 363/800
24/24 [============== ] - 0s 180us/step - loss: 0.0267
Epoch 364/800
Epoch 365/800
24/24 [=============== ] - 0s 231us/step - loss: 0.0269
Epoch 366/800
24/24 [=============== ] - 0s 204us/step - loss: 0.0273
Epoch 367/800
Epoch 368/800
Epoch 369/800
Epoch 370/800
Epoch 371/800
Epoch 372/800
24/24 [=============== ] - 0s 201us/step - loss: 0.0268
Epoch 373/800
Epoch 374/800
24/24 [============ ] - 0s 259us/step - loss: 0.0269
Epoch 375/800
Epoch 376/800
Epoch 377/800
Epoch 378/800
Epoch 379/800
Epoch 380/800
Epoch 381/800
Epoch 382/800
Epoch 383/800
Epoch 384/800
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Epoch	385/800				
	[========]	-	0s	173us/step - loss:	0.0265
	386/800				
	[========] 387/800	-	0s	232us/step - loss:	0.0265
	[=========]	ı –	0s	260us/step - loss:	0.0270
Epoch	388/800			_	
	[======================================	-	0s	314us/step - loss:	0.0267
	389/800 [=======]	ı _	0s	200us/step - loss:	0.0267
Epoch	390/800			_	
	[========]	-	0s	188us/step - loss:	0.0270
	391/800 [=======]	ı _	0s	223us/sten - loss:	0.0269
Epoch	392/800			_	
	[======]	–	0s	228us/step - loss:	0.0273
	393/800 [=======]	ı _	Λα	23411g/gton - logg.	0 0267
	394/800		0 D	234d3/5ccp - 1055.	0.0207
	[=======]	–	0s	238us/step - loss:	0.0267
	395/800 [========]	ı _	Λα	23611g/gton - logg.	0 0272
	396/800		0 D	230d3/5ccp - 1055.	0.0272
	[======]	-	0s	185us/step - loss:	0.0268
	397/800 [=======]	ı _	Λα	21111g/gton _ logg.	0 0266
	398/800	-	VS	211us/scep - 10ss.	0.0200
	[======]	-	0s	201us/step - loss:	0.0270
	399/800 [=======]		۸c	223ug/gton logg.	0 0267
	400/800	_	US	223us/scep - 10ss.	0.0207
	[=========]	-	0s	194us/step - loss:	0.0267
	401/800 [===================================	ı _	Λα	28811g/gton _ logg.	0 0268
	402/800	-	VS	20003/Scep - 1055.	0.0200
	[======]	-	0s	220us/step - loss:	0.0273
_	403/800 [========]		Λe	19911g/sten - loss.	0 0268
	404/800		0 D	1990878009 1008.	0.0200
	[========]	-	0s	218us/step - loss:	0.0268
	405/800 [===================================	ı _	Ωs	173us/sten - loss:	0.0269
	406/800		0 D	1730575000	0.0203
	[========]	-	0s	328us/step - loss:	0.0271
	407/800 [===================================	ı _	Ωs	228us/sten = loss:	0.0272
	408/800		0 D	220d5/5ccp = 1055.	0.0272
	[======]	-	0s	228us/step - loss:	0.0266
	409/800 [===================================	ı	۸c	2/2ug/gton logg.	0 0267
	410/800	_	US	242us/scep - 10ss.	0.0207
24/24	[=======]	-	0s	351us/step - loss:	0.0272
	411/800 [=========]	l .	Λe	265118/stan - loss.	በ በ26ዩ
Epoch	412/800				
	[======]	-	0s	299us/step - loss:	0.0268
Epoch	413/800				

24/24	[=====]	_	0s	310us/step - los	ss:	0.0266
	414/800 [=======]		0 ~	26429/9409		0 0265
	415/800	_	US	204us/step - 108	55:	0.0265
24/24	[======]	_	0s	188us/step - los	ss:	0.0266
	416/800		٥٩	25/112/2500 100		0 0260
	417/800	_	US	254us/step - 10s	55:	0.0208
24/24	[======]	_	0s	295us/step - los	ss:	0.0267
	418/800 [=========]		٥٩	27799/9509		0 0260
	419/800	_	US	z//us/step = 10s	55:	0.0269
24/24	[======]	_	0s	212us/step - los	ss:	0.0271
	420/800 [=======]		٥٥	202ug/g+op log		0 0267
	421/800	_	05	202us/scep - 10	55:	0.0207
24/24	[======]	-	0s	289us/step - los	ss:	0.0270
	422/800 [=======]		Λα	286ug/g+on log	cc•	0 0275
	423/800	_	US	200us/scep - 10	55.	0.0273
	[======]	_	0s	267us/step - los	ss:	0.0266
	424/800 [=======]	_	Λe	203us/sten - los	cc•	0 0267
	425/800		V.S	203us/scep - 10.	55.	0.0207
	[======]	-	0s	242us/step - los	ss:	0.0270
	426/800 [=======]	_	Λς	30311s/sten = 109	cc•	0 0266
Epoch	427/800					
	[======]	-	0s	484us/step - los	ss:	0.0266
	428/800 [=======]	_	٥g	24311s/sten = los	55:	0.0270
Epoch	429/800					
	[======]	-	0s	344us/step - los	ss:	0.0266
	430/800	_	0s	304us/step - los	ss:	0.0266
Epoch	431/800			_		
	[=========]	-	0s	383us/step - los	ss:	0.0266
	432/800 [=======]	_	0s	388us/step - los	ss:	0.0266
Epoch	433/800					
	[=======] 434/800	-	0s	350us/step - los	ss:	0.0268
	[=========]	_	0s	357us/step - los	ss:	0.0273
Epoch	435/800					
	[=======] 436/800	-	0s	387us/step - los	ss:	0.0270
	[========]	_	0s	495us/step - los	ss:	0.0265
	437/800		•	261 / 1		0 0060
	[=======] 438/800	-	0s	361us/step - los	ss:	0.0268
24/24	[======]	_	0s	797us/step - los	ss:	0.0272
	439/800		0 =	441.00/5555	a .c.	0.0266
	[======] 440/800	-	υS	441us/step - los	5 5 :	0.0266
24/24	[======]	_	0s	328us/step - los	ss:	0.0265
	441/800 [=========]		0~	220ug/g+op 1	c c -	0 0260
24/24	[]	-	บร	Jous/step - 109	55:	0.0208

Epoch	442/800				
	[========]	_	0s	270us/step - loss: 0.02	66
	443/800				
	[======] 444/800	-	0s	192us/step - loss: 0.02	66
	[======================================	_	0s	197us/step - loss: 0.02	68
Epoch	445/800				
	[=======]	-	0s	262us/step - loss: 0.02	67
	446/800 [=======]	_	۸e	250us/sten = loss. 0 02	69
	447/800		V D	2304375669 - 1055: 0:02	0,5
	[=======]	-	0s	239us/step - loss: 0.02	64
	448/800 [=======]		٥٩	102::2/2+05 1022.0.02	<i>c</i> 1
	449/800	_	US	193us/step - 10ss: 0.02	04
	[=======]	-	0s	229us/step - loss: 0.02	64
	450/800		•		
	[======] 451/800	-	0s	333us/step - loss: 0.02	68
	[========]	_	0s	250us/step - loss: 0.02	68
	452/800				
	[======] 453/800	-	0s	279us/step - loss: 0.02	74
	[==========]	_	0s	250us/step - loss: 0.02	67
Epoch	454/800			_	
	[======================================	-	0s	367us/step - loss: 0.02	68
	455/800 [=========]	_	0s	361us/step - loss: 0.02	69
Epoch	456/800				
	[=======]	-	0s	477us/step - loss: 0.02	65
	457/800 [========]	_	0s	241us/step = loss: 0.02	65
Epoch	458/800				
	[======]	-	0s	307us/step - loss: 0.02	68
	459/800 [=======]		۸c	452us/sten loss: 0 02	61
	460/800		VS	432u3/3cep - 1033: 0:02	04
	[=======]	-	0s	367us/step - loss: 0.02	68
	461/800 [========]		٥a	20019/3409 1033 0 02	67
	462/800	_	US	300us/step - 10ss: 0.02	0 /
24/24	[======]	_	0s	421us/step - loss: 0.02	69
	463/800		0 -	240/	6 -
	[======] 464/800	-	US	248us/step - loss: 0.02	65
	[========]	_	0s	295us/step - loss: 0.02	66
	465/800				
	[=======] 466/800	-	0s	274us/step - loss: 0.02	68
	[========]	_	0s	273us/step - loss: 0.02	70
	467/800			_	
	[=======] 468/800	-	0s	392us/step - loss: 0.02	69
	[===========]	_	0s	241us/step - loss: 0.02	65
Epoch	469/800				
	[=========]	-	0s	273us/step - loss: 0.02	63
гьоси	470/800				

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Epoch 471/800
Epoch 472/800
Epoch 473/800
24/24 [=============== ] - 0s 339us/step - loss: 0.0264
Epoch 474/800
Epoch 475/800
Epoch 476/800
Epoch 477/800
24/24 [============== ] - 0s 253us/step - loss: 0.0267
Epoch 478/800
Epoch 479/800
24/24 [============== ] - 0s 214us/step - loss: 0.0265
Epoch 480/800
24/24 [=============== ] - 0s 191us/step - loss: 0.0268
Epoch 481/800
Epoch 482/800
Epoch 483/800
Epoch 484/800
Epoch 485/800
Epoch 486/800
Epoch 487/800
Epoch 488/800
24/24 [============== ] - 0s 385us/step - loss: 0.0270
Epoch 489/800
Epoch 490/800
24/24 [=============== ] - 0s 274us/step - loss: 0.0264
Epoch 491/800
24/24 [============== ] - 0s 244us/step - loss: 0.0264
Epoch 492/800
Epoch 493/800
24/24 [=============== ] - 0s 254us/step - loss: 0.0264
Epoch 494/800
Epoch 495/800
Epoch 496/800
Epoch 497/800
Epoch 498/800
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Epoch	499/800				
	[========]	-	0s	218us/step - loss: 0.026	67
	500/800				
	[========] 501/800	–	0s	180us/step - loss: 0.020	63
	[==========]	ı –	0s	233us/step - loss: 0.026	64
Epoch	502/800			_	
	[=======]	–	0s	206us/step - loss: 0.026	66
	503/800 [========]		۸e	214us/sten = loss 0 026	64
	504/800	_	0.5	214us/sccp = 10ss. 0.020	0 1
	[========]	-	0s	263us/step - loss: 0.026	66
	505/800 [=========]	ı	٥a	21949/9409 1099 0 029	c c
	506/800	_	05	210us/step - 10ss: 0.020	00
	[========]	-	0s	244us/step - loss: 0.02	72
	507/800		•		<i>-</i> -
	[=====================================	-	0s	316us/step - loss: 0.026	65
	[=========]	ı –	0s	252us/step - loss: 0.020	67
	509/800				
	[========] 510/800	–	0s	235us/step - loss: 0.026	69
	[==========]	ı –	0s	231us/step - loss: 0.020	65
Epoch	511/800			_	
	[======================================	–	0s	206us/step - loss: 0.020	64
	512/800 [=======]	ı –	0s	231us/step - loss: 0.026	67
Epoch	513/800			_	
	[========]	-	0s	208us/step - loss: 0.020	63
	514/800 [===================================	ı _	0 s	215us/step = loss: 0.026	63
	515/800	l	0 D	21348/8009 1088. 0.020	00
	[======]	-	0s	192us/step - loss: 0.020	65
	516/800 [========]	ı	۸c	2/2us/sten loss 0 02/	65
	517/800	_	US	242us/scep - 10ss. 0.020	0.5
	[========]	-	0s	247us/step - loss: 0.026	69
	518/800 [===================================	ı	٥a	107ug/gton logg. 0 024	6 E
	519/800	_	05	19/us/step - 10ss: 0.020	00
24/24	[=======]	-	0s	208us/step - loss: 0.020	65
	520/800		0 -	214/	
	[========] 521/800	-	US	214us/step - loss: 0.026	00
	[=========]	–	0s	248us/step - loss: 0.026	64
	522/800				- -
	[========] 523/800	–	0s	214us/step - loss: 0.020	67
	[=========]	l –	0s	244us/step - loss: 0.026	63
	524/800			_	
	[========] 525/800	-	0s	210us/step - loss: 0.020	65
	[==========]	l –	0s	268us/step - loss: 0.026	69
Epoch	526/800				
	[======================================	-	0s	252us/step - loss: 0.020	68
гьоси	527/800				

24/24	[======]	_	0s	252us/step - loss:	0.0263
Epoch	528/800				
	[======]	-	0s	242us/step - loss:	0.0264
	529/800		•	054 / 1	
	[======] 530/800	-	0s	254us/step - loss:	0.0265
	[==========]		۸e	23211g/gton - logg.	0 0272
	531/800		V.S	232us/scep - 10ss.	0.0272
	[=========]	_	0s	227us/step - loss:	0.0266
Epoch	532/800				
	[======]	-	0s	223us/step - loss:	0.0262
	533/800				
	[=======]	-	0s	214us/step - loss:	0.0265
	534/800 [==========]		0 a	251ug/g+on logg.	0 0265
	535/800	_	US	251us/step - 10ss:	0.0203
	[========]	_	0s	252us/step - loss:	0.0269
	536/800		0.0	10145/200P 1025	00000
24/24	[======]	_	0s	369us/step - loss:	0.0271
	537/800				
	[=====]	-	0s	423us/step - loss:	0.0265
	538/800				
	[=========]	-	0s	688us/step - loss:	0.0265
	539/800 [==========]		Λc	520ug/gton logg.	0 0262
	540/800	_	US	J20us/scep - 10ss.	0.0202
	[========]	_	0s	493us/step - loss:	0.0266
	541/800			1	
24/24	[======]	_	0s	414us/step - loss:	0.0262
	542/800				
	[======]	-	0s	348us/step - loss:	0.0264
_	543/800		0 ~	21000/0400 1000	0 0267
	[=======] 544/800	_	US	310us/step - 10ss:	0.0267
_	[========]	_	0s	329us/step - loss:	0.0264
	545/800		0.0		000201
24/24	[======]	_	0s	285us/step - loss:	0.0263
_	546/800				
	[========]	-	0s	316us/step - loss:	0.0265
	547/800		0	206 / 1	0 0064
	[======] 548/800	-	US	206us/step - loss:	0.0264
	[========]	_	0s	261us/step = loss:	0.0266
	549/800		Ů.	20100/2009 1000	0.0200
	[=======]	_	0s	226us/step - loss:	0.0262
Epoch	550/800				
	[======]	-	0s	237us/step - loss:	0.0267
	551/800				
	[=========]	-	0s	199us/step - loss:	0.0272
	552/800 [========]		Λe	32211g/gton - logg.	0 0270
	553/800		US	322us/scep - 10ss.	0.0270
	[========]	_	0s	264us/step - loss:	0.0265
Epoch	554/800				
	[======]	-	0s	282us/step - loss:	0.0270
	555/800		•	200 / : -	
24/24	[======]	-	0s	320us/step - loss:	0.0264

Epoch	556/800				
	[========]	_	0s	311us/step - loss: 0.	.0262
	557/800				
	[========]	-	0s	387us/step - loss: 0.	.0266
	558/800 [=======]		۸e	411us/sten _ loss. 0	0269
	559/800		V S	411us/scep - 10ss. 0.	.0203
	[=========]	_	0s	563us/step - loss: 0.	.0264
	560/800				
	[=========]	-	0s	423us/step - loss: 0.	.0263
	561/800 [======]	_	۸e	381us/sten = loss. 0	0265
	562/800		0.D	301us/scep = 10ss. 0.	.0203
	[======]	_	0s	406us/step - loss: 0.	.0263
	563/800				
	[======] 564/800	-	0s	288us/step - loss: 0.	.0262
	[==========]	_	0s	351us/step = loss: 0.	.0266
	565/800		• •		
	[]	_	0s	434us/step - loss: 0.	0262
	566/800		0 -	470 /	0060
	[======] 567/800	-	US	4/9us/step - loss: 0.	.0263
	[========]	_	0s	467us/step - loss: 0.	.0266
Epoch	568/800			_	
	[======]	_	0s	275us/step - loss: 0.	.0264
	569/800 [=======]		٥٥	266ug/g+on logg. 0	0267
	570/800	_	US	200us/step - 10ss: 0.	.0207
	[========]	_	0s	301us/step - loss: 0.	.0262
	571/800				
	[======] 572/800	-	0s	287us/step - loss: 0.	.0263
	[==========]	_	0s	201us/step - loss: 0.	.0267
Epoch	573/800			_	
	[]	-	0s	187us/step - loss: 0.	.0264
	574/800 [=======]		٥٩	107ug/gton logg. 0	0260
	575/800	_	US	18/us/step - 10ss: 0.	.0208
	[========]	_	0s	210us/step - loss: 0.	.0268
Epoch	576/800				
	[=========]	-	0s	193us/step - loss: 0.	.0269
	577/800 [=======]	_	Λq	201us/sten = loss: 0.	.0263
	578/800		V.S	201db/bccp - 10bb. 07	.0203
	[======]	_	0s	184us/step - loss: 0.	.0265
	579/800				
	[=======] 580/800	-	0s	211us/step - loss: 0.	.0267
	[=========]	_	0s	225us/step - loss: 0.	.0264
Epoch	581/800				
	[=====]	-	0s	315us/step - loss: 0.	.0262
	582/800		0 -	271,19 / g + op 1 0	0267
	[======] 583/800	-	US	Z/IUS/Step - IOSS: 0	.026/
	[=======]	_	0s	205us/step - loss: 0.	.0263
	584/800				

24/24	[======]	_	0s	250us/step - loss:	0.0264
	585/800				
	[======]	-	0s	191us/step - loss:	0.0265
	586/800		0 -	202/	0 0065
	[======] 587/800	-	US	292us/step - loss:	0.0265
	[========]	_	0 s	24111s/sten - loss:	0.0265
	588/800		O D	21146/5666 1055.	0.0203
	[=======]	_	0s	227us/step - loss:	0.0261
	589/800				
	[=====]	-	0s	173us/step - loss:	0.0261
	590/800		•		0 0060
	[======] 591/800	-	0s	214us/step - loss:	0.0263
	[==========]	_	0 s	201us/sten - loss:	0.0265
	592/800		UD	20100/5000	0.0203
	[========]	_	0s	194us/step - loss:	0.0260
Epoch	593/800				
	[======]	-	0s	203us/step - loss:	0.0263
	594/800		•	0.60 / 1	0 0051
	[=======] 595/800	-	0s	263us/step - loss:	0.0271
	[======================================	_	۸e	25411g/gton - logg.	0 0263
	596/800	_	V.S	254us/scep - 10ss.	0.0203
	[========]	_	0s	321us/step - loss:	0.0265
Epoch	597/800				
	[======]	-	0s	285us/step - loss:	0.0265
	598/800				
	[=========]	-	0s	287us/step - loss:	0.0262
	599/800 [=======]		٥٥	210ug/gton logg.	0 0262
	600/800	_	V.S	217us/scep - 10ss.	0.0202
_	[========]	_	0s	253us/step - loss:	0.0264
	601/800			-	
	[======]	-	0s	205us/step - loss:	0.0267
	602/800		•	000 / 1 3	0 0060
	[======] 603/800	-	0s	230us/step - loss:	0.0263
_	[========]	_	0 s	230us/sten - loss:	0.0264
	604/800		O D	2304676666 1055.	0.0201
	[========]	_	0s	233us/step - loss:	0.0272
Epoch	605/800				
	[=====]	-	0s	232us/step - loss:	0.0264
	606/800		•	0.65 /	
	[=========]	-	0s	26/us/step - loss:	0.0266
	607/800 [========]	_	۸e	26211g/gton - logg.	0 0262
	608/800	_	V.S	202us/scep - 10ss.	0.0202
	[========]	_	0s	302us/step - loss:	0.0264
Epoch	609/800				
	[======]	-	0s	231us/step - loss:	0.0266
	610/800				
	[=========]	-	0s	302us/step - loss:	0.0262
	611/800 [=======]		٥٥	253ug/g+on logg:	0 0262
	612/800	_	US	255us/step - 1088:	0.0203
	[========]	_	0s	365us/step - loss:	0.0267
·					/

Epoch	613/800				
	[========]	_	0s	347us/step - loss: 0.0262	2
	614/800				
	[========]	-	0s	324us/step - loss: 0.026	1
	615/800 [=======]	_	Λς	380us/sten = loss: 0.026	<u>.</u>
	616/800		V.S	300us/ sccp = 10ss. 0.020	,
	[=======]	_	0s	503us/step - loss: 0.026	1
	617/800				
	[======] 618/800	-	0s	377us/step - loss: 0.026	1
	[==========]	_	0s	534us/step = loss: 0.026	5
	619/800		• •		
	[========]	_	0s	352us/step - loss: 0.0268	3
	620/800		•	216 / 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	4
	[======] 621/800	_	US	316us/step - 10ss: 0.0264	±
	[=======]	_	0s	340us/step - loss: 0.026	1
Epoch	622/800			_	
	[======]	_	0s	267us/step - loss: 0.026	5
	623/800 [======]		Λc	33/us/step loss 0 026	1
	624/800	_	US	334us/scep - 10ss. 0.020.	L
	[=======]	_	0s	232us/step - loss: 0.026	l
	625/800				_
	[======] 626/800	-	0s	245us/step - loss: 0.0260)
	[==========]	_	0s	349us/step - loss: 0.0262	2
Epoch	627/800			_	
	[=====]	-	0s	190us/step - loss: 0.026	7
	628/800 [======]		۸a	25/ug/gton logg. 0 026	2
	629/800	_	US	254us/step - 10ss: 0.020.)
	[========]	_	0s	306us/step - loss: 0.026	5
	630/800				
	[======] 631/800	-	0s	258us/step - loss: 0.0268	3
_	[=========]	_	0s	322us/step - loss: 0.0262	2
Epoch	632/800				
	[======]	-	0s	297us/step - loss: 0.026	5
	633/800 [========]		٥٥	22229/9409 1099 0 026	1
	634/800	_	US	232us/step - 10ss: 0.020	±
	[========]	_	0s	428us/step - loss: 0.026	1
	635/800				
	[======] 636/800	_	0s	362us/step - loss: 0.026	L
	[=========]	_	0s	341us/step - loss: 0.026	5
Epoch	637/800				
	[======]	_	0s	384us/step - loss: 0.026	L
	638/800 [=======]		٥٥	453ug/gtop logg: 0 026	1
	639/800	_	υÞ	1055: 0.020	_
24/24	[======]	_	0s	420us/step - loss: 0.026	1
	640/800		_	486	_
	[======] 641/800	-	0s	4/6us/step - loss: 0.0260	J
просп	041/000				

24/24	[=====]	_	0s	334us/step - loss:	0.0261
	642/800		0 ~	427ug/gton logg.	0 0265
	[======] 643/800	_	US	42/us/step - loss:	0.0265
	[======]	_	0s	448us/step - loss:	0.0266
	644/800		0	200 / 1	0 0071
	[======] 645/800	-	0s	292us/step - loss:	0.02/1
	[=======]	_	0s	305us/step - loss:	0.0261
	646/800		0	252 / 1	0.0063
	[======] 647/800	_	US	353us/step - loss:	0.0263
	[=======]	_	0s	597us/step - loss:	0.0266
	648/800		0 -	215/	0 0060
	[======] 649/800	-	0s	315us/step - loss:	0.0262
	[=======]	_	0s	288us/step - loss:	0.0262
	650/800		•		0 0066
	[======] 651/800	-	0s	331us/step - loss:	0.0266
	[========]	_	0s	273us/step - loss:	0.0261
	652/800		•	255 /	0 0066
	[======] 653/800	-	0s	37/us/step - loss:	0.0266
	[=======]	_	0s	243us/step - loss:	0.0265
	654/800		•	456 / 1	0 0000
	[======] 655/800	-	0s	4/6us/step - loss:	0.0262
	[=======]	_	0s	252us/step - loss:	0.0261
	656/800		•		0 0065
	[======] 657/800	-	0s	282us/step - loss:	0.0265
	[=======]	_	0s	249us/step - loss:	0.0264
	658/800		0 -	100/	0 0060
	[======] 659/800	_	US	182us/step - 10ss:	0.0268
	[======]	_	0s	196us/step - loss:	0.0262
	660/800 [=======]		٥٠	22224/4+09 1044	0 0262
	661/800	_	US	223us/step - 10ss:	0.0263
24/24	[======]	_	0s	218us/step - loss:	0.0259
	662/800 [=======]		٥٥	20/ug/g+on logg.	0 0261
	663/800	_	US	204us/step - 10ss:	0.0201
	[======]	-	0s	221us/step - loss:	0.0263
	664/800 [=======]		٥٥	220ug/g+on logg.	0 0262
	665/800	_	US	220us/step - 10ss:	0.0202
24/24	[======]	-	0s	345us/step - loss:	0.0265
	666/800 [=======]		٥٥	200ug/g+op logg.	0 0262
	667/800	_	UB	200us/scep - 10ss:	0.0202
24/24	[======]	_	0s	183us/step - loss:	0.0263
	668/800 [=======]	_	Λc	17111g/gten = logg.	0.0267
	669/800	_	va	1,105/5ceb - 1055:	0.0207
24/24	[=====]	-	0s	210us/step - loss:	0.0261

Epoch	670/800				
	[========]	_	0s	230us/step - loss: 0.0	0260
	671/800				
	[========]	-	0s	205us/step - loss: 0.0	0263
	672/800 [======]	_	۸c	283us/sten = loss. 0 (1261
	673/800		V.S	20343/3669 - 1033: 0.0	7201
	[=======]	_	0s	221us/step - loss: 0.0	0264
	674/800				
	[======] 675/800	-	0s	197us/step - loss: 0.0	0270
	[==========]	_	0s	276us/step = loss: 0.0	1263
	676/800		• •	2,002,200p 2022; 000	
	[========]	_	0s	237us/step - loss: 0.0	0260
	677/800		•	100 / 1 2 2	2050
	[======] 678/800	_	US	198us/step - 10ss: 0.0	1259
	[=======]	_	0s	212us/step - loss: 0.0	0266
Epoch	679/800			_	
	[======]	_	0s	170us/step - loss: 0.0	0260
	680/800 [======]		Λc	172us/sten loss. 0 (1260
	681/800	_	US	1/2us/scep - 10ss. 0.0	7200
	[=======]	_	0s	244us/step - loss: 0.0	0262
	682/800			,	
	[======] 683/800	-	0s	277us/step - loss: 0.0	0261
	[==========]	_	0s	214us/step - loss: 0.0	0264
Epoch	684/800			_	
	[=====]	-	0s	270us/step - loss: 0.0	0260
	685/800 [=======]		٥٥	225ug/gton logg. 0 (1262
	[] 686/800	_	US	223us/step - 10ss: 0.0	1203
	[========]	_	0s	233us/step - loss: 0.0	0265
	687/800				
	[======] 688/800	-	0s	26lus/step - loss: 0.0	0260
	[=========]	_	0s	304us/step - loss: 0.0	0266
Epoch	689/800				
	[======]	-	0s	241us/step - loss: 0.0	0265
	690/800 [=======]		۸a	229ug/gton logg. 0 (1262
	[] 691/800	_	US	320us/step - 10ss: 0.0	1202
	[========]	_	0s	230us/step - loss: 0.0	0262
	692/800				
	[======] 693/800	-	0s	20/us/step - loss: 0.0)263
	[========]	_	0s	359us/step - loss: 0.0	0260
Epoch	694/800				
	[======]	-	0s	266us/step - loss: 0.0	0264
	695/800 [=======]		٥٥	272ug/gton logg. 0 (1250
	[] 696/800	_	υÞ	2/2us/scep - 10ss: 0.0	1433
24/24	[======]	_	0s	337us/step - loss: 0.0	0260
	697/800		_	001	
	[======] 698/800	-	0s	281us/step - loss: 0.0	1263
просп	0,50,7000				

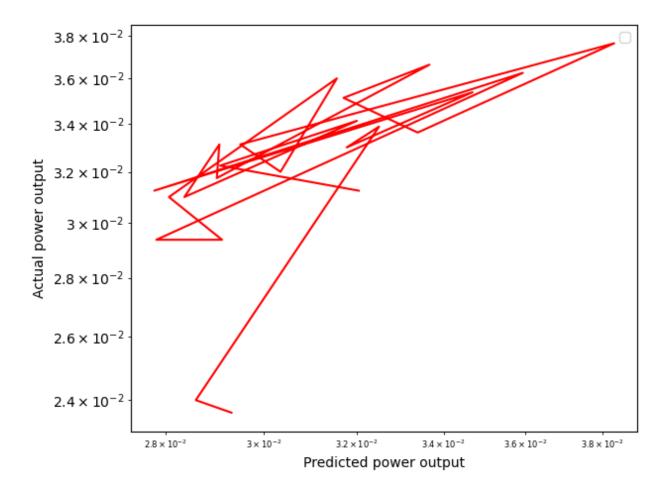
	[=====]	_	0s	251us/step -	loss:	0.0267
	699/800 [=======]	_	0s	296us/step -	· loss:	0.0264
Epoch	700/800					
	[======] 701/800	-	0s	286us/step -	loss:	0.0261
	[========]	_	0s	214us/step -	loss:	0.0261
	702/800		•	0.54		0.0064
	[======] 703/800	-	0s	2/4us/step -	· loss:	0.0264
24/24	[======]	-	0s	245us/step -	loss:	0.0262
	704/800	_	Λς	28811g/gten -	. 1099•	0 0259
Epoch	705/800					
	[======] 706/800	-	0s	184us/step -	loss:	0.0261
	[=======]	_	0s	223us/step -	loss:	0.0258
	707/800		0 -	242/	1	0.0262
	[======] 708/800	_	US	242us/step -	· loss:	0.0262
	[======]	-	0s	212us/step -	loss:	0.0257
	709/800 [=======]	_	0s	208us/step -	· loss:	0.0258
Epoch	710/800					
	[======] 711/800	-	0s	228us/step -	· loss:	0.0262
	[=======]	_	0s	240us/step -	loss:	0.0263
	712/800 [========]		0 a	26222/2405	1000.	0 0266
Epoch	713/800					
	[=======]	-	0s	365us/step -	loss:	0.0268
	714/800 [=========]	_	0s	257us/step -	· loss:	0.0267
Epoch	715/800					
	[======] 716/800	-	0s	196us/step -	· loss:	0.0265
24/24	[======]	-	0s	246us/step -	loss:	0.0259
	717/800	_	0s	282us/step -	· loss:	0.0262
Epoch	718/800					
	[======] 719/800	-	0s	209us/step -	· loss:	0.0262
	[========]	_	0s	297us/step -	loss:	0.0260
	720/800 [========]		Λσ	222ug/g+on	logg•	0 0261
	721/800	_	US	zssus/scep -	. 1022.	0.0201
	[========]	-	0s	201us/step -	loss:	0.0257
	722/800 [=========]	_	0s	304us/step -	· loss:	0.0262
Epoch	723/800					
	[=======] 724/800	-	0s	338us/step -	· loss:	0.0259
24/24	[======]	_	0s	482us/step -	loss:	0.0259
	725/800 [========]	_	0 <	34411s/sten -	. 1055.	0.0267
Epoch	726/800					
24/24	[=====]	-	0s	377us/step -	· loss:	0.0261

Epoch	727/800				
24/24	[========]	-	0s	625us/step - loss:	0.0269
	728/800		•		0 0064
	[=====================================	-	0s	330us/step - loss:	0.0264
	[=========]	ı –	0s	542us/step - loss:	0.0260
Epoch	730/800			_	
	[======================================	-	0s	341us/step - loss:	0.0260
	731/800	ı _	0s	310us/step = loss:	0.0265
Epoch	732/800			_	
	[======]	-	0s	212us/step - loss:	0.0261
	733/800	ı _	۸e	254us/sten _ loss.	0 0259
	734/800		0.5	234db/5ccp - 1055.	0.0233
	[=========]	-	0s	404us/step - loss:	0.0260
	735/800		٥a	262ug/g+on logg.	0 0260
	736/800	_	05	303us/step - 10ss:	0.0200
24/24	[========]	-	0s	459us/step - loss:	0.0265
	737/800		0 -	222/	0 0061
	[=====================================	–	US	322us/step - loss:	0.0261
	[=========]	–	0s	223us/step - loss:	0.0261
	739/800				
	[=====================================	-	0s	316us/step - loss:	0.0265
	[==========]	-	0s	525us/step - loss:	0.0260
	741/800				
	[=====================================	-	0s	363us/step - loss:	0.0260
	[======================================	ı –	0s	515us/step - loss:	0.0260
Epoch	743/800				
	[=====================================	–	0s	759us/step - loss:	0.0257
	[======================================	ı –	0s	352us/step - loss:	0.0261
Epoch	745/800			_	
	[======================================	-	0s	639us/step - loss:	0.0262
	746/800 [=======]	ı _	0s	469us/step - loss:	0.0263
Epoch	747/800				
	[========]	-	0s	616us/step - loss:	0.0270
	748/800 [==========]		۸e	27711s/sten = loss.	0 0259
	749/800		0 D	2774575CCP - 1055.	0.0233
	[======]	-	0s	216us/step - loss:	0.0258
	750/800 [==========]	ı	۸c	313ug/g+on logg.	0 0261
	751/800	_	US	515us/scep - 10ss.	0.0201
	[=========]	-	0s	622us/step - loss:	0.0265
	752/800 [========]		0.~	262ug/gton 1077	0 0261
	753/800	_	US	202us/step - 10SS:	0.0201
24/24	[========]	-	0s	279us/step - loss:	0.0260
	754/800		0	212	0 0061
	[========] 755/800	-	US	<pre>212us/step - loss:</pre>	0.0261
TPOCII	,55,600				

	[======]	-	0s	359us/step -	loss:	0.0263
	756/800 [=======]	_	0s	463us/step -	loss:	0.0264
Epoch	757/800					
	[======] 758/800	_	0s	2/2us/step -	loss:	0.0259
	[=======]	-	0s	228us/step -	loss:	0.0260
	759/800 [=======]	_	0s	223us/step -	loss:	0.0265
	760/800		0 ~	277119/9+09	1000.	0 0260
Epoch	761/800			_		
	[======] 762/800	-	0s	276us/step -	loss:	0.0260
	[=======]	_	0s	245us/step -	loss:	0.0261
	763/800		Λσ	200us/stop	logge	0 0250
Epoch	764/800			_		
	[======] 765/800	-	0s	432us/step -	loss:	0.0259
24/24	[======]	_	0s	235us/step -	loss:	0.0261
	766/800 [=======]	_	Λe	411ug/g+en -	1000	0 0263
Epoch	767/800					
	[======] 768/800	-	0s	314us/step -	loss:	0.0259
24/24	[======]	_	0s	493us/step -	loss:	0.0262
	769/800 [=======]	_	Λς	29111g/gten -	10991	0 0266
Epoch	770/800					
	[======] 771/800	-	0s	449us/step -	loss:	0.0265
24/24	[======]	_	0s	384us/step -	loss:	0.0265
	772/800	_	0s	419us/step -	loss:	0.0260
Epoch	773/800			_		
	[======] 774/800	-	0s	457us/step -	loss:	0.0259
24/24	[======]	_	0s	349us/step -	loss:	0.0261
	775/800 [=======]	_	0s	343us/step -	loss:	0.0256
Epoch	776/800					
	[=======] 777/800	_	0s	250us/step -	loss:	0.0259
	[=======]	-	0s	434us/step -	loss:	0.0262
	778/800 [=======]	_	0s	201us/step -	loss:	0.0259
	779/800		0 ~	22222 / 5 + 0 =	1000.	0 0264
Epoch	780/800					
	[=======] 781/800	-	0s	265us/step -	loss:	0.0259
	[========]	_	0s	266us/step -	loss:	0.0260
	782/800 [======]		Ωc	191112/2+05	logg•	0 0261
Epoch	783/800					
24/24	[=====]	-	0s	260us/step -	loss:	0.0262

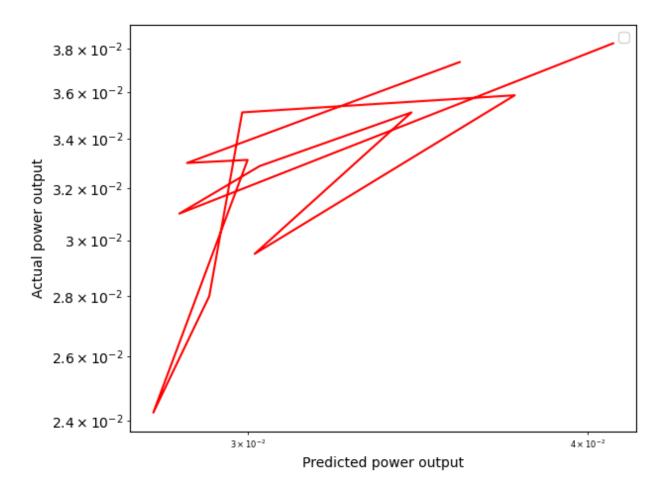
```
Epoch 784/800
Epoch 785/800
Epoch 786/800
Epoch 787/800
24/24 [=============== ] - 0s 288us/step - loss: 0.0263
Epoch 788/800
24/24 [=============== ] - 0s 244us/step - loss: 0.0258
Epoch 789/800
Epoch 790/800
24/24 [=============== ] - 0s 227us/step - loss: 0.0262
Epoch 791/800
Epoch 792/800
24/24 [============== ] - 0s 211us/step - loss: 0.0264
Epoch 793/800
Epoch 794/800
Epoch 795/800
Epoch 796/800
24/24 [============= ] - 0s 219us/step - loss: 0.0260
Epoch 797/800
24/24 [============= ] - 0s 239us/step - loss: 0.0258
Epoch 798/800
24/24 [=============== ] - 0s 232us/step - loss: 0.0261
Epoch 799/800
Epoch 800/800
best epoch = 775
smallest loss = 0.025612175464630127
```

In [429... # Task 1.2 Part e from sklearn import metrics # This line of code can be used to reconstruct the saved model. The name of t recon model = keras.models.load model("best model") import matplotlib.pyplot as plt y_predict = [] Wdotpred = [] Wdotorig = [] for i in range(len(X trainn)): test = [[X_trainn[i][0], X_trainn[i][1], X_trainn[i][2]]] testarray = np.array(test) a3 = recon_model.predict(testarray) y_predict.append([a3[0][0], a3[0][1]]) Wdotpred.append([a3[0][1]]) Wdotorig.append([y_trainn[i][1]]) plt.figure() plt.loglog(Wdotpred, Wdotorig, c='r') plt.xlabel("Predicted power output") plt.ylabel("Actual power output") plt.legend() plt.tight layout() plt.show() #MAE of predicted vs test data mae_Wdot = metrics.mean_absolute_error(Wdotpred, Wdotorig) mae Vl = metrics.mean_absolute_error(y predict[:][1],y_trainn[:][1]) print('mean absolute error between predictions and the collection of test dat



No handles with labels found to put in legend. mean absolute error between predictions and the collection of test data: Vl = 0.20995893429219725 Wdot = 0.0023914916813373576

In [390... # Task 1.2 Part f # This line of code can be used to reconstruct the saved model. The name of t recon model = keras.models.load model("best model") import matplotlib.pyplot as plt y predictn = [] y traino = [] Wdotpred2 = [] Wdotorig2 = [] for i in range(len(X testn)): testn = [[X_testn[i][0], X_testn[i][1], X_testn[i][2]]] testarrayn = np.array(testn) a3 = recon_model.predict(testarrayn) y_predictn.append([a3[0][0], a3[0][1]]) Wdotpred2.append([a3[0][1]]) y_traino.append([y_testn[i][0], y_testn[i][1]]) Wdotorig2.append([y_testn[i][1]]) plt.figure() plt.loglog(Wdotpred2, Wdotorig2, c='r') plt.rc('xtick', labelsize=6) plt.xlabel("Predicted power output") plt.ylabel("Actual power output") plt.legend() plt.tight layout() plt.show() #MAE of predicted vs test data mae_Wdot = metrics.mean_absolute_error(Wdotpred2, Wdotorig2) mae V1 = metrics.mean absolute error(y predictn[:][1],y traino[:][1]) print('mean absolute error between predictions and the collection of test date



No handles with labels found to put in legend. mean absolute error between predictions and the collection of test data: Vl = 0.032343255385756484 Wdot = 0.002482627061506114

```
In [17]:
          #Task1.2 Part q
          #Part 1 input HI FLUX DATA: Air temp (degC), ID (W/sqm), load resistance (ohm
          xdata = [[-10.0, 1550, 4.464],
            [-10.0, 1850, 4.464],
            [10.0, 1550, 4.464],
            [10.0, 1850, 4.464],
            [30.0, 1550, 4.464],
            [30.0, 1850, 4.464],
            [-10.0, 1550, 6.696],
            [-10.0, 1850, 6.696],
            [10.0, 1550, 6.696],
            [10.0, 1850, 6.696],
            [30.0, 1550, 6.696],
            [30.0, 1850, 6.696],
            [-10.0, 1550, 8.928],
            [-10.0, 1850, 8.928],
            [10.0, 1550, 8.928],
```

```
[10.0, 1850, 8.928],
  [30.0, 1550, 8.928],
  [30.0, 1850, 8.928]]
#Part 1 output HI FLUX DATA: load voltage (V) and Power out (W)
ydata = [[26.1, 152.8],
 [26.5, 157.4],
 [27.9, 174.5],
 [28.3, 179.9],
 [29.6, 197.5],
 [30.1, 203.88396644646863],
 [26.9, 108.3334196813148],
 [27.2, 111.25283762284167],
 [28.8, 123.90621088656334],
 [29.1, 127.3006573252854],
 [30.6, 140.4799701696024],
 [31.0, 144.39313467349314],
 [27.3, 83.77924895974105],
 [27.6, 85.91711375810277],
 [29.2, 95.88391097375488],
 [29.6, 98.3599961391009],
 [31.1, 108.78119217392532],
 [31.5, 111.62434462334976]]
xarray= numpy.array(xdata)
yarray= numpy.array(ydata)
Vlh = []
Wdoth = []
Tairh =[]
Idh =[]
Rlh =[]
for x in range(len(xarray)):
    Tairh.append(xarray[x][0])
    Idh.append(xarray[x][1])
    Rlh.append(xarray[x][2])
for y in range(len(yarray)):
    Vlh.append(xarray[y][0])
    Wdoth.append(xarray[y][1])
medTairh = median(Tairh)
medIdh = median(Idh)
medRlh = median(Rlh)
medVlh = median(Vlh)
medWdoth = median(Wdoth)
Tairhn = Tairh/medTairh
Idhn = Idh/medIdh
Rlhn = Rlh/medRlh
Vlhn = Vlh/medVlh
```

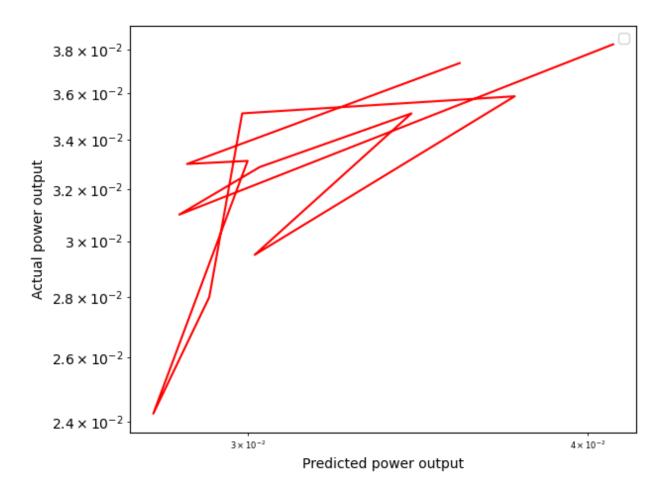
```
Wdothn = Wdoth/medWdoth

xarrayhn = np.column_stack((Tairhn, Idhn, Rlhn))
yarrayhn = np.column_stack((Vlhn, Wdothn))

print(xarrayhn)
print(yarrayhn)
```

```
[[-1.
                0.91176471 0.66666667]
[-1.
               1.08823529 0.666666671
[ 1.
               0.91176471 0.666666671
[ 1.
               1.08823529 0.666666671
               0.91176471
 [ 3.
                             0.66666667]
 [ 3.
               1.08823529 0.66666667]
 [-1.
               0.91176471
                             1.
               1.08823529
\lceil -1.
                            1.
                                        ]
 [ 1.
               0.91176471
                                        ]
 [ 1.
               1.08823529
                            1.
                                        ]
 [ 3.
               0.91176471
                             1.
                                        1
               1.08823529
 [ 3.
                            1.
               0.91176471
                            1.333333331
 [-1.
 [-1.
               1.08823529
                            1.333333331
 [ 1.
               0.91176471
                            1.333333331
               1.08823529
                            1.33333333]
 [ 1.
[ 3.
               0.91176471
                            1.33333333]
[ 3.
               1.08823529
                            1.33333333]]
[-1.
               0.91176471]
\lceil -1.
               1.088235291
 [ 1.
               0.91176471]
 [ 1.
                1.088235291
               0.91176471]
 [ 3.
 [ 3.
               1.088235291
               0.91176471]
 [-1.
               1.088235291
 [-1.
               0.91176471]
 [ 1.
 [ 1.
               1.08823529]
 [ 3.
               0.91176471]
               1.088235291
 [ 3.
 [-1.
               0.91176471]
[-1.
                1.08823529]
 [ 1.
               0.91176471]
 [ 1.
               1.08823529]
               0.91176471]
 [ 3.
 [ 3.
                1.08823529]]
```

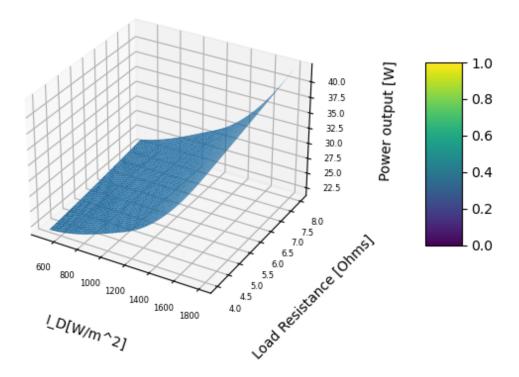
In [393... # Task 1.2 Part q # This line of code can be used to reconstruct the saved model. The name of t recon model = keras.models.load model("best model") import matplotlib.pyplot as plt y predicthn = [] y train = [] Wdotpredh = [] Wdotorigh = [] for i in range(len(xarrayhn)): testhn = [[xarrayhn[i][0], xarrayhn[i][1], xarrayhn[i][2]]] testarrayhn = np.array(testhn) a3 = recon_model.predict(testarrayhn) y_predicthn.append([a3[0][0], a3[0][1]]) Wdotpredh.append([a3[0][1]]) y_train.append([yarrayhn[i][0], yarrayhn[i][1]]) Wdotorigh.append([yarrayhn[i][1]]) plt.figure() plt.loglog(Wdotpred2, Wdotorig2, c='r') plt.rc('xtick', labelsize=6) plt.xlabel("Predicted power output") plt.ylabel("Actual power output") plt.legend() plt.tight layout() plt.show() #MAE of predicted vs test data mae_Wdot = metrics.mean_absolute_error(Wdotpredh,Wdotorigh) mae V1 = metrics.mean absolute error(y predicthn[:][1],y train[:][1]) print('mean absolute error between predictions and the collection of test date



No handles with labels found to put in legend. mean absolute error between predictions and the collection of test data: Vl = 2.244589985183933 Wdot = 0.9696147735748026

In [394...

```
#Task1.2 part h
import matplotlib.pyplot as plt
import numpy as np
fig = plt.figure()
ax = plt.axes(projection='3d')
X = np.linspace(500, 1800) #Id
Y = np.linspace(4, 8) \#R1
Zp = []
Xp = []
Yp = []
Tair = 20
testdata = []
Tn = Tair/medTair
Xn = X/medId
Yn = Y/medRl
for x in range(len(Xn)):
    for y in range(len(Yn)):
        testdata.append([Tn, Xn[x], Yn[y]])
        Xp.append(Xn[x]*medId)
        Yp.append(Yn[y]*medRl)
for x in range(len(testdata)):
    test = [[testdata[x][0], testdata[x][1], testdata[x][2]]]
    testarray = np.array(test)
    outptn = recon_model.predict(testarray)
    Zp.append(outptn[0][1]*medWdot)
surf = ax.plot_trisurf(Xp, Yp, Zp)
fig.colorbar(surf, shrink=0.5, aspect=5, pad=0.2)
ax.set_zlabel('Power output [W]', rotation=60)
ax.set_ylabel('Load Resistance [Ohms]')
ax.set_xlabel('I_D[W/m^2]', rotation=150)
ax.xaxis.labelpad=15
ax.yaxis.labelpad=15
ax.zaxis.labelpad=15
plt.show()
```



```
In [18]: #Task 1.3
# define neural network model

from keras import backend as K
#initialize weights
initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)

model2 = keras.Sequential([
    keras.layers.Dense(6, activation=K.elu, input_shape=[3], kernel_initiali
    keras.layers.Dense(8, activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(12, activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(16, activation=K.elu, kernel_initializer=initializer)
    keras.layers.Dense(8, activation=K.elu, kernel_initializer=initializer),
    keras.layers.Dense(2, kernel_initializer=initializer)
])
```

```
In [25]: #from tf.keras import optimizers
    rms = keras.optimizers.RMSprop(0.0003)
    model2.compile(loss='mean_absolute_error',optimizer=rms)
```

```
In [26]:
          # Add an early stopping callback
          es = keras.callbacks.EarlyStopping(
              monitor='loss',
              mode='min',
              patience = 80,
              restore best weights = True,
              verbose=1)
          # Add a checkpoint where loss is minimum, and save that model
          mc = keras.callbacks.ModelCheckpoint('best model2.SB', monitor='loss',
                               mode='min', verbose=1, save best only=True)
          historyData = model2.fit(X trainn,y trainn,epochs=800,callbacks=[es])
          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))
          model2.save('./best_model2')
```

```
Epoch 1/800
Epoch 2/800
Epoch 3/800
Epoch 4/800
Epoch 5/800
Epoch 6/800
Epoch 7/800
24/24 [=========== ] - 0s 566us/step - loss: 0.0328
Epoch 8/800
Epoch 9/800
Epoch 10/800
Epoch 11/800
Epoch 12/800
Epoch 13/800
Epoch 14/800
Epoch 15/800
Epoch 16/800
Epoch 17/800
```

```
Epoch 18/800
24/24 [============== ] - 0s 249us/step - loss: 0.0323
Epoch 19/800
Epoch 20/800
24/24 [=============== ] - 0s 270us/step - loss: 0.0333
Epoch 21/800
Epoch 22/800
Epoch 23/800
Epoch 24/800
Epoch 25/800
Epoch 26/800
24/24 [=============== ] - 0s 256us/step - loss: 0.0317
Epoch 27/800
Epoch 28/800
Epoch 29/800
24/24 [============== ] - 0s 266us/step - loss: 0.0324
Epoch 30/800
Epoch 31/800
24/24 [=============== ] - 0s 310us/step - loss: 0.0321
Epoch 32/800
Epoch 33/800
Epoch 34/800
Epoch 35/800
24/24 [============= ] - 0s 326us/step - loss: 0.0319
Epoch 36/800
Epoch 37/800
24/24 [=============== ] - 0s 198us/step - loss: 0.0325
Epoch 38/800
Epoch 39/800
Epoch 40/800
24/24 [=============== ] - 0s 210us/step - loss: 0.0318
Epoch 41/800
Epoch 42/800
Epoch 43/800
Epoch 44/800
Epoch 45/800
```

Epoch	46/800				
	[========]	_	0s	417us/step - loss: 0.032	3
Epoch	47/800				
	[======]	-	0s	342us/step - loss: 0.032	5
	48/800				_
	[=========]	-	0s	268us/step - loss: 0.031	2
	49/800 [=======]		٥٥	206ug/gtop logg: 0 031	1
	50/800	_	US	2000s/scep = 10ss: 0:031	_
	[=======]	_	0s	205us/step - loss: 0.031	5
Epoch	51/800			-	
	[======]	-	0s	237us/step - loss: 0.032	2
	52/800		•		_
	[======================================	-	0s	299us/step - loss: 0.032	2
	53/800 [======]		۸e	251us/sten _ loss. 0 031	1
	54/800		V.S	231us/scep - 10ss. 0:031	_
	[=======]	_	0s	373us/step - loss: 0.031	1
	55/800				
	[=======]	-	0s	353us/step - loss: 0.031	3
	56/800		•	100 / 1 2 0 001	_
	[======] 57/800	-	0s	189us/step - loss: 0.031	/
	[=========]	_	0s	235us/step = loss: 0.031	6
	58/800		OB	200487 8 6 6 9 10 8 8 10 8 10 8 10 8 10 8 10 8 10 8	•
	[=======]	_	0s	282us/step - loss: 0.031	1
	59/800				
	[======]	-	0s	234us/step - loss: 0.031	1
	60/800 [======]		0~	220/	1
	[=====================================	_	US	239us/step - loss: 0.031	1
	[========]	_	0s	289us/step - loss: 0.030	8
	62/800				_
	[======]	_	0s	180us/step - loss: 0.031	1
	63/800				
	[========]	-	0s	280us/step - loss: 0.031	3
	64/800 [=======]		Λc	217us/sten loss 0 032	Ω
	65/800	_	US	21/us/scep - 10ss. 0:032	0
	[=======]	_	0s	234us/step - loss: 0.032	0
Epoch	66/800				
	[=======]	-	0s	225us/step - loss: 0.030	8
	67/800		^	204 / 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	_
	[======] 68/800	-	0s	204us/step - loss: 0.030	8
	[========]	_	0s	228us/step - loss: 0.030	9
	69/800		٥٥		
24/24	[=======]	_	0s	325us/step - loss: 0.031	2
	70/800				
	[=======]	-	0s	384us/step - loss: 0.030	9
	71/800		٥٠	20/112/2402 1022 0 021	7
	[======] 72/800	_	υS	Juaus/scep - 1088: 0.031	1
	[=======]	_	0s	220us/step - loss: 0.031	2
Epoch	73/800				
	[======]	-	0s	419us/step - loss: 0.030	9
Epoch	74/800				

```
Epoch 75/800
24/24 [============== ] - 0s 233us/step - loss: 0.0310
Epoch 76/800
Epoch 77/800
Epoch 78/800
Epoch 79/800
Epoch 80/800
Epoch 81/800
Epoch 82/800
Epoch 83/800
Epoch 84/800
Epoch 85/800
Epoch 86/800
24/24 [=============== ] - 0s 180us/step - loss: 0.0301
Epoch 87/800
Epoch 88/800
Epoch 89/800
Epoch 90/800
Epoch 91/800
Epoch 92/800
24/24 [============= ] - 0s 229us/step - loss: 0.0315
Epoch 93/800
Epoch 94/800
24/24 [=============== ] - 0s 194us/step - loss: 0.0301
Epoch 95/800
24/24 [=============== ] - 0s 199us/step - loss: 0.0300
Epoch 96/800
Epoch 97/800
24/24 [============== ] - 0s 213us/step - loss: 0.0299
Epoch 98/800
Epoch 99/800
Epoch 100/800
Epoch 101/800
Epoch 102/800
```

Epoch	103/800				
24/24	[=======]	-	0s	225us/step - loss: 0	0.0311
	104/800		0 -	242/	0 0 0 0 0
	[======] 105/800	_	US	242us/step - loss: (0.0309
	[=========]	_	0s	290us/step - loss: (0.0300
	106/800		•		1
	[======] 107/800	-	0s	231us/step - loss: (0.0301
	[=========]	_	0s	271us/step - loss: (0.0297
	108/800				
	[======] 109/800	-	0s	219us/step - loss: (0.0296
	[=========]	_	0s	270us/step - loss: (0.0295
	110/800				
	[======] 111/800	-	0s	372us/step - loss: (0.0295
	[===========]	_	0s	259us/step - loss: (0.0297
Epoch	112/800			_	
	[======================================	-	0s	216us/step - loss: (0.0296
	113/800	_	0s	359us/step - loss: (0.0308
Epoch	114/800			_	
	[=========]	-	0s	276us/step - loss: (0.0309
	115/800 [======]	_	0 s	39311s/sten - loss: (0.0296
Epoch	116/800			_	
	[======]	-	0s	299us/step - loss: (0.0298
	117/800 [=======]		۸e	375ug/gten _ logg. (0 0297
	118/800		0 D	3/3u3/5ccp - 1055. (0.0257
	[=====]	-	0s	369us/step - loss: 0	0.0294
	119/800 [======]		۸e	36211g/gten - logg. (n n293
	120/800	_	VS	302us/scep - 10ss. (0.0273
	[=====]	-	0s	223us/step - loss: 0	0.0293
_	121/800		۸c	397ug/g+an logg. (0 0303
	122/800	_	VS	377us/scep - 10ss. (0.0303
	[=====]	-	0s	327us/step - loss: 0	0.0309
_	123/800 [======]		۸c	379ug/g+an logg. (n n208
	124/800	_	VS	3/7us/scep - 10ss. (0.0290
	[=======]	_	0s	385us/step - loss: 0	0.0297
	125/800 [======]		٥٥	271ug/g+on logg. (0 0202
	126/800	_	05	2/1us/step - 10ss: (0.0292
24/24	[======]	_	0s	264us/step - loss: 0	0.0292
	127/800		0 ~	264	0 0000
	[=======] 128/800	_	US	204us/step - loss: (0.0290
	[=======]	_	0s	300us/step - loss: 0	0.0289
	129/800		0	420	0.000
	[=======] 130/800	-	US	429us/step - loss: (0.0288
24/24	[=======]	_	0s	254us/step - loss: (0.0287
Epoch	131/800				

24/24	[======]	_	0s	282us/step - loss:	0.0290
	132/800				
	[========]	-	0s	449us/step - loss:	0.0293
	133/800		•	252 / 1	
	[======] 134/800	-	0s	368us/step - loss:	0.0302
	[==========]	_	۸e	33211g/gten _ logg.	0 0303
	135/800		V.S	332us/scep - 10ss.	0.0303
	[========]	_	0s	384us/step - loss:	0.0289
	136/800				
	[======]	-	0s	384us/step - loss:	0.0287
	137/800				
	[=======]	_	0s	425us/step - loss:	0.0287
	138/800		0 ~	410/	0 0005
	[======] 139/800	-	US	418us/step - 10ss:	0.0285
	[=========]	_	0 =	417us/sten - loss:	0.0285
	140/800		OB	1174575665 1055.	0.0203
	[=======]	_	0s	403us/step - loss:	0.0284
Epoch	141/800				
	[======]	-	0s	282us/step - loss:	0.0284
	142/800				
	[=======]	-	0s	427us/step - loss:	0.0283
	143/800 [=========]		0 a	467ug/gton logg.	0 0205
	144/800	_	US	40/us/scep - 10ss:	0.0263
	[========]	_	0s	657us/step - loss:	0.0285
	145/800		0.0	20, 42, 200p	0.0200
	[======]	_	0s	314us/step - loss:	0.0283
_	146/800				
	[=======]	-	0s	351us/step - loss:	0.0283
_	147/800		0 -	240/	0 0000
	[=======] 148/800	-	US	349us/step - loss:	0.0283
	[=========]	_	0s	457us/step = loss:	0.0288
	149/800		Ů.	13,48,500	0.0200
	[=======]	_	0s	380us/step - loss:	0.0297
_	150/800				
	[=======]	-	0s	298us/step - loss:	0.0300
	151/800			.=-	
	[=========]	-	0s	4/3us/step - loss:	0.0306
	152/800 [========]	_	۸e	346us/sten - loss.	0 0286
	153/800		0.5	340dB/BCCP = 10BB.	0.0200
	[=======]	_	0s	223us/step - loss:	0.0282
Epoch	154/800				
	[======]	_	0s	204us/step - loss:	0.0280
	155/800				
	[=========]	-	0s	258us/step - loss:	0.0279
	156/800 [========]		٥٥	270ug/gtop logg.	0 0270
	157/800	_	US	270us/scep - 10ss:	0.0279
	[========]	_	0s	229us/step - loss:	0.0278
Epoch	158/800				
	[======]	-	0s	216us/step - loss:	0.0278
	159/800				
24/24	[======]	-	0s	4/9us/step - loss:	0.0277

Epoch	160/800			
24/24	[======]	_	0s	205us/step - loss: 0.0278
	161/800		0	204
	[=======] 162/800	_	US	304us/step - loss: 0.02/6
	[========]	_	0s	589us/step - loss: 0.0275
Epoch	163/800			-
	[======================================	-	0s	944us/step - loss: 0.0275
	164/800 [======]	_	٥g	369us/sten - loss: 0.0278
	165/800		0 D	3034B/BCCP 10BB: 0:02/0
	[======]	-	0s	472us/step - loss: 0.0304
	166/800 [======]		٥٥	506ug/gton logg. 0 0203
	167/800	_	US	Judus/scep - 10ss: 0.0293
	[=======]	_	0s	238us/step - loss: 0.0289
	168/800		•	500 / · · · · · · · · · · · · · · · · · ·
	[======] 169/800	-	0s	/89us/step - loss: 0.02/6
	[========]	_	0s	291us/step - loss: 0.0275
	170/800			<u>-</u>
	[==========]	-	0s	179us/step - loss: 0.0274
	171/800 [=======]	_	0s	220us/step - loss: 0.0273
Epoch	172/800			
	[=======]	-	0s	194us/step - loss: 0.0272
	173/800 [=======]		Λe	222115/sten - loss. 0 0271
	174/800	_	US	222us/scep - 10ss. 0.02/1
	[======]	-	0s	194us/step - loss: 0.0277
	175/800 [=======]		0 ~	1000-/
	176/800	_	US	198us/step - 10ss: 0.0285
	[=======]	_	0s	311us/step - loss: 0.0276
	177/800			
	[======] 178/800	-	0s	20/us/step - loss: 0.02/4
_	[========]	_	0s	280us/step - loss: 0.0277
_	179/800			-
	[=======] 180/800	-	0s	467us/step - loss: 0.0280
	[========]	_	0s	528us/step - loss: 0.0278
Epoch	181/800			
	[==========]	-	0s	229us/step - loss: 0.0278
	182/800 [======]	_	0s	273us/step - loss: 0.0274
	183/800		0 D	2/345/5665 1055. 0.02/1
	[=====]	-	0s	228us/step - loss: 0.0272
	184/800 [=======]		٥٥	207ug/gton logg: 0 0260
	185/800	_	UB	20/us/scep - 10ss: 0.0209
24/24	[======]	_	0s	174us/step - loss: 0.0268
	186/800		0 -	1630-/
	[======] 187/800	-	US	103us/step - 10ss: 0.02/1
	[========]	_	0s	202us/step - loss: 0.0267
Epoch	188/800			

	[=====]	-	0s	189us/step -	loss:	0.0273
	189/800 [=======]	_	Λs	208us/sten -	1055:	0.0283
Epoch	190/800					
	[======] 191/800	-	0s	214us/step -	loss:	0.0273
	[=========]	_	0s	238us/step -	loss:	0.0274
Epoch	192/800					
	[======] 193/800	-	0s	256us/step -	loss:	0.0275
24/24	[======]	_	0s	494us/step -	loss:	0.0274
	194/800 [=======]		۸c	693ug/g+op	logge	0 0274
Epoch	195/800					
	[======]	-	0s	531us/step -	loss:	0.0268
	196/800 [=======]	_	0s	669us/step -	loss:	0.0267
Epoch	197/800					
	[======] 198/800	-	0s	359us/step -	loss:	0.0267
	[=======]	_	0s	539us/step -	loss:	0.0265
	199/800		0 -	470/	1	0 0265
	[======] 200/800	_	US	4/9us/step -	TOSS:	0.0265
24/24	[======]	_	0s	289us/step -	loss:	0.0266
	201/800 [=======]	_	Λe	53711g/gten -	1000.	0 0265
Epoch	202/800			_		
	[=========]	-	0s	187us/step -	loss:	0.0266
	203/800 [==========]	_	0s	274us/step -	loss:	0.0263
Epoch	204/800					
	[======] 205/800	-	0s	196us/step -	loss:	0.0264
24/24	[======]	_	0s	215us/step -	loss:	0.0264
	206/800	_	Λs	210us/sten -	1055:	0.0265
Epoch	207/800			_		
	[=======] 208/800	-	0s	176us/step -	loss:	0.0261
	[========]	_	0s	182us/step -	loss:	0.0261
	209/800 [=======]		٥٥	225ug/g+op	1000.	0 0266
	210/800	_	US	233us/scep -	1055:	0.0200
	[======================================	-	0s	193us/step -	loss:	0.0272
	211/800 [=======]	_	0s	240us/step -	loss:	0.0277
Epoch	212/800					
	[======] 213/800	-	0s	240us/step -	loss:	0.0272
24/24	[======]	_	0s	429us/step -	loss:	0.0281
	214/800 [=======]	_	Λe	23911c/c+on	1000	0 0202
Epoch	215/800					
	[=======]	-	0s	313us/step -	loss:	0.0267
	216/800 [=======]	_	0s	280us/step -	loss:	0.0263
			-	<u> </u>		

Epoch	217/800				
	[========]	_	0s	331us/step - loss:	0.0260
	218/800				
	[======] 219/800	-	0s	238us/step - loss:	0.0258
	[===========]	_	0s	240us/step - loss:	0.0258
Epoch	220/800			_	
	[=====]	_	0s	226us/step - loss:	0.0262
	221/800 [======]		٥٥	201ug/g+on logg.	0 0257
	222/800	_	US	201us/scep - 10ss.	0.0237
24/24	[======]	_	0s	254us/step - loss:	0.0256
	223/800		0 -	252/	0 0060
	[======] 224/800	_	US	253us/step - loss:	0.0263
	[========]	_	0s	260us/step - loss:	0.0256
	225/800				
	[======] 226/800	-	0s	271us/step - loss:	0.0255
	[=========]	_	0s	254us/step - loss:	0.0257
	227/800				
	[======] 228/800	-	0s	281us/step - loss:	0.0258
	[==========]	_	0s	283us/step - loss:	0.0258
Epoch	229/800				
	[=======]	-	0s	338us/step - loss:	0.0255
	230/800 [=======]	_	Λq	270us/sten - loss:	0.0262
	231/800		0 D	270db/bccp 10bb.	0.0202
	[=====]	-	0s	279us/step - loss:	0.0278
	232/800 [=======]		٥٥	226ug/g+on logg.	0 0271
	233/800	_	US	220us/step - 10ss:	0.02/1
	[======]	-	0s	216us/step - loss:	0.0263
	234/800		0~	200/	0 0250
	235/800	_	US	208us/step - loss:	0.0258
_	[=======]	_	0s	250us/step - loss:	0.0257
	236/800		•	205 / 1	0 0050
	[=======] 237/800	-	US	305us/step - loss:	0.0258
	[========]	_	0s	218us/step - loss:	0.0254
	238/800				
	[=======] 239/800	-	0s	236us/step - loss:	0.0254
-	[=========]	_	0s	192us/step - loss:	0.0253
Epoch	240/800				
	[=======] 241/800	-	0s	186us/step - loss:	0.0253
	[======================================	_	0s	201us/step - loss:	0.0251
Epoch	242/800				
	[======================================	-	0s	186us/step - loss:	0.0253
	243/800 [========]	_	0s	234us/step - loss:	0.0251
Epoch	244/800				
	[=======]	-	0s	196us/step - loss:	0.0252
Epoch	245/800				

	[======]	_	0s	233us/step - 1	loss:	0.0256
	246/800		0 ~	221/	1	0 0250
	[======] 247/800	_	US	231us/step - 1	Loss:	0.0259
	[======]	_	0s	231us/step - 1	loss:	0.0275
	248/800		•	200 / 1	,	0.0065
	[======] 249/800	-	0s	208us/step - 1	Loss:	0.0265
	[=======]	_	0s	222us/step - 1	loss:	0.0262
	250/800					
	[======] 251/800	-	0s	211us/step - 1	Loss:	0.0256
	[========]	_	0s	200us/step - 1	loss:	0.0252
Epoch	252/800			_		
	[======] 253/800	-	0s	213us/step - 1	Loss:	0.0249
	[========]	_	0s	170us/step - 1	loss:	0.0247
Epoch	254/800					
	[=======]	-	0s	204us/step - 1	Loss:	0.0247
	255/800 [=======]	_	0s	209us/step - 1	loss:	0.0247
Epoch	256/800					
	[======]	-	0s	233us/step - 1	loss:	0.0247
	257/800 [=======]	_	Λq	196119/sten - 1	logg•	0 0245
	258/800		05	17005/500p - 1	1055.	0.0243
	[=====]	-	0s	186us/step - 1	loss:	0.0246
	259/800 [=======]		Λα	278ug/g+ap 1	logg•	0 0246
	260/800	_	US	2/0us/scep - 1	1055.	0.0240
	[======]	_	0s	228us/step - 1	loss:	0.0245
	261/800 [=======]		٥٥	520ug/g+op 1	logg•	0 0244
	262/800	_	US	329us/scep - 1	1055.	0.0244
24/24	[======]	_	0s	245us/step - 1	loss:	0.0261
	263/800 [=======]		٥٩	25/22/2500	1000.	0 0200
	264/800	_	05	254us/step - 1	1055;	0.0290
24/24	[======]	_	0s	220us/step - 1	loss:	0.0255
	265/800 [======]		٥٩	205,19/9+05	1000.	0 0240
	266/800	_	US	295us/step = 1	LOSS:	0.0249
24/24	[======]	_	0s	237us/step - 1	loss:	0.0244
	267/800		0 ~	226	1	0 0242
	[======] 268/800	_	US	236us/step - 1	loss:	0.0242
24/24	[======]	_	0s	223us/step - 1	loss:	0.0243
	269/800		0 -	214/	1	0 0041
	[======] 270/800	-	0s	214us/step - 1	Loss:	0.0241
	[=======]	_	0s	250us/step - 1	loss:	0.0241
	271/800		0	226/	1	0 0041
	[======] 272/800	-	υs	326us/step - 1	LOSS:	0.0241
	[=======]	_	0s	323us/step - 1	loss:	0.0241
Epoch	273/800					
24/24	[=====]	-	0s	305us/step - 1	Loss:	0.0245

Epoch	274/800				
24/24	[======]	_	0s	328us/step - loss: 0	.0241
	275/800		•	101	0040
	[======] 276/800	-	0s	494us/step - loss: 0	.0242
	[========]	_	0s	541us/step - loss: 0	.0242
Epoch	277/800			_	
	[======================================	-	0s	248us/step - loss: 0	.0250
	278/800 [======]	_	0s	306us/step = loss: 0.	.0245
Epoch	279/800			_	
	[]	-	0s	342us/step - loss: 0	.0253
	280/800 [======]		٥٥	303ug/g+on logg. 0	0250
	281/800	_	US	393ds/scep - 10ss. 0	•0230
24/24	[======]	_	0s	352us/step - loss: 0	.0245
	282/800		•	100 / 1 2	0055
	[======] 283/800	_	US	400us/step - loss: 0	.0255
	[========]	_	0s	318us/step - loss: 0	.0253
	284/800				
	[======] 285/800	-	0s	3/2us/step - loss: 0	.0239
	[========]	_	0s	489us/step - loss: 0	.0238
Epoch	286/800			_	
	[======] 287/800	-	0s	203us/step - loss: 0	.0235
	[==========]	_	0s	302us/step - loss: 0	.0237
Epoch	288/800			_	
	[=========]	-	0s	254us/step - loss: 0	.0238
	289/800 [======]	_	0s	252us/step = loss: 0.	.0235
Epoch	290/800			_	
	[========]	-	0s	176us/step - loss: 0	.0239
	291/800 [======]	_	0s	192us/step - loss: 0.	.0240
Epoch	292/800			_	
	[========]	-	0s	209us/step - loss: 0	.0243
	293/800 [=======]	_	0s	308us/step = loss: 0.	.0254
	294/800		Ů.	Tobbi of	.0231
	[=====]	-	0s	265us/step - loss: 0	.0238
	295/800 [=======]		۸c	230ug/g+on logg. 0	0245
	296/800	_	US	230ds/scep - 10ss. 0	.0243
	[=======]	-	0s	276us/step - loss: 0	.0240
	297/800 [=======]		٥٩	220,12/2+02 1022 0	0226
	298/800	_	05	229us/step - 10ss: 0	.0230
	[=======]	_	0s	366us/step - loss: 0	.0235
	299/800		•	200 / 1 2	0000
	[======] 300/800	-	0s	329us/step - loss: 0	.0238
	[=======]	_	0s	300us/step - loss: 0	.0237
Epoch	301/800				
	[======] 302/800	-	0s	204us/step - loss: 0	.0241
просп	302,000				

```
Epoch 303/800
24/24 [============== ] - 0s 532us/step - loss: 0.0237
Epoch 304/800
Epoch 305/800
Epoch 306/800
Epoch 307/800
Epoch 308/800
Epoch 309/800
24/24 [============== ] - 0s 407us/step - loss: 0.0248
Epoch 310/800
Epoch 311/800
24/24 [=============== ] - 0s 321us/step - loss: 0.0246
Epoch 312/800
24/24 [=============== ] - 0s 804us/step - loss: 0.0234
Epoch 313/800
Epoch 314/800
Epoch 315/800
Epoch 316/800
24/24 [=============== ] - 0s 201us/step - loss: 0.0237
Epoch 317/800
Epoch 318/800
Epoch 319/800
Epoch 320/800
24/24 [============ ] - 0s 199us/step - loss: 0.0224
Epoch 321/800
Epoch 322/800
24/24 [=============== ] - 0s 300us/step - loss: 0.0231
Epoch 323/800
24/24 [============== ] - 0s 313us/step - loss: 0.0234
Epoch 324/800
Epoch 325/800
Epoch 326/800
Epoch 327/800
Epoch 328/800
Epoch 329/800
Epoch 330/800
24/24 [=============== ] - 0s 257us/step - loss: 0.0220
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Epoch	331/800					
24/24	[======]	_	0s	387us/step - los	s: 0.02	234
	332/800		•	000 / 1	0 0	006
	[======] 333/800	_	US	232us/step - los	s: 0.02	226
	[========]	_	0s	227us/step - los	s: 0.0	226
	334/800			-		
	[=======]	-	0s	331us/step - los	s: 0.02	229
	335/800 [=======]	_	Λς	266115/sten = los	s: 0.0	238
	336/800		0 D	2000075000	3. 0.0.	
	[========]	_	0s	410us/step - los	s: 0.02	227
	337/800		٥٥	200ug/gton log	a • 0 0°	230
	338/800	_	US	2000s/step - 10s	5. 0.02	230
24/24	[=======]	_	0s	305us/step - los	s: 0.02	220
	339/800		•	226 / 1	0.0	
	[======] 340/800	-	0s	336us/step - los	s: 0.02	225
	[========]	_	0s	310us/step - los	s: 0.02	229
	341/800					
	[======] 342/800	-	0s	294us/step - los	s: 0.02	234
	[==========]	_	0s	271us/step - los	s: 0.0	220
Epoch	343/800			_		
	[=======]	-	0s	210us/step - los	s: 0.02	215
	344/800 [========]	_	۸e	174us/sten - los	s• 0 0'	214
	345/800		0 D	1710070000 100	3. 0.0.	
	[======]	-	0s	276us/step - los	s: 0.02	212
	346/800 [=======]		٥a	225ug/g+on log	a	21/
	347/800	_	US	333us/step - 10s	5. 0.02	21 4
	[======]	_	0s	333us/step - los	s: 0.02	219
	348/800 [=======]		0~	257/	0 0:	226
	349/800	_	US	25/us/step - 10s	5: 0.02	236
_	[=======]	_	0s	281us/step - los	s: 0.02	255
_	350/800		•	400 / 1	0.0	
	[========] 351/800	_	US	429us/step - los	s: 0.02	235
	[========]	_	0s	334us/step - los	s: 0.02	230
	352/800					
	[=======] 353/800	-	0s	286us/step - los	s: 0.02	216
	[========]	_	0s	234us/step - los	s: 0.0	213
Epoch	354/800					
	[======] 355/800	-	0s	358us/step - los	s: 0.02	213
	[==========]	_	0s	292us/step - los	s: 0.0	216
Epoch	356/800					
	[======================================	-	0s	406us/step - los	s: 0.02	218
	357/800 [=========]	_	0s	351us/step = los	s: 0.0	214
Epoch	358/800					
	[=======]	-	0s	373us/step - los	s: 0.02	210
Epoch	359/800					

```
Epoch 360/800
24/24 [============== ] - 0s 540us/step - loss: 0.0219
Epoch 361/800
Epoch 362/800
24/24 [================ ] - 0s 207us/step - loss: 0.0214
Epoch 363/800
Epoch 364/800
Epoch 365/800
Epoch 366/800
24/24 [============== ] - 0s 260us/step - loss: 0.0212
Epoch 367/800
Epoch 368/800
Epoch 369/800
Epoch 370/800
Epoch 371/800
24/24 [============== ] - 0s 231us/step - loss: 0.0225
Epoch 372/800
Epoch 373/800
Epoch 374/800
Epoch 375/800
Epoch 376/800
Epoch 377/800
24/24 [============ ] - 0s 504us/step - loss: 0.0204
Epoch 378/800
Epoch 379/800
Epoch 380/800
Epoch 381/800
Epoch 382/800
24/24 [=============== ] - 0s 318us/step - loss: 0.0204
Epoch 383/800
Epoch 384/800
Epoch 385/800
Epoch 386/800
Epoch 387/800
```

Epoch	388/800				
24/24	[=======]	-	0s	311us/step - loss: 0	.0209
	389/800 [=======]		٥٩	10Eug/gton logg. 0	0214
	390/800	_	US	195us/step - 10ss: 0	.0214
24/24	[=======]	_	0s	213us/step - loss: 0	.0208
	391/800		0 -	211/	0200
	[======] 392/800	-	US	211us/step - loss: 0	.0200
	[=========]	_	0s	362us/step - loss: 0	.0200
	393/800				
	[======] 394/800	-	0s	218us/step - loss: 0	.0208
	[========]	_	0s	184us/step - loss: 0	.0216
	395/800				
	[======] 396/800	-	0s	309us/step - loss: 0	.0214
	[=========]	_	0s	291us/step - loss: 0	.0217
Epoch	397/800			_	
	[======] 398/800	-	0s	428us/step - loss: 0	.0212
	[==========]	_	0s	214us/step - loss: 0	.0203
Epoch	399/800			_	
	[======================================	-	0s	227us/step - loss: 0	.0201
	400/800 [=======]	_	0s	314us/step - loss: 0	.0198
Epoch	401/800			_	
	[=======]	-	0s	199us/step - loss: 0	.0200
	402/800 [=======]	_	0 s	273us/sten = loss: 0	. 0205
Epoch	403/800			_	
	[======]	-	0s	318us/step - loss: 0	.0196
	404/800 [========]	_	Ωs	27911s/sten - loss: 0	.0205
Epoch	405/800				
	[======]	-	0s	343us/step - loss: 0	.0196
-	406/800 [=======]	_	۸e	21511s/sten - loss. 0	0199
	407/800		0.5	213d3/5ccp = 1055. 0	•0100
	[=====]	-	0s	343us/step - loss: 0	.0204
	408/800 [=========]		۸c	301ug/g+on logg. 0	0103
	409/800	_	US	301us/scep - 10ss: 0	.0193
24/24	[=======]	-	0s	517us/step - loss: 0	.0198
	410/800 [=======]		٥٩	22000/5500 logg. 0	0100
	411/800	_	US	338us/step - 10ss: 0	.0198
24/24	[=======]	_	0s	469us/step - loss: 0	.0216
	412/800		0 -	220/	0000
	[======] 413/800	-	US	339us/step - loss: 0	.0222
	[=========]	_	0s	499us/step - loss: 0	.0234
	414/800		•	E40 / 1 3 0	0000
	[======] 415/800	-	US	549us/step - loss: 0	.0220
	[========]	_	0s	483us/step - loss: 0	.0197
Epoch	416/800				

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Epoch 417/800
24/24 [============== ] - 0s 297us/step - loss: 0.0193
Epoch 418/800
Epoch 419/800
Epoch 420/800
24/24 [=============== ] - 0s 491us/step - loss: 0.0198
Epoch 421/800
Epoch 422/800
Epoch 423/800
24/24 [============== ] - 0s 508us/step - loss: 0.0200
Epoch 424/800
Epoch 425/800
Epoch 426/800
24/24 [============== ] - 0s 619us/step - loss: 0.0189
Epoch 427/800
Epoch 428/800
24/24 [=============== ] - 0s 523us/step - loss: 0.0189
Epoch 429/800
Epoch 430/800
Epoch 431/800
Epoch 432/800
Epoch 433/800
Epoch 434/800
24/24 [============== ] - 0s 255us/step - loss: 0.0210
Epoch 435/800
Epoch 436/800
Epoch 437/800
Epoch 438/800
Epoch 439/800
Epoch 440/800
Epoch 441/800
24/24 [================ ] - 0s 205us/step - loss: 0.0184
Epoch 442/800
Epoch 443/800
Epoch 444/800
```

Epoch	445/800				
	[=======]	_	0s	276us/step - loss: 0.01	94
	446/800				
	[======] 447/800	-	0s	291us/step - loss: 0.01	86
	[=========]	_	0s	292us/step - loss: 0.019	90
Epoch	448/800			<u>-</u>	
	[=======]	-	0s	316us/step - loss: 0.01	87
	449/800 [=======]	_	۸e	308us/sten = loss: 0 02	Λ 4
	450/800		V.S	300us/scep = 10ss. 0.02	0 1
	[=======]	-	0s	259us/step - loss: 0.02	24
	451/800 [=======]		۸c	296us/sten loss 0 02	1 1
	452/800	_	US	290us/step - 10ss. 0.02	11
24/24	[======]	-	0s	242us/step - loss: 0.02	80
	453/800 [=======]		0~	255/5+5	0.0
	[=====================================	_	US	255us/step - 10ss: 0.018	80
	[======]	_	0s	213us/step - loss: 0.01	86
	455/800		0 -	272/	0 1
	[======] 456/800	_	US	2/3us/step - loss: 0.018	81
	[=======]	_	0s	466us/step - loss: 0.01	79
	457/800		•	500 / 1 3 0 011	
	[======] 458/800	-	0s	608us/step - loss: 0.01	/9
	[========]	_	0s	225us/step - loss: 0.01	82
	459/800				
	[======] 460/800	-	0s	648us/step - loss: 0.01	80
	[========]	_	0s	588us/step - loss: 0.01	78
	461/800				
	[======] 462/800	-	0s	218us/step - loss: 0.01	78
	[========]	_	0s	274us/step - loss: 0.01	81
-	463/800				
	[======] 464/800	-	0s	314us/step - loss: 0.01	79
	[========]	_	0s	367us/step - loss: 0.01	80
	465/800				
	[======] 466/800	-	0s	346us/step - loss: 0.01	89
	[========]	_	0s	343us/step - loss: 0.01	83
	467/800			_	
	[======] 468/800	-	0s	365us/step - loss: 0.02	16
	[========]	_	0s	332us/step - loss: 0.02	29
Epoch	469/800				
	[======] 470/800	-	0s	351us/step - loss: 0.02	03
	[=========]	_	0s	238us/step - loss: 0.019	91
Epoch	471/800				
	[======] 472/800	-	0s	250us/step - loss: 0.019	93
	[=========]	_	0s	255us/step - loss: 0.019	90
	473/800			-	

24/24	[======]	_	0s	260us/step - loss: 0.0177
	474/800			
	[=========]	-	0s	283us/step - loss: 0.0178
	475/800 [=======]	_	۸e	231us/sten = loss 0 0181
	476/800		V.S	231u3/scep - 1035. 0:0101
	[========]	_	0s	299us/step - loss: 0.0178
Epoch	477/800			
	[======]	-	0s	299us/step - loss: 0.0174
	478/800		•	057 / 1 3 0 0176
	[======] 479/800	-	0s	25/us/step - loss: 0.01/6
	[======================================	_	0s	296us/step - loss: 0.0185
	480/800		-	
	[======]	-	0s	262us/step - loss: 0.0187
	481/800			
	[========]	-	0s	487us/step - loss: 0.0203
	482/800 [=======]		Λc	310us/step loss 0 0191
	483/800	_	VS	510us/scep - 10ss. 0.0191
	[=======]	_	0s	248us/step - loss: 0.0181
Epoch	484/800			
	[=====]	-	0s	301us/step - loss: 0.0185
	485/800		0	514/
	[======] 486/800	-	US	514us/step - 10ss: 0.0189
	[========]	_	0s	264us/step - loss: 0.0184
	487/800		0.5	
24/24	[======]	_	0s	394us/step - loss: 0.0173
	488/800			
	[=========]	-	0s	366us/step - loss: 0.0176
_	489/800 [=======]	_	۸c	249us/sten = loss 0 0173
	490/800		OB	2134878669 1088. 0.0173
24/24	[======]	_	0s	196us/step - loss: 0.0173
	491/800			
	[========]	-	0s	288us/step - loss: 0.0171
_	492/800 [=======]	_	۸e	298us/step _ loss
	493/800		V.S	230us/scep - 10ss. 0:01/3
	[=======]	_	0s	225us/step - loss: 0.0177
Epoch	494/800			
	[=======]	-	0s	216us/step - loss: 0.0196
	495/800		٥٩	170::2/2+05 1022 0 0200
	[======] 496/800	_	US	1/9us/step = 10ss: 0.0200
	[========]	_	0s	271us/step - loss: 0.0207
Epoch	497/800			
	[======]	-	0s	233us/step - loss: 0.0195
	498/800		•	004 / 1 3 0 0104
	[======] 499/800	-	0s	284us/step - loss: 0.0194
	[=========]	_	0s	396us/step - loss: 0.0184
	500/800			1000. 0.0101
24/24	[======]	_	0s	243us/step - loss: 0.0170
	501/800			
24/24	[=====]	-	0s	465us/step - loss: 0.0169

Epoch	502/800				
	[========]	_	0s	423us/step - loss: 0.0170)
	503/800				
	[======]	-	0s	339us/step - loss: 0.0181	L
	504/800		۸c	317us/sten loss 0 0185	=
	505/800	_	US	31/us/scep - 10ss. 0.0103	,
	[========]	_	0s	591us/step - loss: 0.0181	1
	506/800				
	[=======]	-	0s	877us/step - loss: 0.0175	5
	507/800 [======]	_	۸c	906us/step = loss 0 0178	2
	508/800		05	J0003/BCCP = 1088: 0:01/C	,
	[======]	_	0s	841us/step - loss: 0.0178	3
	509/800			.== /	
	[======] 510/800	-	0s	4//us/step - loss: 0.0181	L
	[========]	_	0s	312us/step - loss: 0.0192	2
Epoch	511/800			<u>-</u>	
	[======]	-	0s	309us/step - loss: 0.0183	3
	512/800		0 ~	250/	7
	[======] 513/800	_	US	258us/step - 10ss: 0.01//	/
	[=======]	_	0s	442us/step - loss: 0.0166	5
Epoch	514/800			<u>-</u>	
	[======]	-	0s	611us/step - loss: 0.0165	5
	515/800 [======]		Λσ	361us/sten loss 0 0169	a
	516/800	_	US	301us/scep - 10ss. 0.0103	,
	[========]	_	0s	261us/step - loss: 0.0179	9
	517/800				
	[======] 518/800	-	0s	287us/step - loss: 0.0168	3
	[========]	_	0s	227us/step - loss: 0.0177	7
Epoch	519/800				
	[=====]	-	0s	279us/step - loss: 0.0193	3
_	520/800		٥٥	221,127,24.00 1022.000	1
	521/800	_	US	331us/scep - 10ss: 0.0200	,
_	[========]	_	0s	217us/step - loss: 0.0201	1
_	522/800				
	[=======]	-	0s	301us/step - loss: 0.0181	L
_	523/800 [======]	_	0s	309us/step = loss: 0.0173	3
	524/800		Ů.	10505, 5005	
	[======]	-	0s	349us/step - loss: 0.0164	1
	525/800		0	200 / 1 2 0 0165	_
	[======] 526/800	-	US	309us/step - loss: 0.0165)
	[======]	_	0s	194us/step - loss: 0.0165	5
Epoch	527/800				
	[=======]	-	0s	295us/step - loss: 0.0173	3
	528/800 [=======]	_	Λe	183us/sten = loss. 0 0171	1
	529/800	_	va	10345/5ccp - 1055. 0.01/1	-
24/24	[======]	_	0s	279us/step - loss: 0.0174	1
Epoch	530/800				

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Epoch 531/800
Epoch 532/800
Epoch 533/800
Epoch 534/800
Epoch 535/800
Epoch 536/800
Epoch 537/800
24/24 [===============] - 0s 314us/step - loss: 0.0179
Epoch 538/800
Epoch 539/800
Epoch 540/800
Epoch 541/800
Epoch 542/800
Epoch 543/800
Epoch 544/800
24/24 [=============== ] - 0s 424us/step - loss: 0.0183
Epoch 545/800
Epoch 546/800
24/24 [=============== ] - 0s 446us/step - loss: 0.0171
Epoch 547/800
Epoch 548/800
24/24 [============== ] - 0s 496us/step - loss: 0.0156
Epoch 549/800
Epoch 550/800
24/24 [=============== ] - 0s 244us/step - loss: 0.0165
Epoch 551/800
Epoch 552/800
Epoch 553/800
Epoch 554/800
Epoch 555/800
Epoch 556/800
Epoch 557/800
Epoch 558/800
24/24 [============== ] - 0s 323us/step - loss: 0.0190
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Epoch	559/800				
	[=======]	_	0s	286us/step - loss:	0.0178
Epoch	560/800			_	
	[======]	-	0s	590us/step - loss:	0.0169
	561/800				
	[=========]	-	0s	391us/step - loss:	0.0159
	562/800 [======]		٥٥	2/5ug/gton logg.	0 0160
	563/800	_	US	243us/scep - 10ss:	0.0108
	[=======]	_	0s	232us/step - loss:	0.0174
Epoch	564/800			_	
	[]	-	0s	289us/step - loss:	0.0172
	565/800		•		0 0150
	[======================================	_	0s	209us/step - loss:	0.0158
	566/800 [======]	_	۸e	198115/sten - loss.	0 0165
	567/800		V S	170us/scep - 10ss.	0.0103
	[========]	_	0s	247us/step - loss:	0.0175
	568/800				
	[======]	-	0s	254us/step - loss:	0.0167
	569/800		•	241 / 1	0 01 50
	[======] 570/800	-	0s	341us/step - loss:	0.0179
	[=========]	_	0s	273us/sten - loss:	0.0183
	571/800		O D	2/3ub/bccp 1000.	0.0103
	[========]	_	0s	239us/step - loss:	0.0168
	572/800				
	[======]	-	0s	375us/step - loss:	0.0156
	573/800 [======]		0 ~	270/a+an lass.	0 0155
	[=====================================	_	US	2/9us/step - loss:	0.0155
	[========]	_	0s	239us/step - loss:	0.0168
	575/800				
	[======]	_	0s	308us/step - loss:	0.0170
	576/800				
	[======================================	-	0s	293us/step - loss:	0.0169
	577/800 [======]		Λc	306ug/g+on logg.	0 0169
	578/800	_	US	300us/scep - 10ss.	0.0100
	[========]	_	0s	330us/step - loss:	0.0161
Epoch	579/800				
	[=======]	-	0s	362us/step - loss:	0.0179
	580/800		^	222 / 1	0 0174
	[======] 581/800	_	US	333us/step - loss:	0.01/4
	[=========]	_	0s	308us/step - loss:	0.0171
	582/800		0.5	2002 - 20	0001,1
	[=======]	_	0s	211us/step - loss:	0.0180
	583/800				
	[=======]	-	0s	298us/step - loss:	0.0164
	584/800		٥٠	ENErg/gton logge	0 0162
	[======] 585/800	-	υS	Judus/step - 1088:	0.0103
	[=======]	_	0s	255us/step - loss:	0.0154
Epoch	586/800				
	[=======]	-	0s	303us/step - loss:	0.0173
Epoch	587/800				

```
Epoch 588/800
24/24 [============== ] - 0s 300us/step - loss: 0.0151
Epoch 589/800
Epoch 590/800
Epoch 591/800
Epoch 592/800
Epoch 593/800
Epoch 594/800
24/24 [============= ] - 0s 301us/step - loss: 0.0177
Epoch 595/800
Epoch 596/800
Epoch 597/800
24/24 [=============== ] - 0s 344us/step - loss: 0.0161
Epoch 598/800
Epoch 599/800
Epoch 600/800
Epoch 601/800
24/24 [===============] - 0s 1ms/step - loss: 0.0167
Epoch 602/800
Epoch 603/800
Epoch 604/800
Epoch 605/800
24/24 [============== ] - 0s 267us/step - loss: 0.0159
Epoch 606/800
Epoch 607/800
24/24 [=============== ] - 0s 203us/step - loss: 0.0149
Epoch 608/800
24/24 [=============== ] - 0s 343us/step - loss: 0.0173
Epoch 609/800
Epoch 610/800
24/24 [=============== ] - 0s 265us/step - loss: 0.0148
Epoch 611/800
Epoch 612/800
24/24 [===============] - 0s 248us/step - loss: 0.0167
Epoch 613/800
Epoch 614/800
Epoch 615/800
```

Epoch	616/800			
	[========]	_	0s	299us/step - loss: 0.0177
	617/800			
	[======================================	-	0s	408us/step - loss: 0.0184
	618/800 [======]	_	۸e	314us/sten = loss. 0 0162
	619/800		V.S	314d3/30cp = 1033. 0.0102
	[======]	_	0s	309us/step - loss: 0.0162
	620/800			
	[======] 621/800	-	0s	291us/step - loss: 0.0161
	[========]	_	0s	348us/step - loss: 0.0153
Epoch	622/800			-
	[=======]	-	0s	429us/step - loss: 0.0165
	623/800 [======]		Λc	578us/sten loss 0 0173
	624/800		V.S	370d3/3cep - 1035. 0.0173
	[======]	-	0s	237us/step - loss: 0.0157
	625/800 [======]		٥٩	22002/2502 1022 0 0147
	[] 626/800	_	US	328us/step - 10ss: 0.014/
	[=======]	_	0s	219us/step - loss: 0.0146
	627/800		•	
	[======] 628/800	-	US	220us/step - loss: 0.01/3
	[========]	_	0s	312us/step - loss: 0.0149
	629/800			
	[======] 630/800	-	0s	265us/step - loss: 0.0169
	[=======]	_	0s	276us/step - loss: 0.0169
	631/800			
	[======] 632/800	-	0s	226us/step - loss: 0.0163
	[=========]	_	0s	240us/step - loss: 0.0184
Epoch	633/800			-
	[======================================	-	0s	202us/step - loss: 0.0158
_	634/800 [======]	_	0s	222us/step - loss: 0.0159
Epoch	635/800			-
	[=======]	-	0s	792us/step - loss: 0.0141
	636/800 [======]	_	Λq	291us/sten = loss: 0.0142
	637/800		0 D	23145/5005 1055. 0.0112
	[=====]	-	0s	295us/step - loss: 0.0153
	638/800 [=======]		٥٥	329ug/g+on logg. 0 0156
	639/800	_	US	320us/scep - 10ss. 0.0130
24/24	[======]	-	0s	401us/step - loss: 0.0169
	640/800		0~	2544-7-1
	[======] 641/800	_	US	254us/step - 10ss: 0.01/4
	[========]	_	0s	282us/step - loss: 0.0161
	642/800		•	200 / 1
	[======] 643/800	-	υs	280us/step - loss: 0.0163
	[========]	_	0s	270us/step - loss: 0.0162
Epoch	644/800			

24/24	[======]	_	0s	289us/step - loss:	0.0155
	645/800		0	222 / 1	0.0160
	[======] 646/800	-	0s	233us/step - loss:	0.0160
	[=======]	_	0s	220us/step - loss:	0.0160
	647/800				
	[=========]	-	0s	227us/step - loss:	0.0159
	648/800 [=======]	_	0s	215us/step - loss:	0.0155
Epoch	649/800			_	
	[======]	-	0s	303us/step - loss:	0.0142
	650/800 [=======]		Λσ	323ug/g+on logg.	0 0156
	651/800		05	323us/scep - 10ss.	0.0130
	[======]	-	0s	544us/step - loss:	0.0170
	652/800 [=======]		0 ~	202/5+5	0 0167
	[=====================================	-	US	393us/step - loss:	0.016/
	[=======]	_	0s	292us/step - loss:	0.0155
	654/800				
	[======] 655/800	-	0s	226us/step - loss:	0.0163
	[========]	_	0s	244us/step - loss:	0.0158
Epoch	656/800			_	
	[=========]	-	0s	480us/step - loss:	0.0165
	657/800 [=======]	_	0s	401us/step - loss:	0.0160
Epoch	658/800			_	
	[======]	-	0s	828us/step - loss:	0.0155
	659/800 [=======]	_	Λe	67111g/gton _ logg.	0 0150
	660/800		05	0/103/Scep - 1035.	0.0130
	[======]	-	0s	897us/step - loss:	0.0141
	661/800 [=======]		٥٥	222ug/g+on logg.	0 0142
	662/800	_	US	223us/step - 10ss:	0.0142
	[======]	-	0s	304us/step - loss:	0.0155
	663/800		٥٩	226,19/9+07 logg.	0 0150
	[=======] 664/800	_	US	320us/step - loss:	0.0158
24/24	[======]	_	0s	323us/step - loss:	0.0172
	665/800		0	051 / 1 3	0.0150
	[======] 666/800	-	US	251us/step - loss:	0.0152
	[=======]	_	0s	297us/step - loss:	0.0153
	667/800				
	[======] 668/800	-	0s	354us/step - loss:	0.0162
	[=======]	_	0s	266us/step - loss:	0.0178
Epoch	669/800				
	[========]	-	0s	301us/step - loss:	0.0157
	670/800 [=======]	_	0s	255us/step - loss:	0.0149
Epoch	671/800				
	[=========]	-	0s	306us/step - loss:	0.0140
	672/800 [=======]	_	0s	268us/step = loss:	0.0151
	ı J		7.5	_ 1022, 200p 1000.	3.0101

Epoch	673/800					
	[========]	-	0s	336us/step - los	ss:	0.0139
_	674/800			/		
	[=========] 675/800	-	0s	38/us/step - los	5S:	0.0156
	[======================================	ı –	0s	225us/step - los	ss:	0.0155
	676/800	'	• •			010100
	[======================================	-	0s	213us/step - los	ss:	0.0155
	677/800	_	•	225 / 1		0.0150
	[=====================================	-	0s	335us/step - los	ss:	0.0150
	[======================================	۱ –	0s	245us/step - los	ss:	0.0161
Epoch	679/800					
	[======]	-	0s	267us/step - los	ss:	0.0187
	680/800 [===================================		0~	224/5+5		0 0153
	681/800	-	US	324us/step - 10	35:	0.0153
	[========]	۱ –	0s	349us/step - los	ss:	0.0146
Epoch	682/800					
	[========]	-	0s	285us/step - los	ss:	0.0139
	683/800 [===================================		٥٥	270ug/g+op log		0 0164
	684/800	-	US	2/9us/scep - 10:	55.	0.0104
	[=========]	-	0s	294us/step - los	ss:	0.0165
	685/800					
	[======================================	-	0s	285us/step - los	ss:	0.0166
	686/800 [===================================	ı _	۸e	35511g/gton _ los	cc•	0 0156
	687/800	_	V.S	333db/bccp - 10.	55.	0.0130
	[======================================	-	0s	246us/step - los	ss:	0.0161
	688/800					
	[=====================================	-	0s	503us/step - los	ss:	0.0154
	[======================================	۱ –	0s	245us/step - los	ss:	0.0150
	690/800	•				
	[======================================	-	0s	296us/step - los	ss:	0.0162
_	691/800 [===================================		٥٥	265ug/gtop lo		0 0167
	692/800	-	US	200us/scep - 10:	55.	0.0107
	[======================================	-	0s	324us/step - los	ss:	0.0149
	693/800					
	[======================================	-	0s	311us/step - los	ss:	0.0152
	694/800 [===================================		۸e	25811g/gten = 100	cc •	0 0150
	695/800	_	V.S	250d5/5ccp - 10.	55.	0.0130
	[======================================	-	0s	291us/step - los	ss:	0.0157
	696/800	_				
	[=====================================	-	0s	286us/step - los	ss:	0.0156
	[==========]	ı –	0s	193us/step - los	ss:	0.0162
Epoch	698/800					
	[======================================	-	0s	279us/step - los	ss:	0.0151
	699/800 [===================================		0~	320ug/gton 1	a a -	0 0152
	700/800	ı –	US	320us/step - 109	556	0.0132
	[========]	-	0s	583us/step - los	ss:	0.0142
	701/800			-		

24/24	[======]	_	0s	563us/step	_	loss:	0.0144
	702/800		0 -	200/		1	0.0150
	[======] 703/800	-	0s	389us/step	_	loss:	0.0150
	[========]	_	0s	417us/step	_	loss:	0.0157
	704/800					_	
	[======] 705/800	-	0s	527us/step	-	loss:	0.0152
	[=========]	_	0s	532us/step	_	loss:	0.0161
Epoch	706/800			_			
	[=======]	-	0s	754us/step	-	loss:	0.0156
	707/800	_	0s	224us/step	_	loss:	0.0156
Epoch	708/800			_			
	[======]	-	0s	279us/step	-	loss:	0.0153
	709/800	_	Λc	25911g/g+an	_	1000	0 0162
	710/800		05	237d3/5cep	_	1055.	0.0102
	[======]	-	0s	305us/step	-	loss:	0.0151
	711/800		٥٥	221ug/g+on		1000.	0 0154
	712/800	_	05	331us/scep	_	1055:	0.0154
24/24	[======]	_	0s	256us/step	-	loss:	0.0151
	713/800		0 ~	222		1	0 0157
	714/800	_	US	323us/step	_	1055:	0.0157
24/24	[======]	_	0s	426us/step	-	loss:	0.0147
	715/800		0	220/		1	0 0147
	[======] 716/800	_	US	239us/step	_	loss:	0.014/
	[======]	_	0s	246us/step	_	loss:	0.0141
	717/800		•	241 / .		-	0 0155
	[======] 718/800	-	0s	341us/step	-	loss:	0.015/
	[=======]	_	0s	222us/step	_	loss:	0.0161
	719/800		•	000 / 1		-	0 0150
	[======] 720/800	-	0s	209us/step	-	loss:	0.0158
	[=======]	_	0s	271us/step	_	loss:	0.0156
	721/800		•	005 / 1		-	0 0155
	[======] 722/800	-	0s	225us/step	-	loss:	0.0157
	[=======]	_	0s	314us/step	_	loss:	0.0154
	723/800		•	400 / 1		-	0 0140
	[======] 724/800	-	0s	439us/step	-	loss:	0.0148
	[========]	_	0s	277us/step	_	loss:	0.0152
	725/800			_		_	
	[======] 726/800	-	0s	242us/step	-	loss:	0.0152
	[=========]	_	0s	286us/step	_	loss:	0.0152
Epoch	727/800						
	[======] 728/800	-	0s	337us/step	-	loss:	0.0153
	[=========]	_	0s	278us/step	_	loss:	0.0148
Epoch	729/800						
24/24	[=====]	-	0s	350us/step	-	loss:	0.0149

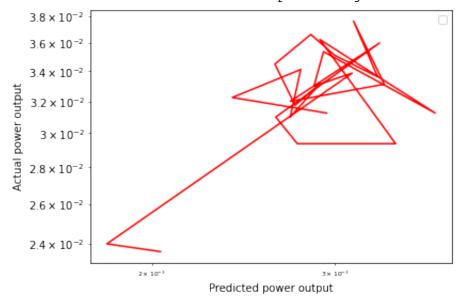
	730/800				
	[=======]	_	0s	209us/step - loss:	0.0151
_	731/800	ı	۸c	229us/sten loss.	0 0152
	732/800	_	US	229us/step - 10ss:	0.0132
	[========]	_	0s	264us/step - loss:	0.0154
	733/800				
	[======] 734/800	_	0s	226us/step - loss:	0.0154
	[==========]	_	0s	253us/step - loss:	0.0152
Epoch	735/800				
	[======================================	_	0s	485us/step - loss:	0.0148
	736/800	_	Λς	633us/sten = loss:	0.0153
	737/800		Ů.	10000	0.0130
	[_	0s	237us/step - loss:	0.0152
	738/800		٥٩	27/119/9+09 1099	0 0150
	739/800	_	US	2/4us/step - loss:	0.0150
	[========]	_	0s	212us/step - loss:	0.0150
	740/800				
	[=======] 741/800	_	0s	225us/step - loss:	0.0153
	[===========]	_	0s	200us/step - loss:	0.0162
Epoch	742/800				
	[======================================	_	0s	248us/step - loss:	0.0148
	743/800 [========]	_	۸e	19611s/sten - loss.	0 0145
	744/800		0 D	13045/5005 1055.	0.0113
	[========]	_	0s	226us/step - loss:	0.0140
	745/800 [=======]		۸a	270ug/g+on logg.	0 0152
	746/800	_	US	2/9us/step - 10ss:	0.0132
24/24	[=======]	_	0s	262us/step - loss:	0.0154
_	747/800		0 -	222/	0 0157
	[=========] 748/800	_	US	323us/step - loss:	0.015/
_	[=========]	_	0s	550us/step - loss:	0.0150
	749/800				
	[======] 750/800	-	0s	224us/step - loss:	0.0155
	[========]	_	0s	315us/step - loss:	0.0148
Epoch	751/800				
	[======] 752/800	_	0s	262us/step - loss:	0.0148
	[==========]	_	0s	220us/step - loss:	0.0150
Epoch	753/800				
	[========]	_	0s	366us/step - loss:	0.0161
	754/800 [=========]	_	Λe	263ug/gten _ logg.	0 0154
	755/800		V.S	203u3/5ccp - 1055.	0.0154
	[========]	_	0s	314us/step - loss:	0.0160
	756/800 [=========]		0.0	22/11g/g+on logg:	0 0144
	757/800	_	US	22409/5CEP - 1055:	0.0144
24/24	[=======]	_	0s	263us/step - loss:	0.0137
Epoch	758/800				

Epoch	[======] 759/800				
	[======] 760/800	-	0s	235us/step - loss: 0	0.0150
24/24	[======]	-	0s	336us/step - loss: 0	0.0153
	761/800 [========]	_	0s	280us/step - loss: (0.0152
	762/800	_	0s	292115/sten - loss: (0.0144
Epoch	763/800			_	
Epoch	[=======] 764/800			_	
	[======] 765/800	-	0s	264us/step - loss: 0	0.0150
24/24	[======]	_	0s	271us/step - loss: 0	0.0158
	766/800	_	0s	500us/step - loss: (0.0145
Epoch	767/800 [=======]			_	
Epoch	768/800			_	
	[======] 769/800	-	0s	266us/step - loss: (0.0138
24/24	[======]	-	0s	348us/step - loss: 0	0.0145
	770/800	_	0s	319us/step - loss: (0.0152
	771/800		٥٥	261ug/gton logg. (0 0160
Epoch	772/800				
	[======] 773/800	-	0s	258us/step - loss: (0.0153
24/24	[======]	-	0s	414us/step - loss: 0	0.0159
	774/800 [==========]	_	0s	406us/step - loss: (0.0152
	775/800	_	Λς	310us/sten = loss. (0158
Epoch	776/800			_	
	[=======] 777/800	-	0s	272us/step - loss: (0.0142
	[=======] 778/800	-	0s	295us/step - loss: (0.0149
24/24	[======]	_	0s	486us/step - loss: (0.0145
_	779/800	_	0s	283us/step - loss: (0.0149
Epoch	780/800			_	
Epoch	[=======] 781/800			_	
	[=======] 782/800	-	0s	262us/step - loss: 0	0.0155
24/24	[======]	_	0s	409us/step - loss: 0	0.0146
	783/800 [=======]	_	0s	262us/step - loss: (0.0153
Epoch	784/800 [======]				
Epoch	785/800				
	[=======] 786/800	-	0s	306us/step - loss: (0.0152
_	[======]	-	0s	598us/step - loss: (0.0148

```
Epoch 787/800
Epoch 788/800
24/24 [=============== ] - 0s 791us/step - loss: 0.0146
Epoch 789/800
Epoch 790/800
24/24 [============= ] - 0s 483us/step - loss: 0.0144
Epoch 791/800
24/24 [=============== ] - 0s 300us/step - loss: 0.0144
Epoch 792/800
Epoch 793/800
Epoch 794/800
Epoch 795/800
24/24 [=============== ] - 0s 236us/step - loss: 0.0145
Epoch 796/800
Epoch 797/800
Epoch 798/800
Epoch 799/800
24/24 [============== ] - 0s 299us/step - loss: 0.0147
Epoch 800/800
24/24 [=========== ] - 0s 509us/step - loss: 0.0148
best epoch = 767
smallest loss = 0.013608266599476337
```

```
In [27]:
          # Task 1.3 Part e
          from sklearn import metrics
          # This line of code can be used to reconstruct the saved model. The name of t
          recon_model2 = keras.models.load_model("best_model2")
          import matplotlib.pyplot as plt
          y_predict = []
          Wdotpred = []
          Wdotorig = []
          for i in range(len(X trainn)):
              test = [[X_trainn[i][0], X_trainn[i][1], X_trainn[i][2]]]
              testarray = np.array(test)
              a3 = recon_model2.predict(testarray)
              y_predict.append([a3[0][0], a3[0][1]])
              Wdotpred.append([a3[0][1]])
              Wdotorig.append([y_trainn[i][1]])
          plt.figure()
          plt.loglog(Wdotpred, Wdotorig, c='r')
          plt.xlabel("Predicted power output")
          plt.ylabel("Actual power output")
          plt.legend()
          plt.tight layout()
          plt.show()
          #MAE of predicted vs test data
          mae_Wdot = metrics.mean_absolute_error(Wdotpred, Wdotorig)
          mae Vl = metrics.mean_absolute_error(y predict[:][1],y_trainn[:][1])
          print('mean absolute error between predictions and the collection of test dat
```

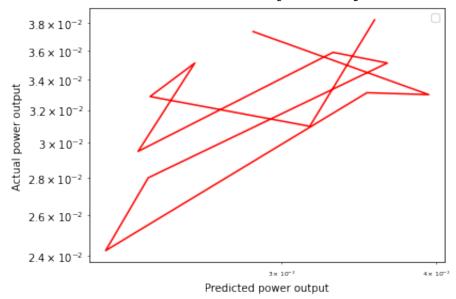
No handles with labels found to put in legend.



mean absolute error between predictions and the collection of test data: Vl = 0.10512211718410257 Wdot = 0.004687307881812254

```
In [28]:
          # Task 1.3 Part f
          # This line of code can be used to reconstruct the saved model. The name of t
          recon model2 = keras.models.load model("best model2")
          import matplotlib.pyplot as plt
          y predictn = []
          y traino = []
          Wdotpred2 = []
          Wdotorig2 = []
          for i in range(len(X testn)):
              testn = [[X_testn[i][0], X_testn[i][1], X_testn[i][2]]]
              testarrayn = np.array(testn)
              a3 = recon_model2.predict(testarrayn)
              y predictn.append([a3[0][0], a3[0][1]])
              Wdotpred2.append([a3[0][1]])
              y_traino.append([y_testn[i][0], y_testn[i][1]])
              Wdotorig2.append([y_testn[i][1]])
          plt.figure()
          plt.loglog(Wdotpred2, Wdotorig2, c='r')
          plt.rc('xtick', labelsize=6)
          plt.xlabel("Predicted power output")
          plt.ylabel("Actual power output")
          plt.legend()
          plt.tight layout()
          plt.show()
          #MAE of predicted vs test data
          mae_Wdot = metrics.mean_absolute_error(Wdotpred2, Wdotorig2)
          mae V1 = metrics.mean absolute error(y predictn[:][1],y traino[:][1])
          print('mean absolute error between predictions and the collection of test date
```

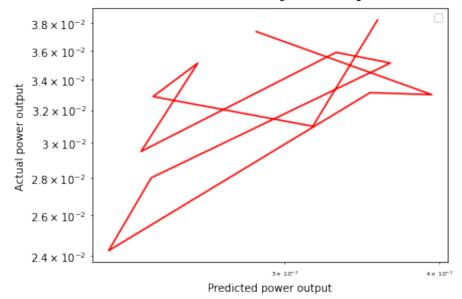
No handles with labels found to put in legend.



mean absolute error between predictions and the collection of test data: Vl = 0.023546777188777915 Wdot = 0.004787884597977001

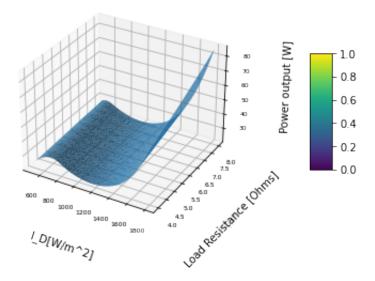
```
In [29]:
         # Task 1.3 Part q
          # This line of code can be used to reconstruct the saved model. The name of t
          recon model2 = keras.models.load model("best model2")
          import matplotlib.pyplot as plt
          y predicthn = []
          y train = []
          Wdotpredh = []
          Wdotorigh = []
          for i in range(len(xarrayhn)):
              testhn = [[xarrayhn[i][0], xarrayhn[i][1], xarrayhn[i][2]]]
              testarrayhn = np.array(testhn)
              a3 = recon_model2.predict(testarrayhn)
              y_predicthn.append([a3[0][0], a3[0][1]])
              Wdotpredh.append([a3[0][1]])
              y_train.append([yarrayhn[i][0], yarrayhn[i][1]])
              Wdotorigh.append([yarrayhn[i][1]])
          plt.figure()
          plt.loglog(Wdotpred2, Wdotorig2, c='r')
          plt.rc('xtick', labelsize=6)
          plt.xlabel("Predicted power output")
          plt.ylabel("Actual power output")
          plt.legend()
          plt.tight layout()
          plt.show()
          #MAE of predicted vs test data
          mae_Wdot = metrics.mean_absolute_error(Wdotpredh,Wdotorigh)
          mae V1 = metrics.mean absolute error(y predicthn[:][1],y train[:][1])
          print('mean absolute error between predictions and the collection of test date
```

No handles with labels found to put in legend.



mean absolute error between predictions and the collection of test data: Vl = 2.2440235184724715 Wdot = 0.9700400130823255

```
In [30]:
          #Task1.3 part h
          import matplotlib.pyplot as plt
          import numpy as np
          fig = plt.figure()
          ax = plt.axes(projection='3d')
          X = np.linspace(500, 1800) #Id
          Y = np.linspace(4, 8) \#R1
          Zp = []
          Xp = []
          Yp = []
          Tair = 20
          testdata = []
          Tn = Tair/medTair
          Xn = X/medId
          Yn = Y/medRl
          for x in range(len(Xn)):
              for y in range(len(Yn)):
                  testdata.append([Tn, Xn[x], Yn[y]])
                  Xp.append(Xn[x]*medId)
                  Yp.append(Yn[y]*medRl)
          for x in range(len(testdata)):
              test = [[testdata[x][0], testdata[x][1], testdata[x][2]]]
              testarray = np.array(test)
              outptn = recon_model2.predict(testarray)
              Zp.append(outptn[0][1]*medWdot)
          surf = ax.plot_trisurf(Xp, Yp, Zp)
          fig.colorbar(surf, shrink=0.5, aspect=5, pad=0.2)
          ax.set_zlabel('Power output [W]', rotation=60)
          ax.set_ylabel('Load Resistance [Ohms]')
          ax.set_xlabel('I_D[W/m^2]', rotation=150)
          ax.xaxis.labelpad=15
          ax.yaxis.labelpad=15
          ax.zaxis.labelpad=15
          plt.show()
```



```
In [4]:
         #Task2.1 Part a
         import math, numpy
         #Part 2 input data: Air temp (degC), ID (W/sqm), load resistance (ohms)
         # - split into a training set and a small (~10) randomly selected validation
         xdata = [[10.0, 200.0, 24.3],
          [10.0, 200.0, 51.8],
          [10.0, 200.0, 96.2],
          [10.0, 200.0, 133.2],
          [10.0, 200.0, 170.1],
          [10.0, 500.0, 7.0],
          [10.0, 500.0, 21.2],
          [10.0, 500.0, 43.2],
          [10.0, 500.0, 61.2],
          [10.0, 500.0, 79.1],
          [10.0, 700.0, 4.9],
          [10.0, 700.0, 14.3],
          [10.0, 700.0, 29.7],
          [10.0, 700.0, 42.9],
          [10.0, 700.0, 55.3],
          [10.0, 1000.0, 3.92],
          [10.0, 1000.0, 11.7],
          [10.0, 1000.0, 25.2],
          [10.0, 1000.0, 33.4],
          [10.0, 1000.0, 41.6],
          [18.1, 500.0, 7.0],
          [18.5, 500.0, 21.2],
          [19.0, 500.0, 43.2],
          [18.6, 500.0, 61.2],
          [18.8, 500.0, 79.1],
          [2.1, 1000.0, 3.92],
          [2.0, 1000.0, 11.7],
          [1.9, 1000.0, 25.2],
          [2.3, 1000.0, 33.4],
```

```
[2.4, 1000.0, 41.6],
 [0.5, 700.0, 4.9],
 [0.7, 700.0, 14.3],
 [1.0, 700.0, 29.7],
 [0.8, 700.0, 42.9],
 [0.2, 700.0, 55.3],
 [15.2, 200.0, 24.3],
 [15.4, 200.0, 51.8],
 [21.2, 1000.0, 3.92],
 [19.4, 1000.0, 11.7],
 [19.2, 1000.0, 25.2]]
#Part 2 output data: Mode providing maximum power outp, VL (V) and Power out
ydata = [[1.0, 46.1, 87.1],
 [2.0, 92.1, 163.9],
 [3.0, 110.6, 127.2],
 [3.0, 147.5, 163.5],
 [3.0, 184.3, 199.7],
 [1.0, 48.4, 335.3],
 [2.0, 96.9, 442.9],
 [3.0, 128.7, 383.6],
 [3.0, 161.3, 429.2],
 [3.0, 193.8, 474.8],
 [1.0, 49.3, 496.1],
 [2.0, 98.6, 680.0],
 [3.0, 124.1, 518.9],
 [3.0, 160.7, 611.2],
 [3.0, 197.2, 703.4],
 [1.0, 50.8, 659.0],
 [2.0, 101.65, 883.1],
 [3.0, 148.7, 877.2],
 [3.0, 176.0, 935.4],
 [3.0, 203.3, 993.5],
 [1.0, 47.6, 327.0],
 [2.0, 96.1, 432.3],
 [3.0, 127.9, 374.4],
 [3.0, 160.5, 418.9],
 [3.0, 193.0, 463.4],
 [1.0, 50.0, 674.7],
 [2.0, 100.9, 904.3],
 [3.0, 147.9, 898.3],
 [3.0, 175.2, 957.8],
 [3.0, 202.4, 1017.3],
 [1.0, 50.3, 511.0],
 [2.0, 100.6, 700.4],
 [3.0, 125.1, 534.5],
 [3.0, 161.7, 629.5],
 [3.0, 198.2, 724.5],
 [1.0, 45.6, 85.8],
 [2.0, 91.5, 161.4],
 [1.0, 49.8, 639.2],
```

```
[2.0, 100.6, 856.6],
 [3.0, 147.7, 850.9] ]
xarray= numpy.array(xdata)
yarray= numpy.array(ydata)
Mmaxm = []
Vlm = []
Wdotm = []
Tairm =[]
Idm = []
Rlm = []
for x in range(len(xarray)):
    Tairm.append(xarray[x][0])
    Idm.append(xarray[x][1])
    Rlm.append(xarray[x][2])
for y in range(len(yarray)):
    Mmaxm.append(yarray[y][0])
    Vlm.append(yarray[y][1])
    Wdotm.append(yarray[y][2])
medTairm = median(Tairm)
medIdm = median(Idm)
medRlm = median(Rlm)
medVlm = median(Vlm)
medWdotm = median(Wdotm)
medMmaxm = median(Mmaxm)
Tairmn = Tairm/medTairm
Idmn = Idm/medIdm
Rlmn = Rlm/medRlm
Vlmn = Vlm/medVlm
Wdotmn = Wdotm/medWdotm
Mmaxmn = Mmaxm/medMmaxm
xarraymn = np.column_stack((Tairmn, Idmn, Rlmn))
yarraymn = np.column stack((Mmaxmn, Vlmn, Wdotmn))
print(xarraymn)
print(yarraymn)
[[1.
             0.28571429 0.818181821
[1.
             0.28571429 1.744107741
[1.
             0.28571429 3.239057241
             0.28571429 4.484848481
[1.
             0.28571429 5.727272731
[1.
             0.71428571 0.235690241
[1.
[1.
             0.71428571 0.71380471]
[1.
             0.71428571 1.454545451
             0.71428571 2.06060606]
[1.
[1.
             0.71428571 2.66329966]
```

1.

0.164983161

[1.

[1. [1. [1. [1. [1. [1.]	1. 1. 1. 1. 1. 1. 1. 1. 1.42857143 1.42857143 1.42857143 1.42857143 0.71428571 0.71428571 0.71428571 0.71428571 1.42857143 1.42857143 1.42857143 1.42857143 1.42857143 1.42857143 1.42857143 1.42857143 1.42857143 1.42857143 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.	0.48148148] 1.
[1.		-
[1.	1.18699839	1.70552497]

```
1.40609952 1.8184925 ]
         [1.
                      1.62439807 1.931460031
         [1.
          [0.33333333 0.40369181 0.97019176]
         [0.66666667 0.80738363 1.32978925]
                      1.00401284 1.014809191
                      1.29775281 1.19517752]
         [1.
         [1.
                      1.59069021 1.37554585]
         [0.33333333 0.36597111 0.16290108]
         [0.66666667 0.73434992 0.3064363 ]
         [0.33333333 0.39967897 1.21359408]
         [0.66666667 0.80738363 1.62635276]
                      1.18539326 1.61553066]]
In [5]:
         #Task 2.1 Part b
         from sklearn.model selection import train test split
         X_train2, X_test2, y_train2, y_test2 = train_test_split(xarraymn, yarraymn, te
         print(X train2)
         print(y train2)
         print(X_test2)
         print(y_test2)
         [[0.21
                      1.42857143 0.131986531
                      0.71428571 2.66329966]
         [1.
         [1.
                                 1.44444441
         [0.07
                                  0.48148148]
                      1.
         [0.02
                      1.
                                  1.86195286]
         [1.
                      0.71428571 2.060606061
         [1.
                      1.42857143 0.84848485]
         [1.88
                      0.71428571 2.66329966]
                      0.28571429 0.81818182]
         [1.
         80.0]
                                  1.44444441
                      0.71428571 0.23569024]
         [1.
         [1.
                                  0.481481481
                      0.28571429 1.74410774]
         [1.
                      1.42857143 1.4006734 ]
         [0.24
                      0.71428571 0.71380471]
         [1.85]
         [1.
                      0.28571429 3.23905724]
         [0.05
                                  0.164983161
         [1.54]
                      0.28571429 1.74410774]
         [1.
                      0.28571429 4.484848481
         [1.52
                      0.28571429 0.81818182]
         [1.86
                      0.71428571 2.060606061
         [0.1
                      1.
                                  1.
         [1.
                                  0.164983161
                      1.
                      0.71428571 1.45454545]
         [1.9]
         [1.
                      1.42857143 1.124579121
                      0.71428571 0.23569024]
         [1.81
         [1.
                      0.71428571 1.45454545]
         [1.
                                  1.861952861
         [0.23
                      1.42857143 1.12457912]
         [1.94
                      1.42857143 0.393939391]
         [[0.33333333 0.40128411 1.28099487]
         [1.
                      1.55537721 0.90146193
```

```
1.28972713 1.160432881
[0.66666667 0.80738363 1.32978925]
             1.59069021 1.375545851
[1.
             1.29454254 0.814885131
[1.
             1.19341894 1.665464211
             1.54895666 0.87981773]
[1.
[0.33333333 0.36998395 0.16536928]
             1.29775281 1.195177521
[0.33333333 0.38844302 0.63660528]
[0.66666667 0.79133226 1.29105753]
[0.66666667 0.73916533 0.31118284]
             1.62439807 1.931460031
[0.66666667 0.77126806 0.82077084]
             0.88764045 0.2415037 1
[0.33333333 0.40369181 0.97019176]
[0.66666667 0.73434992 0.3064363 ]
             1.18378812 0.31042339]
[0.33333333 0.36597111 0.16290108]
[1.
             1.28812199 0.795329411
             1.00401284 1.014809191
[0.33333333 0.39566613 0.94190241]
[1.
             1.02648475 0.710841091
             1.41252006 1.77596355]
[0.33333333 0.38202247 0.62084678]
[1.
             1.0329053 0.728308331
             1.58266453 1.3354851 ]
[1.
             1.40609952 1.8184925 ]
[0.66666667 0.80738363 1.62635276]]
[[1.
             1.42857143 1.4006734 ]
             1.42857143 0.393939391
[1.
             1.42857143 0.131986531
[1.
             1.42857143 0.393939391
[0.2
[1.
             0.28571429 5.727272731
[1.
                        1.
[2.12
            1.42857143 0.131986531
             1.42857143 0.84848485]
[0.19
             1.42857143 0.84848485]
[1.92
[1.
             0.71428571 0.71380471]]
             1.63162119 1.88627302]
[[1.
[0.66666667 0.81581059 1.67666603]
[0.33333333 0.40770465 1.25118663]
[0.66666667 0.80979133 1.71691665]
             1.47913323 0.379153221
[1.
[1.
             0.99598716 0.98519081]
[0.33333333 0.39967897 1.21359408]
[1.
             1.18699839 1.70552497]
             1.18539326 1.615530661
[0.66666667 0.7776886 0.84089615]]
```

```
In [257...
         # define neural network model
         from keras import backend as K
         #initialize weights
         initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)
         modelv3 = keras.Sequential([
             keras.layers.Dense(16, activation=K.elu, input shape=[3], kernel initial
             keras.layers.Dense(32, activation=K.elu, kernel initializer=initializer)
             keras.layers.Dense(16, activation=K.elu, kernel_initializer=initializer),
             keras.layers.Dense(16, activation=K.elu, kernel initializer=initializer)
             keras.layers.Dense(3, kernel initializer=initializer)
           1)
In [269...
         #from tf.keras import optimizers
         rms = keras.optimizers.RMSprop(0.0001)
         modelv3.compile(loss='mean absolute error',optimizer=rms)
In [272...
         # Add an early stopping callback
         es = keras.callbacks.EarlyStopping(
             monitor='loss',
             mode='min',
             patience = 80,
             restore best weights = True,
             verbose=1)
         # Add a checkpoint where loss is minimum, and save that model
         mc = keras.callbacks.ModelCheckpoint('best model3.SB', monitor='loss',
                              mode='min', verbose=1, save best only=True)
         historyData = modelv3.fit(X_train2,y_train2,epochs=800,callbacks=[es])
         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))
         modelv3.save('./best model3')
         Epoch 1/800
         30/30 [============== ] - 0s 311us/step - loss: 0.0279
         Epoch 2/800
         30/30 [=============== ] - 0s 225us/step - loss: 0.0285
         Epoch 3/800
         30/30 [============= ] - 0s 276us/step - loss: 0.0283
         Epoch 4/800
         30/30 [============= ] - 0s 246us/step - loss: 0.0278
         Epoch 5/800
         30/30 [================ ] - 0s 186us/step - loss: 0.0277
         Epoch 6/800
```

```
30/30 [============== ] - 0s 208us/step - loss: 0.0274
Epoch 7/800
Epoch 8/800
Epoch 9/800
Epoch 10/800
30/30 [============== ] - 0s 213us/step - loss: 0.0278
Epoch 11/800
Epoch 12/800
30/30 [============== ] - 0s 267us/step - loss: 0.0286
Epoch 13/800
30/30 [============== ] - 0s 261us/step - loss: 0.0279
Epoch 14/800
30/30 [============== ] - 0s 263us/step - loss: 0.0279
Epoch 15/800
Epoch 16/800
30/30 [============= ] - 0s 252us/step - loss: 0.0278
Epoch 17/800
30/30 [=============== ] - 0s 673us/step - loss: 0.0281
Epoch 18/800
30/30 [============= ] - 0s 622us/step - loss: 0.0272
Epoch 19/800
Epoch 20/800
30/30 [============== ] - 0s 188us/step - loss: 0.0273
Epoch 21/800
Epoch 22/800
30/30 [=============== ] - 0s 188us/step - loss: 0.0277
Epoch 23/800
30/30 [============== ] - 0s 217us/step - loss: 0.0279
Epoch 24/800
30/30 [============= ] - 0s 254us/step - loss: 0.0286
Epoch 25/800
30/30 [============== ] - 0s 193us/step - loss: 0.0283
Epoch 26/800
30/30 [============= ] - 0s 205us/step - loss: 0.0292
Epoch 27/800
30/30 [============= ] - 0s 224us/step - loss: 0.0284
Epoch 28/800
30/30 [============== ] - 0s 213us/step - loss: 0.0284
Epoch 29/800
30/30 [============= ] - 0s 204us/step - loss: 0.0278
Epoch 30/800
Epoch 31/800
30/30 [============== ] - 0s 533us/step - loss: 0.0278
Epoch 32/800
30/30 [=============== ] - 0s 310us/step - loss: 0.0270
Epoch 33/800
Epoch 34/800
30/30 [============== ] - 0s 183us/step - loss: 0.0275
```

Epoch	35/800				
	[========]	_	0s	212us/step - loss: 0.0283	3
	36/800				
	[=========]	-	0s	181us/step - loss: 0.028	7
	37/800 [======]	_	Λς	171us/step = loss: 0.0278	8
	38/800		V.S	1/1us/scep = 1055: 0:02/0	,
	[=======]	_	0s	193us/step - loss: 0.0296	5
	39/800				_
	[=======] 40/800	_	0s	161us/step - loss: 0.0282	2
	[==========]	_	0s	172us/step - loss: 0.0284	4
Epoch	41/800			<u>-</u>	
	[======]	-	0s	160us/step - loss: 0.027	7
	42/800 [=======]		٥٥	157ug/gton logg. 0 0279	0
	43/800	_	US	13/us/step - 10ss: 0.02/)
	[=========]	_	0s	196us/step - loss: 0.0284	4
	44/800				
	[======] 45/800	-	0s	271us/step - loss: 0.0281	1
	[==========]	_	0s	227us/step - loss: 0.027	7
Epoch	46/800			<u>-</u>	
	[=======]	-	0s	210us/step - loss: 0.0274	4
	47/800 [=======]	_	Λq	185us/step = loss: 0.0273	2
	48/800		0 D	10348/ 5009 1088: 0.02/2	-
	[=======]	_	0s	179us/step - loss: 0.0269	9
	49/800 [=======]		٥a	157ug/gton logg. 0 027	1
	50/800	_	US	15/us/step - 10ss: 0.02/	±
	[========]	_	0s	204us/step - loss: 0.0274	4
	51/800		•	160 / 1 2 0 000	_
	[======] 52/800	_	US	160us/step - loss: 0.02/	/
	[========]	_	0s	184us/step - loss: 0.0278	3
-	53/800				
	[=======] 54/800	-	0s	165us/step - loss: 0.028	7
	[===========]	_	0s	167us/step - loss: 0.028	7
Epoch	55/800				
	[========]	-	0s	160us/step - loss: 0.0278	3
	56/800 [=======]	_	۸e	163us/sten = loss: 0 0290	n
	57/800		0 D	10345/5002	,
	[=======]	_	0s	159us/step - loss: 0.027	7
	58/800 [=========]		٥٩	16199/9409 1099 0 0275	=
	59/800	_	US	161us/step - 10ss: 0.02/)
	[========]	_	0s	181us/step - loss: 0.0278	3
	60/800		•	0.75 / 1 2 0 0.75	_
	[======] 61/800	-	0s	2/5us/step - loss: 0.02/8	3
	[==========]	_	0s	414us/step - loss: 0.0269	9
Epoch	62/800				
	[=========]	-	0s	152us/step - loss: 0.0269)
гьоси	63/800				

30/30	[======]	_	0s	214us/step - loss: 0.027	3
	64/800				
	[========]	-	0s	176us/step - loss: 0.027	9
	65/800 [======]	_	۸c	2021s/sten = loss. 0 028	5
	66/800		V.S	20243/SCEP - 1033: 0:020	,
	[=======]	_	0s	167us/step - loss: 0.028	6
	67/800				
	[=======]	-	0s	188us/step - loss: 0.029	2
	68/800 [=======]	_	۸e	166us/sten _ loss. 0 028	4
	69/800		UB	1000375000 - 1055. 0.020	-
	[======]	_	0s	199us/step - loss: 0.028	2
	70/800				
	[======================================	-	0s	163us/step - loss: 0.027	6
	71/800 [=========]	_	۸e	186us/sten = loss. 0 027	3
	72/800		V S	100d3/Scep - 1033. 0.02/	,
	[======]	_	0s	187us/step - loss: 0.027	6
	73/800				
	[======================================	-	0s	189us/step - loss: 0.026	9
	74/800 [=======]	_	۸c	186us/sten = loss. 0 026	9
	75/800		05	1000375009 - 1055. 0.020	
	[======]	_	0s	173us/step - loss: 0.027	7
_	76/800				
	[=======]	-	0s	201us/step - loss: 0.028	2
_	77/800 [======]	_	0 s	280us/sten = loss: 0.028	2
	78/800		O D	2004575005 1055. 0.020	_
30/30	[======]	_	0s	325us/step - loss: 0.028	1
_	79/800				
	[=======] 80/800	-	0s	409us/step - loss: 0.029	0
	[=======]	_	0s	519us/step - loss: 0.027	7
	81/800				
	[======]	-	0s	298us/step - loss: 0.027	9
_	82/800		0	246/	7
	[=======] 83/800	-	0S	346us/step - loss: 0.02/	/
	[=======]	_	0s	315us/step - loss: 0.027	6
Epoch	84/800				
	[======]	-	0s	309us/step - loss: 0.027	8
	85/800		0 ~	270/=+== 1 0.027	2
	[======] 86/800	_	US	2/8us/step - loss: 0.02/	2
	[=======]	_	0s	168us/step - loss: 0.027	3
Epoch	87/800				
	[======]	-	0s	204us/step - loss: 0.027	4
	88/800 [=======]		٥٥	196ug/gton logg. 0 029	1
	89/800	_	05	100us/step - 10ss: 0.020	4
	[========]	_	0s	194us/step - loss: 0.029	0
Epoch	90/800				
	[========]	-	0s	247us/step - loss: 0.027	9
	91/800 [======]		Λe	278us/stan _ loss. 0 020	1
30/30	[]	_	UB	2/005/50ep - 1055: 0.020	_

Epoch	92/800			
30/30	[======]	_	0s	214us/step - loss: 0.0282
	93/800		•	
	[======] 94/800	-	0s	242us/step - loss: 0.0280
	[=======]	_	0s	142us/step - loss: 0.0278
Epoch	95/800			
	[=======]	-	0s	168us/step - loss: 0.0276
	96/800 [======]	_	0s	206us/step - loss: 0.0281
Epoch	97/800			_
	[=======]	-	0s	209us/step - loss: 0.0272
	98/800 [=======]	_	0s	193us/step - loss: 0.0273
Epoch	99/800			
	[======]	-	0s	232us/step - loss: 0.0281
	100/800 [=========]		۸c	156ug/gton logg: 0 0275
	101/800	_	US	130ds/scep = 10ss. 0.02/3
30/30	[======]	-	0s	235us/step - loss: 0.0275
	102/800 [========]		٥٩	200000/0500 10000 0 0275
	103/800	_	US	208us/step - 10ss: 0.02/5
30/30	[======]	_	0s	353us/step - loss: 0.0281
	104/800		•	202 / 1 2 2 222
	[======] 105/800	-	US	282us/step - loss: 0.0289
	[=======]	_	0s	201us/step - loss: 0.0282
	106/800			
	[======] 107/800	-	0s	215us/step - loss: 0.0278
	[=======]	_	0s	237us/step - loss: 0.0285
	108/800			
	[======] 109/800	-	0s	241us/step - loss: 0.0278
	[=======]	_	0s	182us/step - loss: 0.0273
	110/800			
	[=======] 111/800	-	0s	258us/step - loss: 0.0273
	[=======]	_	0s	231us/step - loss: 0.0267
Epoch	112/800			
	[======] 113/800	-	0s	231us/step - loss: 0.0268
	[=========]	_	0s	221us/step - loss: 0.0270
Epoch	114/800			
	[=========]	-	0s	211us/step - loss: 0.0281
	115/800 [=========]	_	0s	326us/step - loss: 0.0278
Epoch	116/800			
	[=======]	-	0s	208us/step - loss: 0.0288
	117/800 [=========]	_	٥q	197us/sten - loss: 0.0281
Epoch	118/800			
	[========]	-	0s	182us/step - loss: 0.0292
	119/800 [=========]	_	Λα	219us/sten = loss 0 0282
	120/800	_	0.5	21745, 500p - 1055. 0.0202
_				

	[=====]	_	0s	204us/step	-	loss:	0.0284
30/30	121/800 [=======]	_	0s	186us/step	_	loss:	0.0275
	122/800 [========]	_	0s	196us/step	_	loss:	0.0272
Epoch	123/800			_			
Epoch	[======] 124/800			_			
	[======] 125/800	-	0s	187us/step	-	loss:	0.0272
30/30	[======]	-	0s	184us/step	-	loss:	0.0280
30/30	126/800 [======]	_	0s	298us/step	_	loss:	0.0280
	127/800 [========]	_	0s	177us/step	_	loss:	0.0281
Epoch	128/800			_			
Epoch	[======] 129/800			_			
	[======] 130/800	-	0s	209us/step	-	loss:	0.0281
30/30	[======]	-	0s	172us/step	-	loss:	0.0279
	131/800 [==========]	_	0s	232us/step	_	loss:	0.0275
	132/800 [=========]	_	Λς	22011s/sten	_	1099:	0.0278
Epoch	133/800			_			
	[======] 134/800	-	0s	387us/step	-	loss:	0.0279
	[======] 135/800	-	0s	214us/step	-	loss:	0.0270
30/30	[======]	-	0s	158us/step	-	loss:	0.0267
	136/800	_	0s	162us/step	_	loss:	0.0273
	137/800		Λα	15511g/g+en		1088.	0 0274
Epoch	138/800			_			
	[======] 139/800	-	0s	201us/step	-	loss:	0.0283
	[=======] 140/800	-	0s	315us/step	-	loss:	0.0277
30/30	[======]	-	0s	186us/step	_	loss:	0.0285
	141/800 [=========]	_	0s	290us/step	_	loss:	0.0273
Epoch	142/800						
Epoch	143/800						
	[=======] 144/800	-	0s	258us/step	-	loss:	0.0275
	[=======] 145/800	-	0s	205us/step	-	loss:	0.0274
30/30	[======]	-	0s	174us/step	-	loss:	0.0269
	146/800 [=========]	_	0s	180us/step	_	loss:	0.0281
Epoch	147/800 [======]						
Epoch	148/800						
30/30	[=====]	-	0s	251us/step	-	loss:	0.0281

Epoch	149/800				
	[=======]	_	0s	210us/step - loss: 0.0	0283
	150/800		•		
	[======] 151/800	-	0s	220us/step - loss: 0.0)284
	[========]	_	0s	214us/step - loss: 0.0	0282
	152/800			_	
	[======================================	-	0s	260us/step - loss: 0.0	0278
	153/800 [======]	_	0s	557us/step - loss: 0.0	0275
Epoch	154/800			_	
	[=======]	-	0s	436us/step - loss: 0.0	0269
	155/800 [======]	_	Λq	346us/sten = loss: 0.0	1271
Epoch	156/800			_	
	[======]	-	0s	404us/step - loss: 0.0	0275
	157/800 [======]		۸c	30/us/stan loss 0 (1201
	158/800	_	US	304us/scep - 10ss. 0.0	7201
	[======]	-	0s	324us/step - loss: 0.0	0272
	159/800 [=======]		٥٩	102ug/gton logg. 0 (260
	160/800	_	US	193us/step - 10ss: 0.0	1209
30/30	[======]	_	0s	313us/step - loss: 0.0	0273
	161/800		•	070 / 1 7 0 /	
	[======] 162/800	-	US	2/0us/step - loss: 0.0)280
	[========]	_	0s	299us/step - loss: 0.0	0286
	163/800				
	[======] 164/800	-	0s	282us/step - loss: 0.0)277
	[=========]	_	0s	406us/step - loss: 0.0	0276
Epoch	165/800				
	[======] 166/800	-	0s	318us/step - loss: 0.0	0271
	[=========]	_	0s	302us/step - loss: 0.0	0272
Epoch	167/800			_	
	[=======] 168/800	-	0s	442us/step - loss: 0.0	0269
	[==========]	_	0s	315us/step - loss: 0.0	0270
Epoch	169/800				
	[======================================	-	0s	308us/step - loss: 0.0	0269
	170/800 [=======]	_	0s	414us/step - loss: 0.0	274
Epoch	171/800				
	[======]	-	0s	224us/step - loss: 0.0	0272
	172/800 [=======]	_	۸e	245us/sten = loss. 0 (1294
	173/800		V.S	243us/scep - 10ss. 0.0	1274
	[========]	-	0s	143us/step - loss: 0.0	0289
	174/800 [=======]		۸a	202ug/gton logg. 0 (1202
	175/800	_	UB	202us/scep - 10ss: 0.0	1473
30/30	[======]	-	0s	186us/step - loss: 0.0	0279
	176/800		0 -	150ug/ghom] 0 /	1270
	[======] 177/800	-	US	150us/scep - 10ss: 0.0	1219

	[=======] 178/800	-	0s	184us/step - los	ss:	0.0284
30/30	[=======] 179/800	-	0s	169us/step - los	ss:	0.0279
30/30	[======]	-	0s	225us/step - los	ss:	0.0276
	180/800 [=======]	_	0s	155us/step - los	ss:	0.0275
	181/800	_	Λq	14211g/gten - los	cc•	0 0272
Epoch	182/800					
Epoch	[======] 183/800					
	[======] 184/800	-	0s	311us/step - los	ss:	0.0271
30/30	[=======] 185/800	-	0s	307us/step - los	ss:	0.0277
30/30	[======]	_	0s	251us/step - los	ss:	0.0275
	186/800 [=======]	_	0s	170us/step - los	ss:	0.0279
Epoch	187/800 [======]					
Epoch	188/800					
Epoch	[======] 189/800					
	[======] 190/800	-	0s	202us/step - los	ss:	0.0283
30/30	[======]	-	0s	191us/step - los	ss:	0.0278
30/30	191/800 [=======]	_	0s	225us/step - los	ss:	0.0277
	192/800 [=======]	_	0s	149us/step - los	ss:	0.0278
Epoch	193/800 [======]					
Epoch	194/800					
	[======] 195/800	-	0s	158us/step - los	3S:	0.0269
	[======] 196/800	-	0s	165us/step - los	ss:	0.0275
30/30	[======]	_	0s	176us/step - los	ss:	0.0275
	197/800 [=======]	_	0s	179us/step - los	ss:	0.0277
	198/800 [======]	_	0s	221us/step = los	55:	0.0275
Epoch	199/800					
Epoch	[=======] 200/800					
	[======] 201/800	-	0s	306us/step - los	ss:	0.0277
30/30	[=======] 202/800	-	0s	204us/step - los	ss:	0.0286
30/30	[======]	_	0s	203us/step - los	ss:	0.0274
	203/800 [==========]	_	0s	170us/step - los	ss:	0.0273
Epoch	204/800 [======]					
Epoch	205/800					
30/30	[=====]	-	0s	190us/step - los	3S:	0.0273

Epoch	206/800				
30/30	[======]	-	0s	199us/step - loss: 0.027	5
	207/800 [======]		٥٥	171ug/gton logg. 0 027	1
	208/800	_	05	1/1us/step = 10ss: 0.02/	±
30/30	[======]	-	0s	159us/step - loss: 0.026	8
	209/800 [======]		٥٩	217,12 / 2+ 02	0
	210/800	_	US	21/us/step - 10ss: 0.02/	5
30/30	[======]	-	0s	193us/step - loss: 0.028	8
	211/800 [======]		٥٥	166ug/gton logg. 0 020	2
	212/800	_	US	100us/step - 10ss: 0.028	2
30/30	[======]	-	0s	189us/step - loss: 0.027	5
	213/800 [======]		٥٩	200000/04000 10000 0 020	c
	214/800	_	05	20905/Step - 1055: 0:026)
30/30	[======]	-	0s	202us/step - loss: 0.028	1
	215/800 [======]		٥٥	300ug/gtop logg. 0 027	۵
	216/800	_	US	309us/step - 10ss: 0:02/	י
	[======]	-	0s	173us/step - loss: 0.027	7
	217/800 [======]		٥٥	195ug/gtop logg. 0 027	2
	218/800	_	05	103us/step = 10ss: 0.02/	۷
	[=======]	-	0s	242us/step - loss: 0.027	3
	219/800 [======]		Λσ	192us/stan loss 0 026	7
	220/800	_	US	102us/scep - 10ss. 0.020	,
	[=====]	-	0s	217us/step - loss: 0.027	1
	221/800 [======]	_	Λe	1911s/step _ loss. 0 027	1
Epoch	222/800				
	[======]	-	0s	196us/step - loss: 0.027	2
	223/800 [======]	_	Λς	189us/sten = loss. 0 027	1
	224/800		O D	10348/18669 1088. 0.02/	-
	[=========]	-	0s	186us/step - loss: 0.027	7
	225/800 [======]	_	0s	166us/step - loss: 0.029	6
Epoch	226/800				
	[======] 227/800	-	0s	280us/step - loss: 0.028	1
	[=========]	_	0s	377us/step - loss: 0.027	7
Epoch	228/800				
	[======] 229/800	-	0s	241us/step - loss: 0.027	8
	[=========]	_	0s	346us/step - loss: 0.028	2
Epoch	230/800				
	[======] 231/800	-	0s	211us/step - loss: 0.027	3
	[=========]	_	0s	309us/step - loss: 0.027	7
Epoch	232/800				
	[======] 233/800	-	0s	302us/step - loss: 0.027	2
	[=======]	_	0s	280us/step - loss: 0.027	4
Epoch	234/800				

	[=======] 235/800	-	0s	367us/step - loss:	0.0266
30/30	[======]	-	0s	265us/step - loss:	0.0266
30/30	236/800 [======]	_	0s	593us/step - loss:	0.0272
	237/800 [======]	_	0s	440us/step - loss:	0.0273
Epoch	238/800				
Epoch	239/800				
Epoch	[=======] 240/800				
Epoch	[======] 241/800				
	[======] 242/800	-	0s	321us/step - loss:	0.0291
30/30	[========] 243/800	-	0s	192us/step - loss:	0.0277
30/30	[======]	-	0s	339us/step - loss:	0.0274
30/30	244/800 [=======]	_	0s	313us/step - loss:	0.0273
	245/800 [=======]	_	0s	189us/step - loss:	0.0272
Epoch	246/800 [======]				
Epoch	247/800				
Epoch	[=======] 248/800				
Epoch	[======] 249/800				
	[======] 250/800	-	0s	355us/step - loss:	0.0265
30/30	[=======] 251/800	-	0s	136us/step - loss:	0.0271
30/30	[======]	-	0s	153us/step - loss:	0.0274
	252/800 [=======]	_	0s	235us/step - loss:	0.0297
	253/800 [=======]	_	0s	168us/step - loss:	0.0284
Epoch	254/800 [======]				
Epoch	255/800				
Epoch	[=======] 256/800				
Epoch	[=======] 257/800				
	[======] 258/800	-	0s	181us/step - loss:	0.0280
30/30	[=======] 259/800	-	0s	158us/step - loss:	0.0277
30/30	[======]	_	0s	166us/step - loss:	0.0271
30/30	260/800 [=======]	_	0s	212us/step - loss:	0.0268
	261/800 [======]	_	0s	152us/step - loss:	0.0266
Epoch	262/800 [======]				
50,50	j		0.5		3.0207

Epoch	263/800				
30/30	[======================================] –	0s	175us/step - loss:	0.0269
	264/800 [===================================	1 _	۸e	19511g/gten - logg.	0 0273
Epoch	265/800				
	[======================================] –	0s	260us/step - loss:	0.0267
	266/800 [===================================	1 –	0s	217us/step - loss:	0.0266
Epoch	267/800			_	
	[======================================] –	0s	157us/step - loss:	0.0274
	[======================================] –	0s	182us/step - loss:	0.0293
	269/800 [===================================	1	0.0	204ug/gton logg.	0 0204
	270/800] -	US	204us/step - loss:	0.0284
] -	0s	179us/step - loss:	0.0280
	271/800 [===================================	1 –	0s	179us/step - loss:	0.0285
Epoch	272/800				
	[======================================] –	0s	183us/step - loss:	0.0281
30/30	[======================================] -	0s	201us/step - loss:	0.0275
	274/800 [===================================	1 _	۸e	214ug/gtan _ logg.	0 0271
Epoch	275/800	-		_	
	[=====================================] –	0s	219us/step - loss:	0.0272
	[======================================] –	0s	210us/step - loss:	0.0272
Epoch	277/800				
	[======================================] -	0s	2/lus/step - loss:	0.02/1
30/30	[======================================] –	0s	212us/step - loss:	0.0274
	279/800 [===================================	1 –	0s	173us/step - loss:	0.0265
Epoch	280/800				
	[======================================] –	0s	183us/step - loss:	0.0269
30/30	[======================================] –	0s	159us/step - loss:	0.0274
	282/800 [===================================	1	Λα	150ug/gton logg.	0 0274
	283/800	, –	US	139us/scep - 10ss:	0.02/4
	[======================================] –	0s	153us/step - loss:	0.0282
	284/800 [===================================	1 –	0s	148us/step - loss:	0.0286
Epoch	285/800				
	[======================================] -	0s	263us/step - loss:	0.0279
30/30	[======================================] –	0s	232us/step - loss:	0.0279
	287/800 [===================================	1 _	Λς	21211g/gten = logg.	0 0282
Epoch	288/800				
	[======================================] –	0s	257us/step - loss:	0.0279
	[======================================] –	0s	327us/step - loss:	0.0277
Epoch	290/800				
	[======================================	J –	US	4/2us/step - 10ss:	0.02/2
-					

	[=======] 292/800	-	0s	485us/step - loss:	0.0274
30/30	[======]	-	0s	306us/step - loss:	0.0268
30/30	293/800 [=======]	-	0s	418us/step - loss:	0.0271
30/30	294/800 [=======]	_	0s	322us/step - loss:	0.0265
	295/800 [======]	_	0s	171us/step - loss:	0.0269
Epoch	296/800 [======]				
Epoch	297/800 [=======]				
Epoch	298/800 [=======]				
Epoch	299/800				
Epoch	[======] 300/800				
Epoch	[======] 301/800				
	[=======] 302/800	-	0s	311us/step - loss:	0.0278
30/30	[=======] 303/800	-	0s	184us/step - loss:	0.0277
30/30	[=======] 304/800	-	0s	223us/step - loss:	0.0283
30/30	[======]	-	0s	276us/step - loss:	0.0277
30/30	305/800	_	0s	217us/step - loss:	0.0273
30/30	306/800 [=======]	_	0s	193us/step - loss:	0.0270
	307/800 [======]	_	0s	219us/step - loss:	0.0269
	308/800	_	0s	172us/step - loss:	0.0268
Epoch	309/800 [=======]				
Epoch	310/800 [=======]			_	
Epoch	311/800				
Epoch	[=======] 312/800				
Epoch	[=======] 313/800				
	[======] 314/800	-	0s	231us/step - loss:	0.0271
	[======] 315/800	-	0s	180us/step - loss:	0.0279
30/30	[=======] 316/800	-	0s	205us/step - loss:	0.0288
30/30	[=======] 317/800	-	0s	191us/step - loss:	0.0284
30/30	[======]	_	0s	188us/step - loss:	0.0285
30/30	318/800 [======]	_	0s	153us/step - loss:	0.0279
	319/800 [======]	_	0s	246us/step - loss:	0.0275

Epoch	320/800						
	[=======]	_	0s	213us/step	_	loss:	0.0279
Epoch	321/800			_			
	[======]	-	0s	229us/step	-	loss:	0.0272
	322/800					_	
	[========]	-	0s	265us/step	-	loss:	0.0271
	323/800 [======]		٥٥	150ug/gtop		logg•	0 0271
	324/800	_	US	139us/step	_	1055:	0.02/1
	[=======]	_	0s	489us/step	_	loss:	0.0270
	325/800		٥٥	103 00, 200		_0221	000270
	[========]	_	0s	163us/step	_	loss:	0.0270
	326/800						
	[======]	-	0s	237us/step	-	loss:	0.0276
	327/800					_	
	[=========]	-	0s	171us/step	-	loss:	0.0281
	328/800 [=========]		٥٥	101ug/g+op		logg•	0 0201
	329/800	_	US	191us/scep	_	1055:	0.0201
	[=======]	_	0s	170us/step	_	loss:	0.0284
	330/800			,			
	[======]	_	0s	209us/step	_	loss:	0.0276
	331/800						
	[=====]	-	0s	182us/step	-	loss:	0.0272
	332/800						
	[======================================	-	0s	171us/step	-	loss:	0.0273
	333/800 [==========]		Λc	211ug/gton		1000	0 0278
	334/800	_	US	ziius/scep	_	TOSS.	0.0270
	[=======]	_	0s	165us/step	_	loss:	0.0272
	335/800						
	[======]	_	0s	178us/step	-	loss:	0.0274
	336/800						
	[========]	-	0s	156us/step	-	loss:	0.0277
	337/800 [======]		٥٠	201112 / 2+05		1000.	0 0272
	338/800	_	US	201us/step	_	TOSS:	0.0272
	[=======]	_	0s	190us/step	_	loss:	0.0271
	339/800						
30/30	[======]	_	0s	180us/step	_	loss:	0.0265
	340/800						
	[=====]	-	0s	209us/step	-	loss:	0.0272
	341/800		•	177 / .		,	0 0070
	[======] 342/800	-	0s	1//us/step	-	loss:	0.02/3
	[=========]	_	۸c	192118/sten	_	1000	0 0278
	343/800		0 D	19245/5005		TODD.	0.0270
	[========]	_	0s	162us/step	_	loss:	0.0282
	344/800			-			
	[======]	_	0s	251us/step	-	loss:	0.0279
	345/800					_	
	[=======]	-	0s	242us/step	-	loss:	0.0274
	346/800 [=======]		٥٥	262110/0+05		loggs	0 0270
	347/800	_	υS	202us/step	_	TOSS:	0.02/9
	[=======]	_	0s	327us/step	_	loss:	0.0270
	348/800		-				•
-							

	[======] 349/800	-	0s	302us/step	-	loss:	0.0270
30/30	[======]	-	0s	261us/step	-	loss:	0.0265
	350/800 [=======]	_	0s	303us/step	_	loss:	0.0266
Epoch	351/800						
	[======] 352/800	_	US	364us/step	_	loss:	0.0265
	[======]	-	0s	310us/step	_	loss:	0.0272
	353/800 [=======]	_	0s	362us/step	_	loss:	0.0278
	354/800 [======]		0 ~	200		1	0 0206
Epoch	355/800			_			
	[======] 356/800	-	0s	210us/step	-	loss:	0.0288
	[=======]	_	0s	204us/step	_	loss:	0.0276
	357/800 [======]		٥٥	10Eug/g+on		1000.	0 0272
Epoch	358/800			_			
	[======] 359/800	-	0s	182us/step	-	loss:	0.0274
	[=======]	_	0s	164us/step	_	loss:	0.0276
	360/800 [======]		۸c	15/ug/gton		logg•	0 0260
Epoch	361/800			_			
	[======] 362/800	-	0s	156us/step	-	loss:	0.0269
	[========]	_	0s	184us/step	_	loss:	0.0269
	363/800 [======]		Λc	156us/sten		1000	0 0276
Epoch	364/800			_			
	[======] 365/800	-	0s	199us/step	-	loss:	0.0283
30/30	[======]	_	0s	157us/step	_	loss:	0.0281
	366/800 [=======]		Λs	179112/sten	_	10991	0 0279
Epoch	367/800						
	[=======] 368/800	-	0s	160us/step	-	loss:	0.0274
30/30	[======]	_	0s	184us/step	_	loss:	0.0266
	369/800 [=======]	_	0s	166us/sten	_	loss:	0.0269
Epoch	370/800						
	[======] 371/800	-	0s	206us/step	-	loss:	0.0264
30/30	[======]	_	0s	145us/step	_	loss:	0.0265
-	372/800 [======]	_	0s	215us/step	_	loss:	0.0268
Epoch	373/800			_			
	[======] 374/800	-	0s	224us/step	-	loss:	0.0273
30/30	[======]	-	0s	164us/step	-	loss:	0.0263
	375/800 [======]	_	0s	190us/step	_	loss:	0.0268
Epoch	376/800			_			
30/30	[=====]	-	0s	18/us/step	-	loss:	0.0277

Epoch	377/800			
30/30	[=======]	-	0s	169us/step - loss: 0.0281
	378/800 [======]	_	Λe	183us/sten = loss: 0 0284
Epoch	379/800			
	[======================================	-	0s	171us/step - loss: 0.0285
	380/800 [======]	_	0s	193us/step - loss: 0.0282
Epoch	381/800			
	[======] 382/800	-	0s	190us/step - loss: 0.0278
	[=========]	_	0s	183us/step - loss: 0.0275
	383/800 [======]		٥٩	10000 / 0 1000 1000 0 0270
	384/800	_	US	180us/step - 10ss: 0.02/9
	[======]	-	0s	156us/step - loss: 0.0271
	385/800 [======]	_	0s	170us/step - loss: 0.0272
Epoch	386/800			
	[======] 387/800	-	0s	163us/step - loss: 0.0270
30/30	[=======]	_	0s	188us/step - loss: 0.0272
	388/800 [======]		Λe	179us/sten _ loss: 0 0270
Epoch	389/800			
	[======] 390/800	-	0s	190us/step - loss: 0.0268
	[==========]	_	0s	179us/step - loss: 0.0271
	391/800		•	105 / 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
	[======] 392/800	_	US	185us/step - 10ss: 0.02/5
30/30	[=======]	_	0s	160us/step - loss: 0.0278
	393/800 [======]	_	0s	180us/step - loss: 0.0285
Epoch	394/800			
	[======] 395/800	-	0s	172us/step - loss: 0.0283
30/30	[=======]	_	0s	171us/step - loss: 0.0278
	396/800 [=======]		Λe	179us/sten _ loss: 0 0269
Epoch	397/800			
	[======] 398/800	-	0s	174us/step - loss: 0.0273
	[==========]	_	0s	187us/step - loss: 0.0270
	399/800		0	205 /
	[======] 400/800	_	US	205us/step - 10ss: 0.02/0
30/30	[=======]	_	0s	198us/step - loss: 0.0276
	401/800 [=======]	_	0s	154us/step - loss: 0.0268
Epoch	402/800			
	[======] 403/800	-	0s	215us/step - loss: 0.0272
30/30	[=======]	_	0s	188us/step - loss: 0.0270
	404/800 [=======]	_	Λe	17711g/gten = logg. 0 0262
	405/800	_	va	1,, us, scop - 10ss. 0.0203

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30/30 [============== ] - 0s 139us/step - loss: 0.0275
Epoch 406/800
Epoch 407/800
Epoch 408/800
30/30 [================ ] - 0s 157us/step - loss: 0.0277
Epoch 409/800
30/30 [============ ] - 0s 175us/step - loss: 0.0281
Epoch 410/800
Epoch 411/800
30/30 [=============== ] - 0s 188us/step - loss: 0.0273
Epoch 412/800
Epoch 413/800
30/30 [=============== ] - 0s 184us/step - loss: 0.0266
Epoch 414/800
Epoch 415/800
Epoch 416/800
30/30 [=============== ] - 0s 155us/step - loss: 0.0275
Epoch 417/800
Epoch 418/800
Epoch 419/800
30/30 [============= ] - 0s 161us/step - loss: 0.0269
Epoch 420/800
Epoch 421/800
30/30 [=============== ] - 0s 211us/step - loss: 0.0267
Epoch 422/800
30/30 [============== ] - 0s 156us/step - loss: 0.0266
Epoch 423/800
Epoch 424/800
30/30 [============== ] - 0s 155us/step - loss: 0.0294
Epoch 425/800
Epoch 426/800
Epoch 427/800
30/30 [=============== ] - 0s 198us/step - loss: 0.0278
Epoch 428/800
Epoch 429/800
Epoch 430/800
30/30 [============== ] - 0s 214us/step - loss: 0.0270
Epoch 431/800
30/30 [=============== ] - 0s 198us/step - loss: 0.0265
Epoch 432/800
30/30 [=============== ] - 0s 180us/step - loss: 0.0265
Epoch 433/800
```

Epoch	434/800				
30/30	[=======]	-	0s	178us/step - loss: 0.0	268
	435/800 [========]		٥a	102ug/gton logg. 0 0	272
	436/800	_	US	193us/step - 10ss: 0.0	2/3
30/30	[=======]	-	0s	262us/step - loss: 0.0	272
	437/800 [=======]		٥٩	216:22/2402 1022 0 0	200
	438/800	_	US	216us/step - 10ss: 0.0	290
30/30	[=======]	-	0s	223us/step - loss: 0.0	281
	439/800 [=======]		0~	167/5+0	201
	[=====================================	_	US	16/us/step - 10ss: 0.0	281
30/30	[=======]	_	0s	196us/step - loss: 0.0	276
	441/800 [========]		0~	16000/0400 1000 0 0	270
	[=====================================	_	US	108us/step - 10ss: 0.0	2/0
30/30	[=======]	-	0s	193us/step - loss: 0.0	268
	443/800		0 -	150/ 1 0 0	274
	[======] 444/800	_	US	158us/step - 10ss: 0.0	2/4
30/30	[=======]	_	0s	187us/step - loss: 0.0	277
	445/800		•	176 / 1 2 2 2	0.67
	[======] 446/800	-	US	1/6us/step - loss: 0.0	26/
	[=========]	_	0s	195us/step - loss: 0.0	271
	447/800		•	140 /	
	[======] 448/800	-	0s	140us/step - loss: 0.0	268
	[========]	_	0s	193us/step - loss: 0.0	268
	449/800				. = .
	[======] 450/800	-	0s	1/lus/step - loss: 0.0	271
	[========]	_	0s	203us/step - loss: 0.0	274
	451/800				
	[======] 452/800	-	0s	238us/step - loss: 0.0	274
	[=========]	_	0s	183us/step - loss: 0.0	270
	453/800		•	156 / 1 2 2 2	071
	[======] 454/800	-	US	156us/step - 10ss: 0.0	2/1
	[========]	_	0s	203us/step - loss: 0.0	284
	455/800		•	150 / 1 0 0	077
	[======] 456/800	-	US	152us/step - 10ss: 0.0	211
	[========]	_	0s	171us/step - loss: 0.0	279
	457/800		•	161 / 1 2 2 2	077
	[======] 458/800	-	US	161us/step - 10ss: 0.0	211
	[=========]	_	0s	212us/step - loss: 0.0	277
	459/800		•	150 /	0.50
	[======] 460/800	-	US	1/UUS/Step - loss: 0.0	2/2
	[=========]	_	0s	201us/step - loss: 0.0	271
	461/800		0	160/	262
	[======] 462/800	-	US	109us/step - loss: 0.0	∠ b ႘

	[=====]	_	0s	166us/step	_	loss:	0.0267
	463/800 [=======]	_	0s	20011s/sten	_	1055:	0.0262
Epoch	464/800			_			
	[======] 465/800	-	0s	206us/step	-	loss:	0.0269
	[=========]	_	0s	196us/step	_	loss:	0.0271
	466/800		•	-		,	
	[======] 467/800	-	0s	231us/step	_	loss:	0.0280
30/30	[======]	_	0s	200us/step	_	loss:	0.0281
	468/800 [=======]		۸c	233ug/g+an		1000	0 0275
Epoch	469/800			_			
	[=========]	-	0s	248us/step	-	loss:	0.0281
	470/800 [=======]	_	0s	239us/step	_	loss:	0.0274
Epoch	471/800			_			
	[======] 472/800	-	0s	195us/step	-	loss:	0.0278
30/30	[======]	_	0s	239us/step	_	loss:	0.0273
	473/800 [=======]		۸c	200ug/g+an		1055	0 0267
Epoch	474/800			_			
	[=========]	-	0s	160us/step	-	loss:	0.0268
	475/800 [=======]	_	0s	217us/step	_	loss:	0.0268
Epoch	476/800			_			
	[======] 477/800	-	0s	221us/step	-	loss:	0.0277
30/30	[======]	_	0s	224us/step	_	loss:	0.0271
	478/800 [=======]	_	۸e	26511g/g+an	_	1000	0 0277
Epoch	479/800			_			
	[======] 480/800	-	0s	269us/step	-	loss:	0.0277
	[========]	_	0s	189us/step	_	loss:	0.0269
	481/800		0 -	104/		1	0 0065
	[=======] 482/800	_	US	194us/step	_	Toss:	0.0265
30/30	[======]	_	0s	210us/step	_	loss:	0.0263
	483/800 [=======]	_	0s	230us/step	_	loss:	0.0269
Epoch	484/800						
	[======] 485/800	-	0s	305us/step	-	loss:	0.0262
	[========]	_	0s	216us/step	_	loss:	0.0267
	486/800		0 =	407		1	0 0260
	[=======] 487/800	_	US	48/us/step	_	Toss:	0.0268
30/30	[======]	_	0s	542us/step	_	loss:	0.0283
	488/800 [=======]	_	0s	338us/step	_	loss:	0.0291
Epoch	489/800						
	[======] 490/800	-	0s	316us/step	-	loss:	0.0272
	[========]	_	0s	280us/step	_	loss:	0.0273

Epoch	491/800				
30/30	[=========]	-	0s	320us/step - loss:	0.0270
	492/800	_	•		
	[=====================================	-	0s	223us/step - loss:	0.0277
	[========]	ا –	0s	396us/step - loss:	0.0282
Epoch	494/800				
	[======================================	-	0s	272us/step - loss:	0.0282
	495/800 [===================================	ı –	0s	341us/step - loss:	0.0274
Epoch	496/800				
	[=======]	-	0s	402us/step - loss:	0.0272
	497/800 [===================================	١ _	۸e	316us/sten = loss.	0 0271
	498/800	_	V.S	510ds/scep - 10ss.	0.02/1
	[=========]	-	0s	313us/step - loss:	0.0265
	499/800 [===================================		٥a	201ug/g+on logg.	0 0264
	500/800	-	US	291us/step - 10ss:	0.0264
30/30	[=========]	-	0s	265us/step - loss:	0.0265
	501/800		•	412 / 1 7	0 0060
	[=====================================	-	0s	413us/step - loss:	0.0269
	[========]	ı –	0s	170us/step - loss:	0.0262
	503/800				
	[=====================================	-	0s	585us/step - loss:	0.0264
	[======================================	ı –	0s	353us/step - loss:	0.0272
Epoch	505/800				
	[=====================================	-	0s	219us/step - loss:	0.0279
	[======================================	ı –	0s	404us/step - loss:	0.0276
Epoch	507/800				
	[======================================	-	0s	387us/step - loss:	0.0282
	508/800 [===================================	ı _	0s	433us/step = loss:	0.0279
	509/800	•	• •	100 db, 200p	000=75
	[========]	-	0s	298us/step - loss:	0.0281
	510/800 [=========]	ı _	Λe	31711g/gten - logg.	0 0274
	511/800	_	V.S	31/ds/scep - 10ss.	0.02/4
	[=========]	-	0s	478us/step - loss:	0.0265
	512/800 [==========]		۸a	205ug/g+op logg.	0 0262
	513/800	-	US	393us/step - 10ss:	0.0202
30/30	[========]	-	0s	281us/step - loss:	0.0265
	514/800		0 -	200/	0.0066
	[=====================================	-	US	399us/step - loss:	0.0266
	[=========]	-	0s	394us/step - loss:	0.0272
	516/800	_			
	[=====================================	-	0s	279us/step - loss:	0.0277
	[======================================	-	0s	337us/step - loss:	0.0287
Epoch	518/800				
	[=====================================	-	0s	155us/step - loss:	0.0273
тросп	213/000				

	[=====]	-	0s	189us/step	-	loss:	0.0278
	520/800 [=======]	_	0s	191us/step	_	loss:	0.0277
Epoch	521/800			_			
	[======] 522/800	-	0s	153us/step	-	loss:	0.0272
30/30	[======]	-	0s	177us/step	-	loss:	0.0275
	523/800 [=======]	_	0s	213us/sten	_	loss:	0.0267
Epoch	524/800			_			
	[======] 525/800	-	0s	197us/step	-	loss:	0.0265
30/30	[======]	_	0s	183us/step	-	loss:	0.0267
	526/800 [=======]	_	0 s	225115/sten	_	1055:	0.0271
Epoch	527/800			_			
	[======] 528/800	-	0s	215us/step	-	loss:	0.0268
30/30	[======]	_	0s	182us/step	_	loss:	0.0268
	529/800 [=======]	_	Λe	23111g/g+an	_	1000	0 0263
Epoch	530/800			_			
	[======] 531/800	-	0s	263us/step	-	loss:	0.0268
	[========]	_	0s	238us/step	_	loss:	0.0276
	532/800 [=======]		0 =	21000/0400		1000.	0 0200
	533/800	_	US	310us/step	_	TOSS:	0.0288
	[======]	-	0s	251us/step	-	loss:	0.0279
	534/800 [=======]	_	0s	343us/step	_	loss:	0.0278
	535/800		•	220 / 1		,	0.0060
	[======] 536/800	-	0s	338us/step	_	loss:	0.0268
30/30	[======]	-	0s	160us/step	-	loss:	0.0272
	537/800 [=======]	_	0s	199us/step	_	loss:	0.0270
Epoch	538/800			_			
	[======] 539/800	-	0s	184us/step	-	loss:	0.0275
30/30	[======]	_	0s	227us/step	_	loss:	0.0273
	540/800 [=======]	_	0s	191us/sten	_	loss:	0.0269
Epoch	541/800						
	[======] 542/800	-	0s	192us/step	-	loss:	0.0270
30/30	[======]	_	0s	247us/step	_	loss:	0.0274
	543/800 [=======]	_	Λe	22511g/gtan	_	1000	0 0274
Epoch	544/800						
	[========]	-	0s	202us/step	-	loss:	0.0266
	545/800 [=======]	_	0s	250us/step	_	loss:	0.0262
Epoch	546/800						
	[======] 547/800	-	US	214us/step	-	TOSS:	0.0265
	[=====]	-	0s	222us/step	-	loss:	0.0263

Epoch	548/800				
30/30	[=======]	_	0s	223us/step - loss:	0.0269
	549/800			074	
	[========] 550/800	-	0s	2/4us/step - loss:	0.0274
	[=========]	_	0s	204us/step - loss:	0.0282
Epoch	551/800			_	
	[======================================	_	0s	220us/step - loss:	0.0273
	552/800 [=========]	_	0s	208us/step = loss:	0.0282
Epoch	553/800			_	
	[======]	_	0s	195us/step - loss:	0.0274
	554/800 [===================================	_	۸e	208115/sten - loss.	0 0274
	555/800		VS	200d3/3cep - 1035.	0.02/4
	[=========]	_	0s	231us/step - loss:	0.0271
	556/800 [==========]		٥a	206ug/gton logg.	0 0272
	557/800	_	05	200us/step - 10ss:	0.0272
30/30	[========]	_	0s	174us/step - loss:	0.0270
	558/800		0	106 / 1	0 0073
	[=====================================	_	US	196us/step - loss:	0.02/3
	[=========]	_	0s	157us/step - loss:	0.0275
	560/800				
	[========] 561/800	_	0s	282us/step - loss:	0.0273
	[=========]	_	0s	202us/step - loss:	0.0272
Epoch	562/800				
	[=======] 563/800	_	0s	182us/step - loss:	0.0276
	[==========]	_	0s	252us/step - loss:	0.0274
Epoch	564/800			_	
	[=====================================	-	0s	264us/step - loss:	0.0268
	[==========]	_	0s	169us/step - loss:	0.0261
Epoch	566/800				
	[======================================	_	0s	137us/step - loss:	0.0265
	567/800 [==========]	_	0s	190us/step - loss:	0.0272
Epoch	568/800				
	[======================================	-	0s	157us/step - loss:	0.0270
	569/800 [===========]	_	0s	199us/step - loss:	0.0285
Epoch	570/800				
	[========]	_	0s	187us/step - loss:	0.0276
	571/800 [=========]	_	۸e	178us/sten - loss.	0 0274
	572/800		VS	170d3/3cep - 1035.	0.02/4
	[=========]	_	0s	179us/step - loss:	0.0269
	573/800 [===================================		٥a	201ug/g+on logg.	0 0272
	574/800	_	US	201us/step - 10ss:	0.0273
30/30	[=======]	_	0s	222us/step - loss:	0.0267
	575/800		0 ~	10000 / 0 + 0 - 1	0 0275
	[========] 576/800	_	US	109us/step - 10SS:	0.02/5
	- · · · · - · ·				

	[========]	-	0s	196us/step - loss: 0	0.0268
30/30	577/800	_	0s	189us/step - loss: 0	0.0269
30/30	578/800 [=======]	_	0s	184us/step - loss: 0	0.0265
	579/800 [======]	_	0s	240us/step - loss: 0	0.0264
Epoch	580/800 [=======]			_	
Epoch	581/800			_	
Epoch	[=======] 582/800			_	
Epoch	[======] 583/800			_	
	[======] 584/800	-	0s	243us/step - loss: 0	0.0275
30/30	[=======] 585/800	-	0s	210us/step - loss: 0	0.0284
30/30	[======]	_	0s	229us/step - loss: 0	0.0278
30/30	586/800 [======]	_	0s	289us/step - loss: 0	0.0272
	587/800 [======]	_	0s	170us/step - loss: (0.0269
Epoch	588/800 [======]				
Epoch	589/800 [=======]				
Epoch	590/800				
Epoch	[======] 591/800				
	[======] 592/800	-	0s	276us/step - loss: 0	0.0267
	[=======] 593/800	-	0s	294us/step - loss: 0	0.0271
30/30	[=======] 594/800	-	0s	192us/step - loss: 0	0.0270
30/30	[======]	-	0s	177us/step - loss: 0	0.0272
30/30	595/800 [=======]	_	0s	218us/step - loss: 0	0.0263
	596/800 [=======]	_	0s	270us/step - loss: 0	0.0276
Epoch	597/800 [======]				
Epoch	598/800 [=======]				
Epoch	599/800				
Epoch	[========] 600/800				
	[======] 601/800	-	0s	195us/step - loss: (0.0280
	[=======] 602/800	-	0s	195us/step - loss: 0	0.0272
30/30	[======]	-	0s	181us/step - loss: 0	0.0267
30/30	603/800 [=======]	-	0s	172us/step - loss: 0	0.0260
	604/800 [=======]	_	0s	179us/step - loss: 0	0.0264

Epoch	605/800						
	[=======]	_	0s	190us/step	_	loss:	0.0271
	606/800						
	[======]	-	0s	177us/step	-	loss:	0.0270
	607/800			/		_	
	[=========]	-	0s	220us/step	-	loss:	0.0269
	608/800 [=======]		Λc	213ug/g+on		1000	0 0272
	609/800	_	US	213us/scep	_	1055.	0.0272
	[=======]	_	0s	174us/step	_	loss:	0.0271
Epoch	610/800			_			
	[======]	-	0s	185us/step	-	loss:	0.0269
	611/800		•	100 / 1		-	
	[======] 612/800	-	0s	198us/step	-	loss:	0.0266
	[=========]	_	۸e	197112/sten	_	1000	0 0266
	613/800		V.S	13/ds/scep		1055.	0.0200
	[========]	_	0s	197us/step	_	loss:	0.0263
	614/800						
	[=====]	-	0s	189us/step	-	loss:	0.0270
	615/800		•	167 / 1		-	
	[======] 616/800	-	0s	16/us/step	-	loss:	0.0279
	[==========]	_	۸e	15511g/gten	_	1088.	0 0288
	617/800		0.5	1334575665		1055.	0.0200
	[========]	_	0s	293us/step	_	loss:	0.0272
	618/800						
	[=====]	-	0s	293us/step	-	loss:	0.0271
	619/800		•	001 / 1		-	
	[======] 620/800	-	0s	291us/step	-	loss:	0.0272
	[=========]	_	0 s	27311s/sten	_	1055:	0.0266
	621/800		0.5	2730375009		1055.	0.0200
	[=======]	_	0s	613us/step	_	loss:	0.0266
	622/800						
	[======]	-	0s	306us/step	-	loss:	0.0261
_	623/800		0~	266/		1	0 0260
	[=======] 624/800	-	US	266us/step	_	loss:	0.0268
	[=======]	_	0s	442us/step	_	loss:	0.0266
	625/800		٥٥	11200, 500p		_000	0.000
30/30	[======]	_	0s	286us/step	_	loss:	0.0268
	626/800						
	[======]	-	0s	295us/step	-	loss:	0.0275
	627/800		0~	255/		1	0 0000
	[======] 628/800	-	US	355us/step	_	loss:	0.0283
	[=======]	_	0s	291us/step	_	loss:	0.0278
	629/800		٥٥	_, _, _, _, _, _, _, _, _, _, _, _, _, _		_000	0002,0
30/30	[======]	_	0s	292us/step	_	loss:	0.0272
	630/800						
	[=======]	-	0s	298us/step	-	loss:	0.0279
	631/800 [=======]		٥٥	175ug/g+0=		1000	0 0275
	632/800	_	US	1/Jus/step	_	TOSS	0.02/3
	[=======]	_	0s	274us/step	_	loss:	0.0267
	633/800			-			

	[======]	-	0s	252us/step	_	loss:	0.0263
	634/800 [=======]	_	0s	210us/step	_	loss:	0.0264
Epoch	635/800			_			
	[======] 636/800	-	0s	239us/step	-	loss:	0.0259
30/30	[======]	-	0s	203us/step	-	loss:	0.0263
	637/800 [=======]	_	0s	247us/sten	_	loss:	0.0264
Epoch	638/800			_			
	[======] 639/800	-	0s	267us/step	-	loss:	0.0268
30/30	[======]	_	0s	244us/step	_	loss:	0.0264
	640/800 [=======]	_	0 s	291115/sten	_	1055:	0.0268
Epoch	641/800			_			
	[======] 642/800	-	0s	200us/step	-	loss:	0.0284
30/30	[======]	_	0s	218us/step	_	loss:	0.0285
	643/800 [=======]	_	Λe	18811g/g+en	_	1000	0 0274
Epoch	644/800			_			
	[=======] 645/800	-	0s	231us/step	-	loss:	0.0276
	[=======]	_	0s	231us/step	_	loss:	0.0277
	646/800		0 =	225/5+5		1	0 0071
	[======] 647/800	_	US	225us/step	_	Toss:	0.02/1
30/30	[======]	_	0s	202us/step	_	loss:	0.0273
	648/800 [=======]	_	0s	359us/step	_	loss:	0.0271
Epoch	649/800			_			
	[======] 650/800	-	0s	217us/step	-	loss:	0.0263
30/30	[======]	_	0s	251us/step	_	loss:	0.0264
	651/800 [=======]		Λα	103115/5+05		logg•	0 0265
	652/800	_	US	103us/scep	_	1055:	0.0203
	[========]	-	0s	246us/step	-	loss:	0.0273
	653/800 [=======]	_	0s	181us/step	_	loss:	0.0270
Epoch	654/800						
	[======] 655/800	-	0s	149us/step	-	loss:	0.0276
30/30	[======]	-	0s	160us/step	-	loss:	0.0278
	656/800 [=======]	_	0s	146us/sten	_	loss:	0.0274
Epoch	657/800						
	[======] 658/800	-	0s	177us/step	-	loss:	0.0272
	[========]	_	0s	153us/step	_	loss:	0.0270
	659/800		0 =	150/5+5		1	0 0076
	[======] 660/800	_	US	13308/Step	-	TOSS:	0.02/6
30/30	[======]	-	0s	221us/step	-	loss:	0.0272
	661/800 [=======]	_	0s	338us/sten	_	loss:	0.0265
, - 0	ı		- ~				

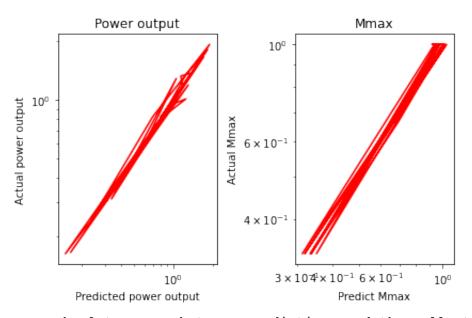
```
Epoch 662/800
30/30 [============== ] - 0s 181us/step - loss: 0.0265
Epoch 663/800
Epoch 664/800
30/30 [============ ] - 0s 268us/step - loss: 0.0262
Epoch 665/800
Epoch 666/800
Epoch 667/800
30/30 [============== ] - 0s 603us/step - loss: 0.0270
Epoch 668/800
Epoch 669/800
Epoch 670/800
30/30 [============== ] - 0s 344us/step - loss: 0.0270
Epoch 671/800
30/30 [=============== ] - 0s 937us/step - loss: 0.0289
Epoch 672/800
Epoch 673/800
Epoch 674/800
30/30 [============= ] - 0s 225us/step - loss: 0.0260
Epoch 675/800
30/30 [============ ] - 0s 149us/step - loss: 0.0263
Epoch 676/800
30/30 [============ ] - 0s 205us/step - loss: 0.0269
Epoch 677/800
Epoch 678/800
30/30 [============== ] - 0s 220us/step - loss: 0.0269
Epoch 679/800
30/30 [=============== ] - 0s 212us/step - loss: 0.0275
Epoch 680/800
Epoch 681/800
30/30 [============ ] - 0s 210us/step - loss: 0.0274
Epoch 682/800
Epoch 683/800
Epoch 684/800
30/30 [============== ] - 0s 220us/step - loss: 0.0266
Epoch 685/800
30/30 [============== ] - 0s 200us/step - loss: 0.0266
Epoch 686/800
30/30 [=============== ] - 0s 273us/step - loss: 0.0271
Epoch 687/800
Epoch 688/800
30/30 [============= ] - 0s 244us/step - loss: 0.0258
Epoch 689/800
30/30 [============ ] - 0s 202us/step - loss: 0.0261
Epoch 690/800
```

	[=====]	-	0s	285us/step	_	loss:	0.0266
	691/800 [=======]	_	0s	159us/step	_	loss:	0.0272
Epoch	692/800			_			
	[======] 693/800	-	0s	175us/step	-	loss:	0.0274
30/30	[======]	-	0s	280us/step	-	loss:	0.0284
	694/800 [=======]	_	0s	23411s/sten	_	loss:	0.0270
Epoch	695/800			_			
	[======] 696/800	-	0s	227us/step	-	loss:	0.0269
30/30	[======]	_	0s	213us/step	_	loss:	0.0271
	697/800 [=======]	_	0s	314us/sten	_	loss:	0.0266
Epoch	698/800			_			
	[======] 699/800	-	0s	245us/step	-	loss:	0.0273
30/30	[======]	_	0s	283us/step	_	loss:	0.0279
	700/800 [======]	_	Λς	29511g/gten	_	10991	0 0272
Epoch	701/800			_			
	[======] 702/800	-	0s	179us/step	-	loss:	0.0268
	[========]	_	0s	205us/step	_	loss:	0.0268
	703/800 [======]		Λc	203us/sten		1000	0 0269
Epoch	704/800			_			
	[======] 705/800	-	0s	224us/step	-	loss:	0.0273
	[========]	_	0s	196us/step	_	loss:	0.0271
	706/800 [======]		0 =	212/~+~~		1	0.0266
	707/800	_	US	213us/step	_	TOSS:	0.0200
	[======================================	-	0s	219us/step	-	loss:	0.0264
	708/800 [======]	_	0s	259us/step	_	loss:	0.0265
	709/800		0 =	210/5+5		1	0 0260
	[=======] 710/800	_	US	210us/step	_	TOSS:	0.0268
	[=========]	-	0s	214us/step	-	loss:	0.0271
	711/800 [=========]	_	0s	223us/step	_	loss:	0.0272
	712/800		0 =	222/5+5		1	0 0076
	[======] 713/800	_	US	333us/step	_	loss:	0.02/6
	[======]	-	0s	265us/step	_	loss:	0.0267
	714/800 [==========]	_	0s	220us/step	_	loss:	0.0267
Epoch	715/800						
	[======] 716/800	-	0s	250us/step	_	loss:	0.0266
30/30	[======]	-	0s	160us/step	-	loss:	0.0269
	717/800 [========]	_	0s	256us/sten	_	loss:	0.0268
Epoch	718/800						
30/30	[=====]	-	0s	188us/step	-	loss:	0.0261

Epoch	719/800				
30/30	[======================================] –	0s	275us/step - loss:	0.0259
	720/800	1 _	Λα	20811g/gten _ logg.	0 0264
	721/800				
	[======================================] –	0s	274us/step - loss:	0.0261
	722/800	1 –	0s	215us/step - loss:	0.0265
Epoch	723/800			_	
	[=====================================] –	0s	268us/step - loss:	0.0262
	[======================================] –	0s	269us/step - loss:	0.0264
	725/800		•	100 / 1	0 0060
	[=====================================] –	US	189us/step - loss:	0.0262
30/30	[======================================] –	0s	336us/step - loss:	0.0292
	727/800	1	۸c	300ug/gtop logg.	0 0276
Epoch	728/800			_	
	[======================================] –	0s	299us/step - loss:	0.0288
	729/800	1 –	0s	325us/step - loss:	0.0269
Epoch	730/800			_	
	[=====================================] –	0s	190us/step - loss:	0.0269
	[======================================] –	0s	319us/step - loss:	0.0278
	732/800		0~	225	0 0270
	733/800	J –	US	225us/step - 10ss:	0.0270
	[======================================] –	0s	264us/step - loss:	0.0276
	734/800	1 –	0s	219us/step - loss:	0.0274
Epoch	735/800				
	[=====================================] –	0s	209us/step - loss:	0.0271
	[======================================] –	0s	302us/step - loss:	0.0267
	737/800		0~	204	0 0267
	738/800	J –	US	204us/step - 10ss:	0.0207
] –	0s	427us/step - loss:	0.0261
	739/800	1 –	0s	569us/step - loss:	0.0263
Epoch	740/800				
	[=====================================] –	0s	252us/step - loss:	0.0262
30/30	[======================================] –	0s	234us/step - loss:	0.0265
	742/800	1	۸c	450ug/gton logg.	0 0267
Epoch	743/800				
30/30 Epoch	[======================================] –	0s	486us/step - loss:	0.0275
	[======================================	1 –	0s	456us/step - loss:	0.0273
Epoch	745/800				
	[=====================================] -	0s	194us/step - loss:	0.0275
30/30	[======================================] –	0s	230us/step - loss:	0.0278
Epoch	747/800				

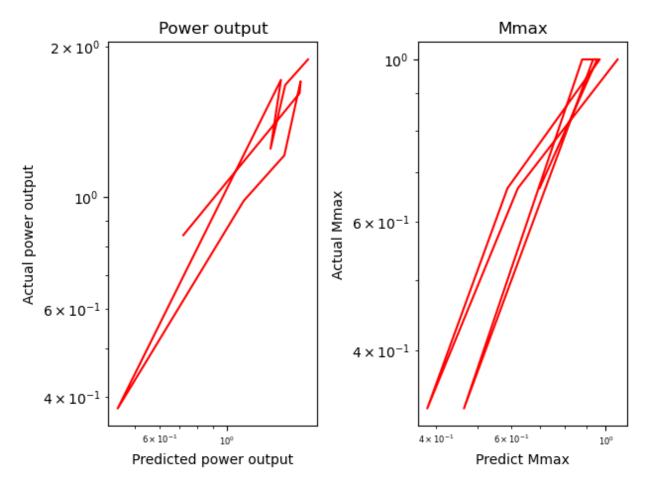
```
30/30 [=============== ] - 0s 244us/step - loss: 0.0267
Epoch 748/800
Epoch 749/800
30/30 [=============== ] - 0s 210us/step - loss: 0.0274
Epoch 750/800
30/30 [============ ] - 0s 210us/step - loss: 0.0274
Epoch 751/800
30/30 [============ ] - 0s 188us/step - loss: 0.0268
Epoch 752/800
30/30 [=============== ] - 0s 222us/step - loss: 0.0266
Epoch 753/800
30/30 [============== ] - 0s 227us/step - loss: 0.0265
Epoch 754/800
30/30 [============= ] - 0s 243us/step - loss: 0.0269
Epoch 755/800
30/30 [============= ] - 0s 474us/step - loss: 0.0273
Epoch 756/800
30/30 [============= ] - 0s 558us/step - loss: 0.0275
Epoch 757/800
30/30 [============= ] - 0s 356us/step - loss: 0.0271
Epoch 758/800
30/30 [============== ] - 0s 570us/step - loss: 0.0270
Epoch 759/800
30/30 [============= ] - 0s 349us/step - loss: 0.0269
Epoch 760/800
30/30 [=============== ] - 0s 698us/step - loss: 0.0267
Epoch 761/800
30/30 [============== ] - 0s 361us/step - loss: 0.0264
Epoch 762/800
30/30 [============= ] - 0s 463us/step - loss: 0.0264
Epoch 763/800
Epoch 764/800
30/30 [=============== ] - 0s 387us/step - loss: 0.0258
Epoch 765/800
Epoch 766/800
30/30 [============ ] - 0s 333us/step - loss: 0.0267
Epoch 767/800
30/30 [============= ] - 0s 394us/step - loss: 0.0261
Epoch 768/800
30/30 [============= ] - 0s 303us/step - loss: 0.0270
Restoring model weights from the end of the best epoch
Epoch 00768: early stopping
best epoch = 688
smallest loss = 0.025820961222052574
```

```
In [7]:
         # Task 2.1 Part e
         from sklearn import metrics
         # This line of code can be used to reconstruct the saved model. The name of t
         recon_model3 = keras.models.load_model("best_model3")
         import matplotlib.pyplot as plt
         y predictm = []
         y_{testm} = []
         Wdotpredm = []
         Wdotorigm = []
         Mmaxpredm = []
         Mmaxorigm = []
         for i in range(len(X_train2)):
             testm = [[X_train2[i][0], X_train2[i][1], X_train2[i][2]]]
             testarraym = np.array(testm)
             a3 = recon model3.predict(testarraym)
             y predictm.append([a3[0][0], a3[0][1], a3[0][2]])
             y_testm.append([y_train2[i][0], y_train2[i][1], y_train2[i][2]])
             Wdotpredm.append([a3[0][2]])
             Mmaxpredm.append([a3[0][0]])
             Wdotorigm.append([y train2[i][2]])
             Mmaxorigm.append([y train2[i][0]])
         fig_{(ax3, ax4)} = plt.subplots(1, 2)
         ax3.loglog(Wdotpredm, Wdotorigm, c='r')
         ax3.set_xlabel('Predicted power output')
         ax3.set_ylabel('Actual power output')
         ax3.title.set_text('Power output');
         ax4.loglog(Mmaxpredm, Mmaxorigm, c='r')
         ax4.set xlabel('Predict Mmax')
         ax4.set_ylabel('Actual Mmax')
         ax4.title.set_text('Mmax');
         fig.tight layout()
         plt.show()
         #MAE of predicted vs test data
         mae_Mmax = metrics.mean_absolute_error(y_predictm[:][0],y_testm[:][0])
         mae Wdot = metrics.mean absolute error(y predictm[:][2],y testm[:][2])
         mae_Vl = metrics.mean_absolute_error(y_predictm[:][1],y_testm[:][1])
         print('mean absolute error between predictions and the collection of test date
```



mean absolute error between predictions and the collection of test data: Vl = 0.021800673051404245 Wdot = 0.017343804523116606 Mmax = 0.0070730010357812 16

In [345... # Task 2.1 Part f # This line of code can be used to reconstruct the saved model. The name of t recon model3 = keras.models.load model("best model3") import matplotlib.pyplot as plt y predictmn = [] y trainmn = [] Wdotpredmn = [] Wdotorigmn = [] Mmaxpredmn = [] Mmaxorigmn = [] for i in range(len(X test2)): testm = [[X_test2[i][0], X_test2[i][1], X_test2[i][2]]] testarraym = np.array(testm) a3 = recon_model3.predict(testarraym) y_predictmn.append([a3[0][0], a3[0][1], a3[0][2]]) Wdotpredmn.append([a3[0][2]]) Mmaxpredmn.append([a3[0][0]])Wdotorigmn.append([y test2[i][2]]) Mmaxorigmn.append([y_test2[i][0]]) $fig_{(ax3, ax4)} = plt.subplots(1, 2)$ ax3.loglog(Wdotpredmn, Wdotorigmn, c='r') ax3.set xlabel('Predicted power output') ax3.set ylabel('Actual power output') ax3.title.set_text('Power output'); ax4.loglog(Mmaxpredmn, Mmaxorigmn, c='r') ax4.set xlabel('Predict Mmax') ax4.set ylabel('Actual Mmax') ax4.title.set text('Mmax'); fig.tight_layout() plt.show() #MAE of predicted vs test data mae Mmax = metrics.mean absolute error(y predictmn[:][0],y test2[:][0]) mae Wdot = metrics.mean absolute error(y predictmn[:][2],y test2[:][2]) mae_Vl = metrics.mean_absolute_error(y_predictmn[:][1],y_test2[:][1]) print('mean absolute error between predictions and the collection of test dat



mean absolute error between predictions and the collection of test data: Vl = 0.07681843488357205 Wdot = 0.06591972105535963 Mmax = 0.038822428489870976

```
In [8]:
         #Task 2.2 Part a
         import math, numpy
         #Part 2 input data: Mode number, Air temp (degC), ID (W/sqm), load resistance
         # - split into training and validation sets, add some noise
         xdata = [[1.0, 10.0, 200.0, 24.3],
          [2.0, 10.0, 200.0, 24.3],
          [3.0, 10.0, 200.0, 24.3],
          [1.0, 10.0, 200.0, 51.8],
          [2.0, 10.0, 200.0, 51.8],
          [3.0, 10.0, 200.0, 51.8],
          [1.0, 10.0, 200.0, 96.2],
          [2.0, 10.0, 200.0, 96.2],
          [3.0, 10.0, 200.0, 96.2],
          [1.0, 10.0, 200.0, 170.1],
          [2.0, 10.0, 200.0, 170.1],
          [3.0, 10.0, 200.0, 170.1],
          [1.0, 10.0, 500.0, 7.0],
          [2.0, 10.0, 500.0, 7.0],
          [3.0, 10.0, 500.0, 7.0],
          [1.0, 10.0, 500.0, 21.2],
          [2.0, 10.0, 500.0, 21.2],
```

```
[3.0, 10.0, 500.0, 21.2],
 [1.0, 10.0, 500.0, 43.2],
 [2.0, 10.0, 500.0, 43.2],
 [3.0, 10.0, 500.0, 43.2],
 [1.0, 10.0, 500.0, 79.1],
 [2.0, 10.0, 500.0, 79.1],
 [3.0, 10.0, 500.0, 79.1],
 [1.0, 10.0, 700.0, 4.9],
 [2.0, 10.0, 700.0, 4.9],
 [3.0, 10.0, 700.0, 4.9],
 [1.0, 10.0, 700.0, 14.3],
 [2.0, 10.0, 700.0, 14.3],
 [3.0, 10.0, 700.0, 14.3],
 [1.0, 10.0, 700.0, 29.7],
 [2.0, 10.0, 700.0, 29.7],
 [3.0, 10.0, 700.0, 29.7],
 [1.0, 10.0, 700.0, 55.3],
 [2.0, 10.0, 700.0, 55.3],
 [3.0, 10.0, 700.0, 55.3],
 [1.0, 10.0, 1000.0, 3.92],
 [2.0, 10.0, 1000.0, 3.92],
 [3.0, 10.0, 1000.0, 3.92],
 [1.0, 10.0, 1000.0, 11.7],
 [2.0, 10.0, 1000.0, 11.7],
 [3.0, 10.0, 1000.0, 11.7],
 [1.0, 10.0, 1000.0, 25.2],
 [2.0, 10.0, 1000.0, 25.2],
 [3.0, 10.0, 1000.0, 25.2],
 [1.0, 10.0, 1000.0, 41.6],
 [2.0, 10.0, 1000.0, 41.6],
 [3.0, 10.0, 1000.0, 41.6]]
#Part 1 output data for above specified Mode and conditons: VL (V) and Power
ydata = [[46.0, 87.3],
         [27.9, 64.21,
         [27.9, 32.1],
         [46.0, 40.9],
         [92.1, 163.9],
         [59.5, 68.5],
         [46.0, 22.0],
         [92.1, 88.2],
         [110.6, 127.2],
         [46.0, 12.4],
         [92.1, 49.9],
         [184.2, 199.6],
         [48.4, 335.3],
         [20.8, 124.3],
         [20.8, 62.1],
         [48.4, 110.7],
         [96.8, 442.9],
         [63.1, 188.2],
         [48.4, 54.3],
         [96.9, 217.3],
```

```
[128.7, 383.6],
         [48.4, 29.6],
         [96.8, 118.7],
         [193.7, 474.8],
         [49.3, 496.1],
         [20.4, 171.2],
         [20.4, 85.6],
         [49.3, 169.9],
         [98.6, 679.9],
         [59.7, 249.8],
         [49.3, 81.8],
         [98.6, 327.4],
         [124.1, 518.9],
         [49.305, 43.9],
         [98.6, 175.8],
         [197.2, 703.3],
         [50.8, 658.9],
         [23.1, 272.9],
         [23.1, 136.4],
         [50.8, 220.7],
         [101.6, 883.1],
         [69.0, 407.2],
         [50.8, 102.5],
         [101.6, 410.0],
         [148.6, 877.2],
         [50.8, 62.0],
         [101.6, 248.3],
         [203.2, 993.5]]
xarray= numpy.array(xdata)
yarray= numpy.array(ydata)
Mp = []
Vlp = []
Wdotp = []
Tairp =[]
Idp =[]
Rlp =[]
for x in range(len(xarray)):
    Mp.append(xarray[x][0])
    Tairp.append(xarray[x][1])
    Idp.append(xarray[x][2])
    Rlp.append(xarray[x][3])
for y in range(len(yarray)):
    Vlp.append(yarray[y][0])
    Wdotp.append(yarray[y][1])
medTairp = median(Tairp)
medIdp = median(Idp)
medRlp = median(Rlp)
medVlp = median(Vlp)
```

```
medWdotp = median(Wdotp)
medMp = median(Mp)
Tairpn = Tairp/medTairp
Idpn = Idp/medIdp
Rlpn = Rlp/medRlp
Vlpn = Vlp/medVlp
Wdotpn = Wdotp/medWdotp
Mpn = Mp/medMp
xarraypn = np.column stack((Mpn, Tairpn, Idpn, Rlpn))
yarraypn = np.column stack((Vlpn, Wdotpn))
print(xarraypn)
print(yarraypn)
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[0.87760653 1.96599238]
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[0.87760653 0.64907652]
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[1.14415231 1.10348871]
[0.87760653 0.31838171]
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[2.33363554 2.24919378]
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[2.25022665 3.04250953]
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[1.84224841 5.17795368]
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[1.84224841 2.4039871 ]
[2.69446963 5.14335972]
[0.92112421 0.36352976]
[1.84224841 1.45587804]
[3.68449683 5.82527118]]
```

```
In [9]:
         #Task 2.2 Part b
         from sklearn.model_selection import train_test_split
         X train3, X test3, y train3, y test3 = train test split(xarraypn, yarraypn, te
         print(X_train3)
         print(y train3)
         print(X test3)
         print(y_test3)
         [[0.5
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          [0.37715322 0.72881853]
          [1.14415231 1.10348871]
          [0.92112421 0.36352976]
          [0.87760653 0.64907652]
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[0.83408885 0.07270595]

```
[1.75521306 2.59689241]
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[1.84224841 2.4039871 ]
[0.89392566 2.90882439]
[0.41885766 1.60011727]
 [0.87760653 1.96599238]
[1.75702629 1.27411316]
[1.66999093 0.9610085 ]
[0.36990027 1.0038112 ]
[2.00543971 0.74582234]
[0.83408885 0.23981237]]
```

```
In [293...
         # define neural network model
         from keras import backend as K
         #initialize weights
         initializer = keras.initializers.RandomUniform(minval= -0.2, maxval=0.7)
         modelv4 = keras.Sequential([
             keras.layers.Dense(16, activation=K.elu, input shape=[4], kernel initial
             keras.layers.Dense(32, activation=K.elu, kernel initializer=initializer)
             keras.layers.Dense(16, activation=K.elu, kernel_initializer=initializer),
             keras.layers.Dense(16, activation=K.elu, kernel initializer=initializer)
             keras.layers.Dense(2, kernel initializer=initializer)
           1)
In [306...
         #from tf.keras import optimizers
         rms = keras.optimizers.RMSprop(0.0001)
         modelv4.compile(loss='mean absolute error',optimizer=rms)
In [307...
         # Add an early stopping callback
         es = keras.callbacks.EarlyStopping(
             monitor='loss',
             mode='min',
             patience = 80,
             restore best weights = True,
             verbose=1)
         # Add a checkpoint where loss is minimum, and save that model
         mc = keras.callbacks.ModelCheckpoint('best model4.SB', monitor='loss',
                             mode='min', verbose=1, save best only=True)
         historyData = modelv4.fit(X_train3,y_train3,epochs=800,callbacks=[es])
         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))
         modelv4.save('./best model4')
        Epoch 1/800
        Epoch 2/800
        36/36 [=============== ] - 0s 375us/step - loss: 0.0293
        Epoch 3/800
        36/36 [============= ] - 0s 360us/step - loss: 0.0329
        Epoch 4/800
        36/36 [============== ] - 0s 545us/step - loss: 0.0312
        Epoch 5/800
        36/36 [================ ] - 0s 469us/step - loss: 0.0297
        Epoch 6/800
```

36/36	[======]	_	0s	536us/step - loss	0.0317
Epoch	7/800 [=======]		٥٥	947ug/g+op logg	. 0 0276
Epoch	8/800				
	[=======]	-	0s	521us/step - loss	: 0.0301
Epoch 36/36	9/800 [======]	_	0s	486us/step - loss	0.0282
Epoch	10/800				
	[========]	-	0s	632us/step - loss	: 0.0287
	11/800	_	0s	363us/step - loss	: 0.0279
Epoch	12/800			_	
	[======] 13/800	-	0s	303us/step - loss	: 0.0271
	[=========]	_	0s	286us/step - loss	0.0290
	14/800 [========]		0 ~	E21ug/gton logg	. 0 0204
	15/800	_	US	521us/step - 10ss	0.0294
36/36	[======]	_	0s	641us/step - loss	0.0304
	16/800 [=======]	_	Λς	44111g/gten = logg	• 0 0291
Epoch	17/800				
	[=======]	-	0s	479us/step - loss	: 0.0270
	18/800 [=======]	_	0s	656us/step - loss	0.0320
Epoch	19/800				
	[======] 20/800	-	0s	629us/step - loss	: 0.0312
	[========]	_	0s	609us/step - loss	0.0294
	21/800		•	222	
	[======] 22/800	-	0s	339us/step - loss	: 0.0290
36/36	[======]	_	0s	563us/step - loss	0.0313
	23/800 [=========]		٥٥	420ug/g+op logg	. 0 0266
	24/800	_	US	420us/scep - 10ss	. 0.0200
	[======]	-	0s	364us/step - loss	0.0290
	25/800 [======]	_	0s	423us/step - loss	0.0274
Epoch	26/800				
	[======] 27/800	-	0s	375us/step - loss	: 0.0275
	[========]	_	0s	388us/step - loss	0.0283
	28/800				
	[======] 29/800	-	0s	540us/step - loss	: 0.0312
	[======]	_	0s	325us/step - loss	0.0288
	30/800		٥٥	252ug/g+op logg	. 0 0200
	31/800	_	05	332us/step - 10ss	. 0.0309
	[======]	-	0s	352us/step - loss	0.0270
	32/800 [=========]	_	0.5	344us/sten = loss	0.0274
Epoch	33/800				
	[======] 34/800	-	0s	274us/step - loss	0.0299
	[==========]	_	0s	302us/step - loss	0.0286
	•			-	

```
Epoch 35/800
Epoch 36/800
Epoch 37/800
36/36 [============= ] - 0s 349us/step - loss: 0.0285
Epoch 38/800
36/36 [============= ] - 0s 328us/step - loss: 0.0279
Epoch 39/800
36/36 [============= ] - 0s 384us/step - loss: 0.0269
Epoch 40/800
36/36 [=============== ] - 0s 530us/step - loss: 0.0271
Epoch 41/800
Epoch 42/800
Epoch 43/800
36/36 [============= ] - 0s 408us/step - loss: 0.0268
Epoch 44/800
Epoch 45/800
Epoch 46/800
36/36 [============== ] - 0s 980us/step - loss: 0.0315
Epoch 47/800
36/36 [============= ] - 0s 562us/step - loss: 0.0304
Epoch 48/800
36/36 [============= ] - 0s 502us/step - loss: 0.0293
Epoch 49/800
Epoch 50/800
36/36 [============== ] - 0s 717us/step - loss: 0.0294
Epoch 51/800
36/36 [============== ] - 0s 506us/step - loss: 0.0309
Epoch 52/800
36/36 [============== ] - 0s 800us/step - loss: 0.0273
Epoch 53/800
Epoch 54/800
36/36 [=============== ] - 0s 705us/step - loss: 0.0308
Epoch 55/800
Epoch 56/800
Epoch 57/800
36/36 [============== ] - 0s 334us/step - loss: 0.0303
Epoch 58/800
36/36 [============== ] - 0s 391us/step - loss: 0.0266
Epoch 59/800
36/36 [============== ] - 0s 333us/step - loss: 0.0288
Epoch 60/800
36/36 [============ ] - 0s 466us/step - loss: 0.0294
Epoch 61/800
36/36 [============= ] - 0s 739us/step - loss: 0.0272
Epoch 62/800
36/36 [============== ] - 0s 299us/step - loss: 0.0273
Epoch 63/800
```

```
36/36 [============== ] - 0s 280us/step - loss: 0.0275
Epoch 64/800
36/36 [============ ] - 0s 302us/step - loss: 0.0268
Epoch 65/800
Epoch 66/800
Epoch 67/800
Epoch 68/800
Epoch 69/800
36/36 [============== ] - 0s 388us/step - loss: 0.0294
Epoch 70/800
36/36 [=============== ] - 0s 341us/step - loss: 0.0288
Epoch 71/800
36/36 [============== ] - 0s 353us/step - loss: 0.0292
Epoch 72/800
Epoch 73/800
36/36 [============== ] - 0s 404us/step - loss: 0.0278
Epoch 74/800
36/36 [============== ] - 0s 353us/step - loss: 0.0283
Epoch 75/800
36/36 [============== ] - 0s 327us/step - loss: 0.0268
Epoch 76/800
Epoch 77/800
Epoch 78/800
Epoch 79/800
36/36 [============== ] - 0s 363us/step - loss: 0.0260
Epoch 80/800
36/36 [============== ] - 0s 303us/step - loss: 0.0319
Epoch 81/800
36/36 [============= ] - 0s 306us/step - loss: 0.0284
Epoch 82/800
36/36 [============== ] - 0s 291us/step - loss: 0.0263
Epoch 83/800
36/36 [============= ] - 0s 289us/step - loss: 0.0275
Epoch 84/800
Epoch 85/800
36/36 [=============== ] - 0s 279us/step - loss: 0.0310
Epoch 86/800
Epoch 87/800
Epoch 88/800
Epoch 89/800
Epoch 90/800
36/36 [=============== ] - 0s 547us/step - loss: 0.0266
Epoch 91/800
36/36 [============== ] - 0s 287us/step - loss: 0.0265
```

Epoch	92/800				
	[=======]	_	0s	306us/step - loss: 0.0273	3
	93/800				
	[======] 94/800	-	0s	312us/step - loss: 0.0292	2
	[========]	_	0s	302us/step - loss: 0.0286	5
Epoch	95/800			_	
	[========]	-	0s	289us/step - loss: 0.0294	Ė
	96/800 [======]	_	0s	303us/step - loss: 0.0278	3
Epoch	97/800			_	
	[======]	-	0s	433us/step - loss: 0.0293	3
	98/800 [======]	_	0s	470us/step = loss: 0.0297	7
Epoch	99/800			_	
	[======]	-	0s	329us/step - loss: 0.0276)
	100/800	_	Λe	332us/sten _ loss• 0 0281	
Epoch	101/800			_	
	[======]	-	0s	325us/step - loss: 0.0263	3
	102/800	_	Λe	300us/step _ loss	2
	103/800	_	US	300ds/scep - 10ss. 0.0326	,
	[=======]	-	0s	341us/step - loss: 0.0273	}
	104/800 [=========]		٥٥	252ug/gton logg. 0 0204	1
	105/800	_	US	333us/scep - 10ss: 0.0304	t
36/36	[======]	_	0s	297us/step - loss: 0.0270)
	106/800		0 ~	276/	
	[======] 107/800	_	US	3/6us/step - loss: 0.0261	-
	[======]	_	0s	330us/step - loss: 0.0285	5
	108/800		0	221/ 1 0 0275	,
	[=======] 109/800	_	US	331us/step - 10ss: 0.02//	,
	[======]	_	0s	368us/step - loss: 0.0281	L
	110/800		•	406 / 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	
	[=======] 111/800	_	US	406us/step - loss: 0.02/4	ŀ
	[=======]	_	0s	330us/step - loss: 0.0272	2
	112/800		•		
	[======] 113/800	-	0s	284us/step - loss: 0.0298	3
	[=======]	_	0s	394us/step - loss: 0.0276	5
	114/800				
	[======] 115/800	-	0s	350us/step - loss: 0.0256)
	[========]	_	0s	416us/step - loss: 0.0288	3
Epoch	116/800				
	[======] 117/800	-	0s	344us/step - loss: 0.0282	2
	[========]	_	0s	494us/step - loss: 0.0262	2
Epoch	118/800				
	[======] 119/800	-	0s	471us/step - loss: 0.0284	t
	[=========]	_	0s	417us/step - loss: 0.0262	2
	120/800			-	

36/36	[======]	_	0s	452us/step - loss: 0.	0284
	121/800				
	[======] 122/800	-	0s	817us/step - loss: 0.	0265
	[=======]	_	0s	574us/step - loss: 0.	0278
Epoch	123/800				
	[=======]	-	0s	695us/step - loss: 0.	0273
	124/800		0	507 / 1	0056
	[======] 125/800	-	US	59/us/step - loss: 0.	0256
	[======]	_	0s	548us/step - loss: 0.	0276
Epoch	126/800				
	[=======]	-	0s	649us/step - loss: 0.	0289
	127/800		0 ~	220	0220
	[======] 128/800	-	US	338us/step - loss: 0.	0338
	[=======]	_	0s	451us/step - loss: 0.	0263
Epoch	129/800				
	[======]	-	0s	457us/step - loss: 0.	0284
	130/800		•	414 / 1	0065
	[======] 131/800	-	0s	414us/step - loss: 0.	0267
	[=========]	_	0s	276us/step - loss: 0.	0292
	132/800		0.5	2,002,000P	V-J-
	[======]	-	0s	325us/step - loss: 0.	0269
	133/800		•	256 / 1	
	[======] 134/800	-	0s	356us/step - loss: 0.	0257
	[========]	_	0s	324us/step = loss: 0.	0270
	135/800		0.5		0_,0
	[======]	-	0s	317us/step - loss: 0.	0278
	136/800		•		0060
	[======] 137/800	-	US	313us/step - loss: 0.	0260
	[=======]	_	0s	283us/step - loss: 0.	0273
Epoch	138/800				
	[=====]	-	0s	279us/step - loss: 0.	0292
_	139/800		٥٥	460ug/gtop logg. 0	0272
	[=======] 140/800	_	US	469us/step - 10ss: 0.	0272
	[=======]	_	0s	691us/step - loss: 0.	0290
Epoch	141/800				
	[=======]	-	0s	634us/step - loss: 0.	0261
	142/800		0	600/	0076
	[=======] 143/800	-	US	600us/step - loss: 0.	0276
	[=======]	_	0s	521us/step - loss: 0.	0268
	144/800				
	[=======]	-	0s	509us/step - loss: 0.	0271
	145/800		0	501 / 1 3 0	0000
	[======] 146/800	-	US	591us/step - 10ss: 0.	0282
	[=======]	_	0s	644us/step - loss: 0.	0273
	147/800				•
36/36	[======]	-	0s	538us/step - loss: 0.	0274
	148/800		•	540 / · · · · · · · · · · · · · · · · · ·	
36/36	[=====]	-	Us	548us/step - loss: 0.	0257

Epoch	149/800				
36/36	[======]	_	0s	701us/step - loss: 0.02	71
	150/800		•	500 / 1 3 0 00	0.5
	[======] 151/800	-	0s	589us/step - loss: 0.02	85
	[=======]	_	0s	504us/step - loss: 0.03	01
	152/800			-	
	[======================================	-	0s	485us/step - loss: 0.02	49
	153/800 [======]	_	0s	546us/step - loss: 0.02	68
Epoch	154/800			_	
	[=======]	-	0s	749us/step - loss: 0.02	63
	155/800 [=======]	_	Λq	541us/step = loss: 0.02	84
	156/800		0 D	311 u 5/5ccp 1055: 0:02	0 1
	[======]	-	0s	561us/step - loss: 0.02	77
	157/800 [======]		۸c	301ug/gton logg: 0 03	Λ1
	158/800	_	US	301us/scep - 10ss. 0.03	01
	[=======]	-	0s	345us/step - loss: 0.02	64
	159/800 [=======]		٥٥	457ug/gton logg: 0.02	50
	160/800	_	US	43/us/scep - 10ss: 0.02	50
	[======]	_	0s	317us/step - loss: 0.02	78
	161/800 [=======]		0~	270/	0.0
	162/800	_	US	2/9us/step - loss: 0.02	98
	[======]	_	0s	304us/step - loss: 0.02	61
	163/800		•	220 / 1 2 0 02	0.6
	[======] 164/800	_	US	339us/step - loss: 0.03	06
	[=======]	_	0s	410us/step - loss: 0.02	71
	165/800		•	460 / 4 3 0 000	
	[======] 166/800	-	US	468us/step - loss: 0.02	90
	[=======]	_	0s	411us/step - loss: 0.02	56
_	167/800		•	404 / 4 3 0 00	
	[=======] 168/800	-	US	484us/step - loss: 0.02	58
	[=======]	_	0s	312us/step - loss: 0.03	03
	169/800		•		
	[======] 170/800	-	0s	328us/step - loss: 0.02	59
	[=======]	_	0s	416us/step - loss: 0.02	71
	171/800				
	[======] 172/800	-	0s	364us/step - loss: 0.02	83
	[========]	_	0s	359us/step - loss: 0.02	93
	173/800				
	[======] 174/800	-	0s	330us/step - loss: 0.02	83
	[========]	_	0s	327us/step - loss: 0.02	86
Epoch	175/800				
	[======] 176/800	-	0s	301us/step - loss: 0.02	81
	[=========]	_	0s	285us/step - loss: 0.02	69
	177/800				

	[=======] 178/800	-	0s	295us/step - lo	oss:	0.0271
36/36	[======]	-	0s	270us/step - lo	oss:	0.0287
	179/800 [========]	_	0s	320us/step - 1	oss:	0.0272
	180/800 [========]	_	Λq	32011g/gten = 10	066.	0 0288
Epoch	181/800					
	[======] 182/800	-	0s	509us/step - lo	oss:	0.0270
	[=======] 183/800	-	0s	327us/step - le	oss:	0.0297
36/36	[======]	_	0s	378us/step - le	oss:	0.0249
	184/800 [=======]	_	0s	433us/step - 10	oss:	0.0295
Epoch	185/800					
Epoch	[======] 186/800					
	[======] 187/800	-	0s	395us/step - 10	oss:	0.0254
36/36	[======]	-	0s	518us/step - le	oss:	0.0279
	188/800 [=======]	_	0s	331us/step - le	oss:	0.0305
Epoch	189/800 [======]					
Epoch	190/800					
	[======] 191/800	-	0s	421us/step - lo	oss:	0.0287
36/36	[======]	-	0s	385us/step - le	oss:	0.0257
	192/800 [=======]	_	0s	397us/step - le	oss:	0.0265
	193/800 [=======]	_	0s	598us/step - 10	oss:	0.0268
Epoch	194/800					
Epoch	[======] 195/800					
	[======] 196/800	-	0s	312us/step - 10	oss:	0.0268
36/36	[======]	-	0s	305us/step - lo	oss:	0.0252
	197/800 [==========]	_	0s	255us/step - 1	oss:	0.0275
	198/800 [========]		Λα	272us/sten _ 1	066.	0 0304
Epoch	199/800					
	[======] 200/800	-	0s	302us/step - 10	oss:	0.0259
	[======] 201/800	-	0s	285us/step - 1	oss:	0.0278
36/36	[======]	_	0s	316us/step - le	oss:	0.0278
	202/800 [=======]	_	0s	314us/step - le	oss:	0.0255
Epoch	203/800 [======]					
Epoch	204/800					
	[=======] 205/800	-	0s	499us/step - lo	oss:	0.0262
	[======]	-	0s	416us/step - le	oss:	0.0280

Enoch	206/800						
	[=======]	_	0s	326us/step	_	loss:	0.0260
	207/800			_			
	[======]	-	0s	317us/step	-	loss:	0.0328
	208/800			/		_	
	[=========]	-	0s	332us/step	-	loss:	0.0277
	209/800 [======]		Λc	185115/stop		1000	0 0279
	210/800	_	US	40Jus/scep	_	1055:	0.0279
	[=======]	_	0s	370us/step	_	loss:	0.0276
Epoch	211/800			_			
	[======]	-	0s	322us/step	-	loss:	0.0277
	212/800		•	250 / 1			
	[======================================	-	0s	3/2us/step	-	loss:	0.0270
	213/800 [=======]	_	۸e	34311g/gten	_	1000	0 0291
	214/800		V.S	J4Jus/scep		1055.	0.0271
	[========]	_	0s	294us/step	_	loss:	0.0275
	215/800						
	[=====]	-	0s	332us/step	-	loss:	0.0249
	216/800		•	050 / 1			
	[======] 217/800	-	0s	259us/step	-	loss:	0.0301
	[==========]	_	۸e	427118/sten	_	1099.	0 0269
	218/800	_	V.S	42/d5/5cep	_	1055.	0.0203
	[========]	_	0s	333us/step	_	loss:	0.0271
Epoch	219/800			_			
	[=====]	-	0s	320us/step	-	loss:	0.0280
	220/800		•	4.1.1 / .			
	[======] 221/800	-	0s	411us/step	-	loss:	0.0274
	[=========]	_	Λs	500us/sten	_	1055:	0.0271
	222/800		0.5	эооць/ всер		1055.	0.0271
	[=======]	_	0s	713us/step	_	loss:	0.0279
	223/800						
	[======]	-	0s	643us/step	-	loss:	0.0308
	224/800 [=======]		0~	450/		1	0 0260
	225/800	_	US	450us/scep	-	TOSS:	0.0269
	[=======]	_	0s	334us/step	_	loss:	0.0250
	226/800						
	[======]	_	0s	326us/step	_	loss:	0.0256
-	227/800					_	
	[========]	-	0s	311us/step	-	loss:	0.0278
	228/800 [=======]		٥٥	20 Eug /g+op		1000.	0 0202
	229/800	_	US	295us/step	_	1055:	0.0293
-	[=======]	_	0s	320us/step	_	loss:	0.0263
	230/800						
	[======]	-	0s	300us/step	-	loss:	0.0254
	231/800					_	
	[=========]	-	0s	385us/step	-	loss:	0.0257
	232/800 [======]		٥٥	291112/2+05		logg•	U U3V0
	233/800	_	υÞ	zgrus/step	_	1055:	0.0300
	[=======]	_	0s	355us/step	_	loss:	0.0279
	234/800			-			

```
36/36 [=============== ] - 0s 327us/step - loss: 0.0255
Epoch 235/800
Epoch 236/800
Epoch 237/800
Epoch 238/800
Epoch 239/800
Epoch 240/800
36/36 [=============== ] - 0s 355us/step - loss: 0.0278
Epoch 241/800
36/36 [============== ] - 0s 467us/step - loss: 0.0264
Epoch 242/800
36/36 [============== ] - 0s 334us/step - loss: 0.0255
Epoch 243/800
Epoch 244/800
36/36 [============== ] - 0s 289us/step - loss: 0.0267
Epoch 245/800
36/36 [=============== ] - 0s 293us/step - loss: 0.0316
Epoch 246/800
36/36 [============== ] - 0s 278us/step - loss: 0.0261
Epoch 247/800
36/36 [=============== ] - 0s 310us/step - loss: 0.0307
Epoch 248/800
36/36 [============== ] - 0s 349us/step - loss: 0.0250
Epoch 249/800
Epoch 250/800
- loss: 0.0253
Epoch 251/800
36/36 [=============== ] - 0s 527us/step - loss: 0.0274
Epoch 252/800
Epoch 253/800
36/36 [============== ] - 0s 553us/step - loss: 0.0278
Epoch 254/800
Epoch 255/800
Epoch 256/800
36/36 [=============== ] - 0s 789us/step - loss: 0.0267
Epoch 257/800
36/36 [============== ] - 0s 388us/step - loss: 0.0280
Epoch 258/800
36/36 [=============== ] - 0s 530us/step - loss: 0.0261
Epoch 259/800
36/36 [============ ] - 0s 369us/step - loss: 0.0260
Epoch 260/800
36/36 [============= ] - 0s 385us/step - loss: 0.0265
Epoch 261/800
36/36 [=============== ] - 0s 417us/step - loss: 0.0262
Epoch 262/800
```

	[======]	-	0s	357us/step -	loss:	0.0281
	263/800 [=======]	_	0s	641us/step -	loss:	0.0279
Epoch	264/800					
	[======] 265/800	-	0s	494us/step -	loss:	0.0276
36/36	[======]	-	0s	642us/step -	loss:	0.0279
	266/800 [=======]	_	0s	548us/sten -	loss:	0.0283
Epoch	267/800					
	[=======] 268/800	-	0s	584us/step -	loss:	0.0283
36/36	[======]	_	0s	482us/step -	loss:	0.0302
	269/800 [=======]	_	0s	715us/step -	loss:	0.0281
Epoch	270/800					
	[======] 271/800	-	0s	322us/step -	loss:	0.0255
36/36	[======]	_	0s	336us/step -	loss:	0.0258
	272/800 [=======]	_	0 s	372115/sten -	loss:	0.0253
Epoch	273/800					
	[======] 274/800	-	0s	453us/step -	loss:	0.0248
36/36	[======]	_	0s	277us/step -	loss:	0.0249
	275/800 [======]		Λc	431ug/gton	logg•	0 0320
Epoch	276/800					
	[======] 277/800	-	0s	283us/step -	loss:	0.0298
	[=======]	_	0s	267us/step -	loss:	0.0280
	278/800 [======]		٥٥	456ug /gtop	1000	0 0270
Epoch	279/800					
	[======] 280/800	-	0s	360us/step -	loss:	0.0250
	[=======]	_	0s	410us/step -	loss:	0.0243
	281/800 [======]		Λc	29/115/sten	loss.	0 0264
Epoch	282/800					
	[======] 283/800	-	0s	308us/step -	loss:	0.0274
	[========]	_	0s	590us/step -	loss:	0.0274
	284/800 [======]		Λσ	471ug/g+op	logg•	0 0276
Epoch	285/800					
	[=======] 286/800	-	0s	501us/step -	loss:	0.0274
	[=======]	_	0s	467us/step -	loss:	0.0272
	287/800 [======]		٥٥	517ug/gtop	1000	0 0201
Epoch	288/800					
	[======] 289/800	-	0s	736us/step -	loss:	0.0274
	[=======]	_	0s	473us/step -	loss:	0.0276
	290/800		0	196119 / gt an	1000	0 0260
30/36	[=====]	-	US	400us/step -	TOSS:	0.0268

```
Epoch 291/800
- loss: 0.0261
Epoch 292/800
Epoch 293/800
36/36 [=============== ] - 0s 351us/step - loss: 0.0265
Epoch 294/800
Epoch 295/800
Epoch 296/800
36/36 [============== ] - 0s 517us/step - loss: 0.0303
Epoch 297/800
36/36 [=============== ] - 0s 479us/step - loss: 0.0261
Epoch 298/800
36/36 [============== ] - 0s 647us/step - loss: 0.0273
Epoch 299/800
36/36 [============= ] - 0s 627us/step - loss: 0.0277
Epoch 300/800
36/36 [============= ] - 0s 704us/step - loss: 0.0244
Epoch 301/800
36/36 [=============== ] - 0s 580us/step - loss: 0.0286
Epoch 302/800
36/36 [============== ] - 0s 457us/step - loss: 0.0282
Epoch 303/800
Epoch 304/800
Epoch 305/800
Epoch 306/800
Epoch 307/800
36/36 [============== ] - 0s 304us/step - loss: 0.0254
Epoch 308/800
36/36 [============== ] - 0s 342us/step - loss: 0.0295
Epoch 309/800
36/36 [=============== ] - 0s 272us/step - loss: 0.0257
Epoch 310/800
Epoch 311/800
36/36 [============== ] - 0s 479us/step - loss: 0.0242
Epoch 312/800
36/36 [============== ] - 0s 328us/step - loss: 0.0288
Epoch 313/800
36/36 [============= ] - 0s 266us/step - loss: 0.0271
Epoch 314/800
Epoch 315/800
36/36 [============== ] - 0s 311us/step - loss: 0.0279
Epoch 316/800
Epoch 317/800
36/36 [============== ] - 0s 308us/step - loss: 0.0274
Epoch 318/800
36/36 [============= ] - 0s 390us/step - loss: 0.0260
```

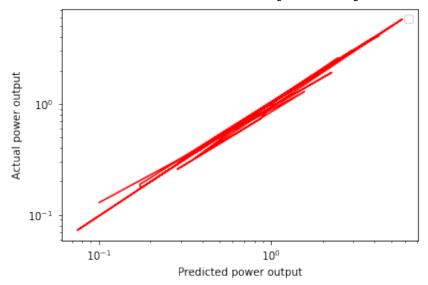
Epoch	319/800				
	[========]	_	0s	339us/step - loss:	0.0270
	320/800		•		
	[======] 321/800	-	0s	304us/step - loss:	0.0265
	[=========]	_	0s	373us/step - loss:	0.0251
	322/800			_	
	[======================================	-	0s	289us/step - loss:	0.0261
	323/800 [=======]	_	0s	332us/step - loss:	0.0266
Epoch	324/800			_	
	[=======]	-	0s	410us/step - loss:	0.0292
	325/800 [=======]	_	Λq	404us/sten - loss:	0.0256
Epoch	326/800			_	
	[======]	-	0s	363us/step - loss:	0.0284
	327/800 [=======]		۸c	307ug/gton logg.	0 0250
	328/800	_	US	30/us/scep - 10ss.	0.0230
	[=======]	-	0s	333us/step - loss:	0.0303
	329/800 [=======]		٥٩	Along/stop logg.	0 0246
	330/800	_	US	418us/step - 10ss:	0.0246
36/36	[=======]	_	0s	307us/step - loss:	0.0287
	331/800		•	210 / 1	0 0000
	[======] 332/800	-	US	318us/step - loss:	0.0302
	[=========]	_	0s	318us/step - loss:	0.0259
	333/800				
	[=======] 334/800	-	0s	338us/step - loss:	0.0278
	[==========]	_	0s	308us/step - loss:	0.0259
Epoch	335/800				
	[=======] 336/800	-	0s	324us/step - loss:	0.0297
	[==========]	_	0s	365us/step - loss:	0.0269
Epoch	337/800				
	[======] 338/800	-	0s	312us/step - loss:	0.0270
	[==========]	_	0s	338us/step - loss:	0.0299
Epoch	339/800				
	[======================================	-	0s	311us/step - loss:	0.0254
	340/800 [=======]	_	0s	344us/step - loss:	0.0247
Epoch	341/800				
	[======================================	-	0s	395us/step - loss:	0.0263
	342/800 [=======]	_	0s	486us/step = loss:	0.0249
Epoch	343/800				
	[=======]	-	0s	492us/step - loss:	0.0261
	344/800 [========]		Λe	65211g/gton _ logg.	0 0244
Epoch	345/800				
	[======]	-	0s	435us/step - loss:	0.0312
	346/800 [=======]		0.5	400ug/g+an logg.	0 0272
	347/800	_	UB	100mg/gcch - 10gg:	0.02/2
-					

	[=======] 348/800	-	0s	346us/step	-	loss:	0.0263
36/36	[======]	-	0s	391us/step	-	loss:	0.0248
36/36	349/800 [=======]	_	0s	315us/step	_	loss:	0.0271
	350/800 [=======]	_	0s	301us/step	_	loss:	0.0251
Epoch	351/800 [======]						
Epoch	352/800						
Epoch	[======] 353/800						
	[======] 354/800	-	0s	350us/step	-	loss:	0.0269
36/36	[======]	-	0s	276us/step	-	loss:	0.0272
36/36	355/800 [=======]	_	0s	566us/step	_	loss:	0.0261
	356/800 [=======]	_	0s	632us/step	_	loss:	0.0333
Epoch	357/800 [======]						
Epoch	358/800						
Epoch	[======] 359/800						
	[======] 360/800	-	0s	714us/step	-	loss:	0.0253
36/36	[=======] 361/800	-	0s	466us/step	-	loss:	0.0278
36/36	[======]	-	0s	542us/step	-	loss:	0.0256
	362/800 [=======]	_	0s	417us/step	_	loss:	0.0262
	363/800 [======]	_	0s	613us/step	_	loss:	0.0245
Epoch	364/800 [=======]						
Epoch	365/800						
	[======] 366/800	-	0s	324us/step	-	loss:	0.0269
	[=======] 367/800	-	0s	515us/step	-	loss:	0.0265
36/36	[======]	-	0s	372us/step	-	loss:	0.0268
36/36	368/800 [=======]	_	0s	476us/step	_	loss:	0.0254
	369/800 [=======]	_	0s	370us/step	_	loss:	0.0249
Epoch	370/800 [======]						
Epoch	371/800						
Epoch	[=======] 372/800						
	[======] 373/800	-	0s	386us/step	-	loss:	0.0255
36/36	[=======] 374/800	-	0s	363us/step	-	loss:	0.0273
36/36	[======]	-	0s	408us/step	_	loss:	0.0295
	375/800 [======]	_	0s	406us/step	_	loss:	0.0258

```
Epoch 376/800
36/36 [=============== ] - 0s 327us/step - loss: 0.0277
Epoch 377/800
36/36 [============= ] - 0s 344us/step - loss: 0.0245
Epoch 378/800
36/36 [============= ] - 0s 387us/step - loss: 0.0285
Epoch 379/800
36/36 [============= ] - 0s 422us/step - loss: 0.0267
Epoch 380/800
36/36 [============== ] - 0s 576us/step - loss: 0.0265
Epoch 381/800
36/36 [=============== ] - 0s 501us/step - loss: 0.0271
Epoch 382/800
36/36 [============== ] - 0s 465us/step - loss: 0.0245
Epoch 383/800
36/36 [=============== ] - 0s 686us/step - loss: 0.0264
Epoch 384/800
36/36 [============= ] - 0s 462us/step - loss: 0.0276
Epoch 385/800
Epoch 386/800
Epoch 387/800
36/36 [============== ] - 0s 558us/step - loss: 0.0304
Epoch 388/800
Epoch 389/800
36/36 [============= ] - 0s 476us/step - loss: 0.0286
Epoch 390/800
36/36 [============= ] - 0s 374us/step - loss: 0.0249
Epoch 391/800
36/36 [============= ] - 0s 356us/step - loss: 0.0277
Restoring model weights from the end of the best epoch
Epoch 00391: early stopping
best epoch = 311
smallest loss = 0.02421319277750121
```

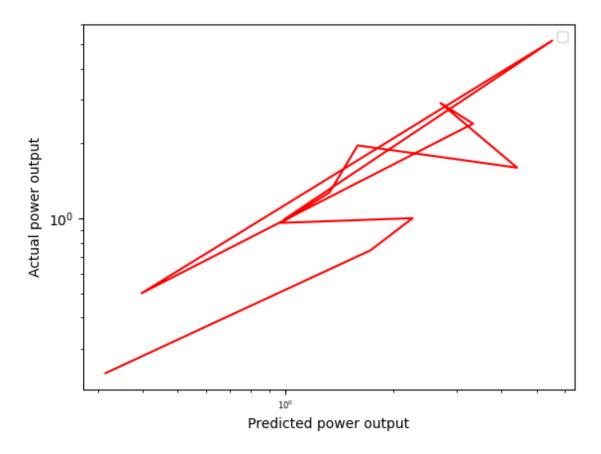
```
In [10]:
          # Task 2.2 Part e
          # This line of code can be used to reconstruct the saved model. The name of t
          recon model4 = keras.models.load model("best model4")
          import matplotlib.pyplot as plt
          y predictp = []
          y_testp = []
          Wdotpredp = []
          Wdotorigp = []
          for i in range(len(X train3)):
              testp = [[X_train3[i][0], X_train3[i][1], X_train3[i][2], X_train3[i][3]]
              testarrayp = np.array(testp)
              a3 = recon_model4.predict(testarrayp)
              y_predictp.append([a3[0][0], a3[0][1]])
              y_testp.append([y_train3[i][0], y_train3[i][1]])
              Wdotpredp.append([a3[0][1]])
              Wdotorigp.append([y_train3[i][1]])
          plt.figure()
          plt.loglog(Wdotpredp, Wdotorigp, c='r')
          plt.rc('xtick', labelsize=6)
          plt.xlabel("Predicted power output")
          plt.ylabel("Actual power output")
          plt.legend()
          fig.tight layout()
          plt.show()
          #MAE of predicted vs test data
          mae_Wdot = metrics.mean_absolute_error(y_predictp[:][1],y_testp[:][1])
          mae V1 = metrics.mean absolute error(y predictp[:][0],y testp[:][0])
          print('mean absolute error between predictions and the collection of test date
```

No handles with labels found to put in legend.



mean absolute error between predictions and the collection of test data: Vl = 0.0161700453573944 Wdot = 0.13746684174071533

```
In [347...
         # Task 2.2 Part f
          # This line of code can be used to reconstruct the saved model. The name of t
          recon model4 = keras.models.load model("best model4")
          import matplotlib.pyplot as plt
          y predictpn = []
          y testpn = []
          Wdotpredpn = []
          Wdotorigpn = []
          for i in range(len(X test3)):
              testp = [[X_test3[i][0], X_test3[i][1], X_test3[i][2], X_test3[i][3]]]
              testarrayp = np.array(testp)
              a3 = recon_model4.predict(testarrayp)
              y_predictpn.append([a3[0][0], a3[0][1]])
              y_testpn.append([y_test3[i][0], y_test3[i][1]])
              Wdotpredpn.append([a3[0][1]])
              Wdotorigpn.append([y_test3[i][1]])
          plt.figure()
          plt.loglog(Wdotpredpn, Wdotorigpn, c='r')
          plt.rc('xtick', labelsize=6)
          plt.xlabel("Predicted power output")
          plt.ylabel("Actual power output")
          plt.legend()
          plt.show()
          #MAE of predicted vs test data
          mae_Wdot = metrics.mean_absolute_error(y_predictpn[:][1],y_testpn[:][1])
          mae V1 = metrics.mean_absolute_error(y predictpn[:][0],y testpn[:][0])
          print('mean absolute error between predictions and the collection of test dat
```



No handles with labels found to put in legend. mean absolute error between predictions and the collection of test data: Vl = 0.01038831024423309 Wdot = 0.20072558901527193

```
In [312...
          #Task 2.2 Part g (i)
          xtestdata = [[10.0, 200, 50],
          [20.0, 200, 130],
          [10.0, 500, 40],
          [20.0, 500, 80],
          [20.0, 700, 30],
          [20.0, 700, 55],
          [10.0, 1000, 12],
          [20.0, 1000, 25],
          [20.0, 1000, 39]]
          Tairx =[]
          Idx = []
          Rlx =[]
          for x in range(len(xtestdata)):
              Tairx.append(xtestdata[x][0])
              Idx.append(xtestdata[x][1])
              Rlx.append(xtestdata[x][2])
          Tairg = Tairx/medTairm
          Idg = Idx/medIdm
          Rlg = Rlx/medRlm
          xarrayg = np.column stack((Tairg, Idg, Rlg))
          print(xarrayg)
          [[1.
                       0.28571429 1.68350168]
          [2.
                       0.28571429 4.37710438]
          [1.
                       0.71428571 1.34680135]
          [2.
                       0.71428571 2.693602691
          [2.
                                  1.01010101]
                       1.
          [2.
                       1.
                                  1.851851851
                      1.42857143 0.4040404 ]
          [1.
          [2.
                      1.42857143 0.84175084]
```

1.42857143 1.31313131]]

[2.

```
In [326...
```

```
# Task 2.2 part q(i) predict
# This line of code can be used to reconstruct the saved model. The name of t
recon model3 = keras.models.load model("best model3")
import matplotlib.pyplot as plt
Mmaxg = []
Vlg = []
Wdotg = []
for i in range(len(xarrayg)):
    testg = [[xarrayg[i][0], xarrayg[i][1], xarrayg[i][2]]]
    testarrayg = np.array(testg)
    a3 = recon_model3.predict(testarrayg)
    Mmaxg.append(a3[0][0]*medMmaxm)
    Vlg.append(a3[0][1]*medVlm)
    Wdotg.append(a3[0][2]*medRlm)
titles = ['Tair', 'I_D', 'R_L', 'Mmax', 'V_L', 'Wdot']
data = [titles] + list(zip(Tairx, Idx, Rlx, Mmaxg, Vlg, Wdotg))
for i, d in enumerate(data):
    line = '|'.join(str(x).ljust(12) for x in d)
    print(line)
    if i == 0:
        print('-' * len(line))
```

Tair	I_D	R_L	Mmax	V_L	Wdot
10.0	200	50	1.960221290	588379 89.8546	5043753624 9.89
956923723220	9				
20.0	200	130	3.1223934888	383972 147.61	776564121246 10
.74990733265	8767				
10.0	500	40	2.7385908365	5249634 123.95	5160114765167 2
2.1065794289	11207	•		·	·
20.0	500	80	3.0291666984	4558105 196.10	0980958938597 2
7.2621600747	10845	•		·	·
20.0	700	30	2.7685380578	3041077 139.98	328702688217 33
.15414147377	014				
20.0	700	55	3.1750456094	474182 199.354	400216579436 36
.27611528635	025	•	•	•	
10.0	1000	12	1.8894925113	7492676 95.918	355140924453 46
.14515111446	381	•		·	
20.0	1000	25	2.8598315119	9743347 156.90	0542230606079 5
1.3584333181	3812	•		·	·
20.0	1000	39	3.3350973129	927246 203.779	947695255278 53
.72723318338	394	•	•	•	·

```
In [336...
          #Task 2.2 Part q (ii)
          Mmaxr = np.round(Mmaxg)
          Mmaxrg = Mmaxr/medMp
          Tairrg = Tairx/medTairp
          Idrg = Idx/medIdp
          Rlrg = Rlx/medRlp
          xtestg = np.column stack((Mmaxrg, Tairrg, Idrg, Rlrg))
          print(xtestq)
         [[1.
                      1.
                                  0.33333333 1.821493621
          [1.5]
                      2.
                                 0.33333333 4.73588342]
                                 0.83333333 1.4571949 1
          [1.5
                     1.
                      2.
                                 0.83333333 2.9143898 ]
          [1.5]
          [1.5
                      2.
                                 1.16666667 1.09289617]
                     2.
                                 1.16666667 2.00364299]
          [1.5
                     1.
          [1.
                                 1.66666667 0.43715847]
                      2.
                                  1.66666667 0.91074681]
          [1.5
                                  1.66666667 1.42076503]]
          [1.5
                      2.
In [348...
          # Task 2.2 part q(ii) predict
          # This line of code can be used to reconstruct the saved model. The name of t
          recon model4 = keras.models.load model("best model4")
          import matplotlib.pyplot as plt
          Vlg2 = []
          Wdotq2 = []
          for i in range(len(xtestg)):
              testg = [[xtestg[i][0], xtestg[i][1], xtestg[i][2], xtestg[i][3]]]
              testarrayg = np.array(testg)
              a3 = recon_model4.predict(testarrayg)
              Vlg2.append(a3[0][0]*medVlp)
              Wdotg2.append(a3[0][1]*medRlp)
          mae Wdot = metrics.mean absolute error(Wdotg, Wdotg2)
          titles = ['Mmax_round', 'Tair', 'I_D', 'R_L', 'V_L', 'Wdot']
          data = [titles] + list(zip(Mmaxr, Tairx, Idx, Rlx, Vlg2, Wdotg2))
          for i, d in enumerate(data):
              line = '|'.join(str(x).ljust(12) for x in d)
              print(line)
              if i == 0:
                  print('-' * len(line))
          print('mean absolute error between predictions from first and second model: W
```

Mmax_round	Tair	I_D	R_L	V_L	Wdot
2.0 871248245	10.0	200	50	91.62284830	808639 27.14180
3.0 06040143965	20.0	200	130	161.8811963	2005692 23.5202
3.0 17718887325	10.0	500	40	114.02570812	2702179 54.8154
3.0 575210571	20.0	500	80	148.4456235	408783 32.26498
3.0 7286896706	20.0	700	30	67.314032709	959854 21.85776
3.0 31798315044	20.0	700	55	137.0444438	6959076 47.8408
2.0 032371521	10.0	1000	12	105.4087967	5149917 151.831
3.0 32392025	20.0	1000	25	116.4298187	6134873 69.3845
3.0 18779802322	20.0	1000	39	180.8309223	1750487 102.592

mean absolute error between predictions from first and second model: Wdot = 29.240247532725334