BAN200 Week 05 Homework

To complete the homework you will need to modify this template by adding Python code and/or text.

Before starting the homework, make sure to save a copy of this template to your personal Google Drive. If you haven't saved your own copy, any changes you make will be lost when you close your browser window.

To submit your homework: go to "File" in the Colab menu bar > select "Download" > select "Download .ipynb". This will download a ".ipynb" file to your computer. You must submit this file.

The homework is to be completed in groups. It is due at the start of next class.

Homework is graded on the following scale:

- *100%* -- The assignment was submitted on time, any code runs without errors, and every question is answered correctly.

- *80%* -- The assignment was submitted on time, any code runs without errors, and every question is answered. Some questions may be incorrect, but the submission demonstrates an average level of effort and average level of understanding of the material.

- *60%* -- The submission demonstrates a below-average level of effort and below-average level of understanding of the material. This is the highest grade that should be given to submissions that are submitted late, have code that throws uncaught errors, or leave some questions unanswered.

- *0%* -- No assignment was submitted, or the submission demonstrates little-to-no effort and little-to-no understanding of the material.

Email Subject Lines Data

This homework follows a case that is very similar to the one from class.

An online retailer has been testing a variety of email promotions. Each promotion offers a certain percentage savings and a different subject line. The retailer is interested in understanding how the percentage savings and subject line content are impacting open rate.

The dataset `email_subject_lines_data.txt` contains one row for each of 80 previous promotions, along with the following variables:

- `subject_line` the email's subject line
- `coupon_or_discount` 1 if the subject line contains the word 'coupon', 0 if it contains the word 'discount' (for the purposes of this analysis, we are going to assume the main difference between subject lines is whether the word 'coupon' or the word 'discount' was used)
- `savings_pct` the percentage savings offered in the email subject line
- `open_rate` the open rate of the email

Question 1

Create a pandas dataframe from `email_subject_lines_data.txt` . You can find this file on the course website. You should download it from the course website and upload it to this VM using the tab on the left. Once you've created the dataframe, display it so you can take a look at it.

```python
In [4]:  # put your answer here
         import pandas as pd
         df = pd.read_csv('email_subject_lines_data.txt',delimiter='\t')
         df
```

Out[4]:

	subject_line	coupon_or_discount	savings_pct	open_rate
0	Unlock your exclusive coupon: Get 32% off now!	1	32	34
1	Savings Alert: 25% off with your special coupo...	1	25	31
2	17% off your next purchase with this coupon code!	1	17	25
3	Save 19% instantly: Your coupon awaits!	1	19	25
4	Exclusive Offer: 14% off with this coupon!	1	14	23
...	...	...	...	...
75	Take 24% Off Your Order with This Coupon!	1	24	23
76	Enjoy 13% Off: Your Special Coupon Inside!	1	13	21
77	Savings Alert: Your 15% Off Coupon Awaits!	1	15	19
78	Special Coupon: Take 28% Off Your Purchase!	1	28	31
79	Act Fast: 15% Off Coupon Inside!	1	15	24

80 rows × 4 columns

Question 2

Create a scatterplot of `savings_pct` vs `open_rate` . Make sure the variable we are trying to predict is on the vertical axis.

```python
In [5]:  # put your answer here
         import matplotlib.pyplot as plt
         df.plot(kind='scatter', x='savings_pct', y='open_rate')
```

Out[5]: <Axes: xlabel='savings_pct', ylabel='open_rate'>
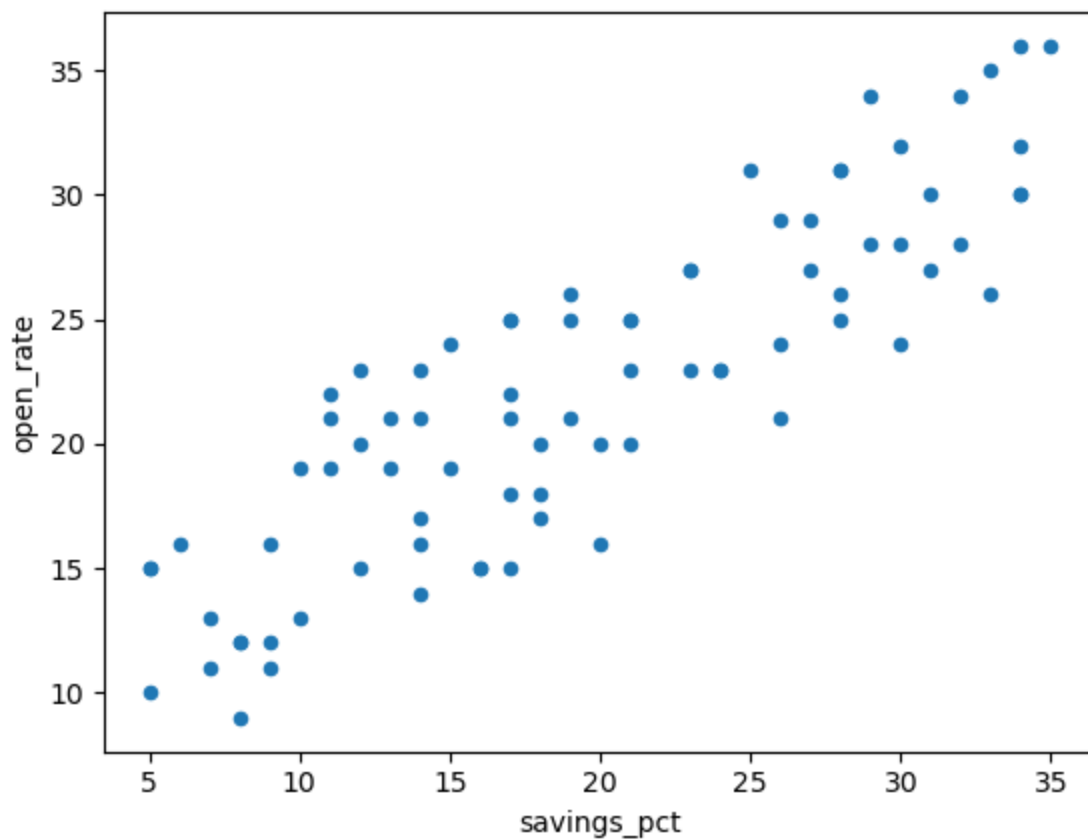
Question 3

Create a numpy array called `y` that contains `open_rate`.

```
In [6]:   # put your answer here
          import numpy as np
          y = df[['open_rate']].to_numpy()
          y[0:5]

Out[6]:   array([[34],
                 [31],
                 [25],
                 [25],
                 [23]])
```

Question 4

Create a numpy array called `x` that contains `savings_pct`.

```
In [7]:   # put your answer here
          x = df[['savings_pct']].to_numpy()
          x[0:5]

Out[7]:   array([[32],
                 [25],
                 [17],
                 [19],
                 [14]])
```

Question 5

Create a keras input object with size 1. Call this object `input`.

```
In [10]:   # put your answer here
           import keras
           import tensorflow as tf
```

```
In [12]:   input = keras.Input(shape=(1))
           input
```

```
Out[12]:   <KerasTensor: shape=(None, 1) dtype=float32 (created by layer 'input_2')>
```

Question 6

Creata a keras layer that takes `input` and returns a single value. Call this layer `linear_regression`.

```
In [13]:   # put your answer here
           linear_regression = keras.layers.Dense(1)(input)
           linear_regression
```

```
Out[13]:   <KerasTensor: shape=(None, 1) dtype=float32 (created by layer 'dense')>
```

Question 7

Create a keras model that takes `input` as the inputs and `linear_regression` as the outputs.

```
In [14]:   # put your answer here
           model = keras.Model(inputs=input, outputs=linear_regression)
           model
```

```
Out[14]:   <keras.engine.functional.Functional at 0x2861f2410>
```

Question 8

Compile the model using the optimizer and loss function discused in class.

```
In [15]:   # put your answer here
           model.compile(optimizer='adam', loss='mean_squared_error')
```

Question 9

Train the model on the `x` and `y` arrays defined earlier. Train for 500 epochs on a batch size of 1. Make sure to save the model history: we'll use it in the next question.

```
In [16]:   # put your answer here
           history = model.fit(x,y,batch_size=1,epochs=500)
```

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```
Epoch 1/500
80/80 [==============================] - 0s 392us/step - loss: 63.6626
Epoch 2/500
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Epoch 3/500
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```

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Epoch 5/500
80/80 [==============================] - 0s 329us/step - loss: 27.3799
Epoch 6/500
80/80 [==============================] - 0s 339us/step - loss: 25.2234
Epoch 7/500
80/80 [==============================] - 0s 426us/step - loss: 24.1242
Epoch 8/500
80/80 [==============================] - 0s 354us/step - loss: 23.4745
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Epoch 35/500
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80/80 [==============================] - 0s 325us/step - loss: 14.5111
Epoch 214/500
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Epoch 215/500
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Epoch 217/500
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Epoch 218/500
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Epoch 221/500
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Epoch 222/500
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Epoch 223/500
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Epoch 224/500
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Epoch 225/500
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Epoch 226/500
80/80 [==============================] - 0s 316us/step - loss: 14.2428
Epoch 227/500
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Epoch 229/500
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Epoch 231/500
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Epoch 232/500
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Epoch 233/500
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Epoch 234/500
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Epoch 235/500
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Epoch 239/500
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Epoch 243/500
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Epoch 249/500
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Epoch 255/500
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Epoch 258/500
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Epoch 259/500
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Epoch 262/500
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Epoch 278/500
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Epoch 281/500
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Epoch 282/500
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Epoch 287/500
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Epoch 288/500
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Epoch 289/500
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Epoch 290/500
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Epoch 291/500
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Loading [MathJax]/extensions/Safe.js

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Epoch 323/500
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Epoch 354/500
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Epoch 355/500
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Epoch 419/500
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Epoch 451/500
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Epoch 483/500
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80/80 [==============================] - 0s 309us/step - loss: 11.4237
Epoch 489/500
80/80 [==============================] - 0s 331us/step - loss: 11.3859
Epoch 490/500
80/80 [==============================] - 0s 322us/step - loss: 11.3837
Epoch 491/500
80/80 [==============================] - 0s 345us/step - loss: 11.3662
Epoch 492/500
80/80 [==============================] - 0s 305us/step - loss: 11.3909
Epoch 493/500
80/80 [==============================] - 0s 309us/step - loss: 11.4278
Epoch 494/500
80/80 [==============================] - 0s 326us/step - loss: 11.3877
Epoch 495/500
80/80 [==============================] - 0s 335us/step - loss: 11.4041
Epoch 496/500
80/80 [==============================] - 0s 432us/step - loss: 11.3716
Epoch 497/500
80/80 [==============================] - 0s 335us/step - loss: 11.3506
Epoch 498/500
80/80 [==============================] - 0s 327us/step - loss: 11.3785
Epoch 499/500
80/80 [==============================] - 0s 351us/step - loss: 11.3973
Epoch 500/500
80/80 [==============================] - 0s 326us/step - loss: 11.3610
```

Question 10

Use the training history to plot how the loss function changed over each training epoch.

```python
In [17]:  # put your answer here
          plt.plot(history.history['loss'])
```

```
Out[17]:  [<matplotlib.lines.Line2D at 0x2875a87c0>]
```
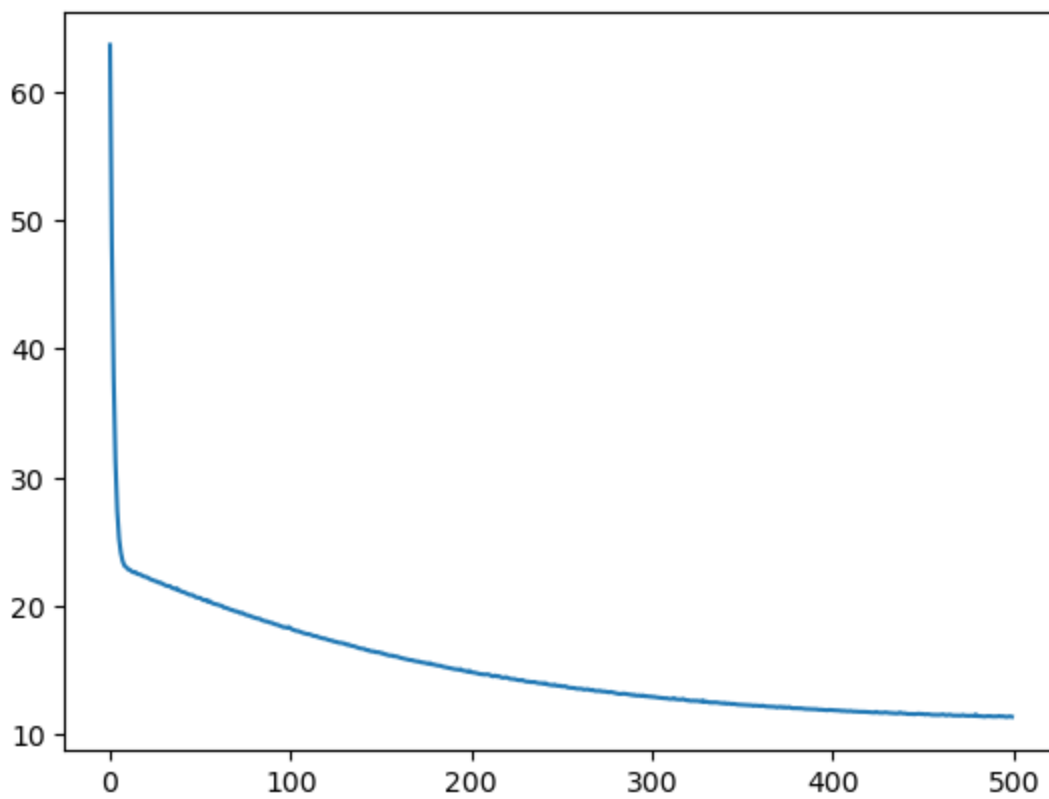
Question 11

What equation does the model provide for predicting open rate?

```
In [18]: model.get_weights()
         w0 = model.get_weights()[1]
         w1 = model.get_weights()[0]
```

```
In [19]: print("equation: student_acquired = %.2f + %.2f * first_class_price"%(w0,w1))

         equation: student_acquired = 7.28 + 0.75 * first_class_price
```

```
In [20]: x[0:3]
```

```
Out[20]: array([[32],
                [25],
                [17]])
```

```
In [21]: y[0:3]
```

```
Out[21]: array([[34],
                [31],
                [25]])
```

```
In [22]: y_pred = w0+w1*x
         y_pred[0:3]
```

```
Out[22]: array([[31.19114971],
                [25.96159953],
                [19.98497075]])
```
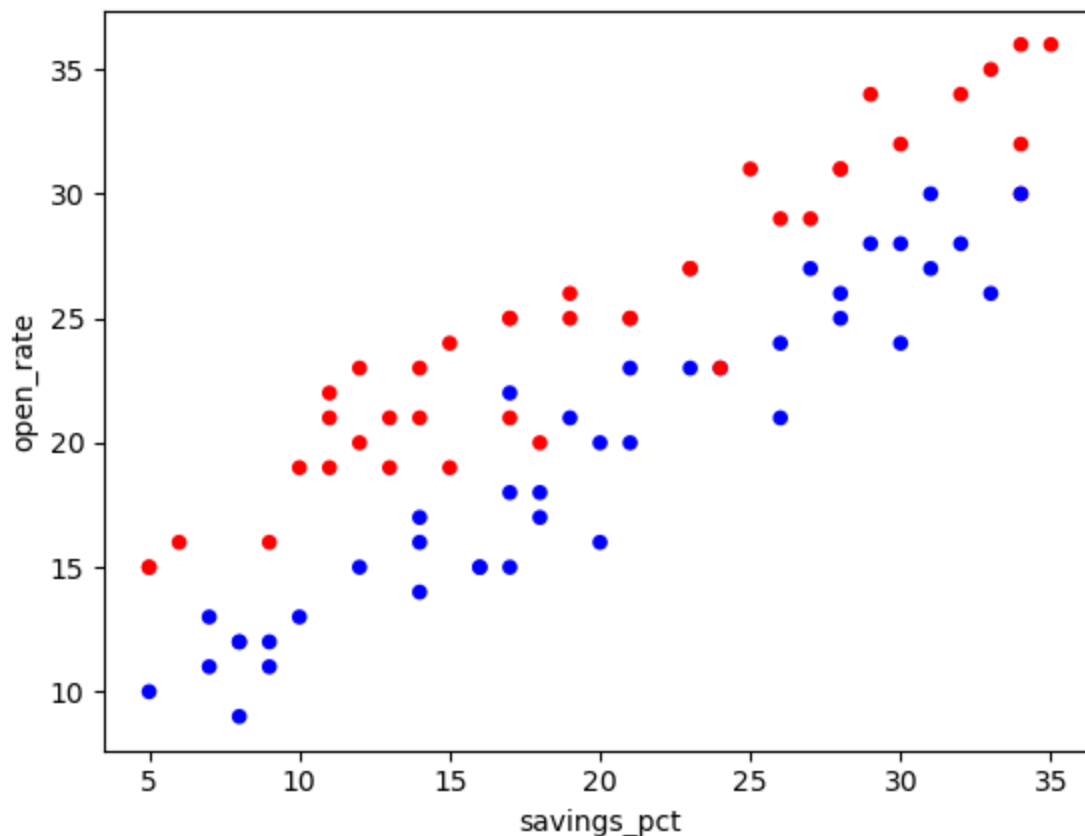
put your answer here

Question 12

Now, let's repeat the whole exercise, but add `coupon_or_discount` as our second predictor. To start, create a scatterplot of `savings_pct` vs `open_rate` with each dot a different colour depending on the value of `coupon_or_discount`.

```
In [23]:  # put your answer here
          df.plot(
              kind='scatter',
              x='savings_pct',
              y='open_rate',
              c=df['coupon_or_discount'].apply(lambda tranquility_or_fitness: 'red' if tranquility
```

Out[23]: <Axes: xlabel='savings_pct', ylabel='open_rate'>

Question 13

Recreate `x` to include both `savings_pct` and `coupon_or_discount`.

```
In [24]:  # put your answer here
          x = df[['savings_pct','coupon_or_discount']].to_numpy()
```

Question 14

Redefine `input`, `linear_regression`, and `model` to accomodate our new predictor.

```
In [25]:  # put your answer here
          input = keras.Input(shape=(2))
```

```
In [26]:  linear_regression = keras.layers.Dense(1)(input)
```

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```
In [27]: model = keras.Model(inputs=input, outputs=linear_regression)
```

```
In [28]: model.compile(optimizer='adam', loss='mean_squared_error')
```

Question 15

Compile the new model and train it for 500 epochs on a batch size of 1. Make sure to save the model history: we'll use it in the next question.

```
In [29]: # put your answer here
         history = model.fit(x,y,batch_size=1,epochs=500)
```

```
Epoch 1/500
80/80 [==============================] - 0s 470us/step - loss: 29.1803
Epoch 2/500
80/80 [==============================] - 0s 332us/step - loss: 28.0849
Epoch 3/500
80/80 [==============================] - 0s 347us/step - loss: 27.5573
Epoch 4/500
80/80 [==============================] - 0s 358us/step - loss: 27.1881
Epoch 5/500
80/80 [==============================] - 0s 351us/step - loss: 26.8859
Epoch 6/500
80/80 [==============================] - 0s 370us/step - loss: 26.6170
Epoch 7/500
80/80 [==============================] - 0s 409us/step - loss: 26.3423
Epoch 8/500
80/80 [==============================] - 0s 360us/step - loss: 26.1137
Epoch 9/500
80/80 [==============================] - 0s 350us/step - loss: 25.8961
Epoch 10/500
80/80 [==============================] - 0s 363us/step - loss: 25.7467
Epoch 11/500
80/80 [==============================] - 0s 362us/step - loss: 25.3959
Epoch 12/500
80/80 [==============================] - 0s 364us/step - loss: 25.2708
Epoch 13/500
80/80 [==============================] - 0s 397us/step - loss: 24.9196
Epoch 14/500
80/80 [==============================] - 0s 369us/step - loss: 24.6812
Epoch 15/500
80/80 [==============================] - 0s 346us/step - loss: 24.4673
Epoch 16/500
80/80 [==============================] - 0s 362us/step - loss: 24.2643
Epoch 17/500
80/80 [==============================] - 0s 337us/step - loss: 24.0198
Epoch 18/500
80/80 [==============================] - 0s 372us/step - loss: 23.8036
Epoch 19/500
80/80 [==============================] - 0s 345us/step - loss: 23.6278
Epoch 20/500
80/80 [==============================] - 0s 348us/step - loss: 23.3692
Epoch 21/500
80/80 [==============================] - 0s 349us/step - loss: 23.1928
Epoch 22/500
80/80 [==============================] - 0s 347us/step - loss: 22.9965
Epoch 23/500
80/80 [==============================] - 0s 340us/step - loss: 22.7123
Epoch 24/500
80/80 [==============================] - 0s 346us/step - loss: 22.4907
Epoch 25/500
80/80 [==============================] - 0s 345us/step - loss: 22.2802
Epoch 26/500
80/80 [==============================] - 0s 345us/step - loss: 22.0501
Epoch 27/500
80/80 [==============================] - 0s 382us/step - loss: 21.9456
Epoch 28/500
80/80 [==============================] - 0s 358us/step - loss: 21.6683
Epoch 29/500
80/80 [==============================] - 0s 321us/step - loss: 21.4372
Epoch 30/500
80/80 [==============================] - 0s 370us/step - loss: 21.2614
Epoch 31/500
80/80 [==============================] - 0s 342us/step - loss: 21.0383
Epoch 32/500
80/80 [==============================] - 0s 345us/step - loss: 20.8669
```

```
Epoch 33/500
80/80 [==============================] - 0s 356us/step - loss: 20.6516
Epoch 34/500
80/80 [==============================] - 0s 372us/step - loss: 20.4914
Epoch 35/500
80/80 [==============================] - 0s 350us/step - loss: 20.2364
Epoch 36/500
80/80 [==============================] - 0s 342us/step - loss: 20.0427
Epoch 37/500
80/80 [==============================] - 0s 368us/step - loss: 19.9189
Epoch 38/500
80/80 [==============================] - 0s 470us/step - loss: 19.6951
Epoch 39/500
80/80 [==============================] - 0s 353us/step - loss: 19.5079
Epoch 40/500
80/80 [==============================] - 0s 317us/step - loss: 19.3143
Epoch 41/500
80/80 [==============================] - 0s 347us/step - loss: 19.1679
Epoch 42/500
80/80 [==============================] - 0s 345us/step - loss: 18.9190
Epoch 43/500
80/80 [==============================] - 0s 349us/step - loss: 18.8145
Epoch 44/500
80/80 [==============================] - 0s 342us/step - loss: 18.5432
Epoch 45/500
80/80 [==============================] - 0s 534us/step - loss: 18.3860
Epoch 46/500
80/80 [==============================] - 0s 460us/step - loss: 18.2110
Epoch 47/500
80/80 [==============================] - 0s 339us/step - loss: 18.0280
Epoch 48/500
80/80 [==============================] - 0s 346us/step - loss: 17.9067
Epoch 49/500
80/80 [==============================] - 0s 331us/step - loss: 17.6954
Epoch 50/500
80/80 [==============================] - 0s 361us/step - loss: 17.5103
Epoch 51/500
80/80 [==============================] - 0s 342us/step - loss: 17.3304
Epoch 52/500
80/80 [==============================] - 0s 360us/step - loss: 17.1515
Epoch 53/500
80/80 [==============================] - 0s 339us/step - loss: 16.9908
Epoch 54/500
80/80 [==============================] - 0s 343us/step - loss: 16.8221
Epoch 55/500
80/80 [==============================] - 0s 332us/step - loss: 16.6634
Epoch 56/500
80/80 [==============================] - 0s 338us/step - loss: 16.4735
Epoch 57/500
80/80 [==============================] - 0s 321us/step - loss: 16.3302
Epoch 58/500
80/80 [==============================] - 0s 336us/step - loss: 16.1845
Epoch 59/500
80/80 [==============================] - 0s 332us/step - loss: 15.9964
Epoch 60/500
80/80 [==============================] - 0s 325us/step - loss: 15.8368
Epoch 61/500
80/80 [==============================] - 0s 332us/step - loss: 15.7154
Epoch 62/500
80/80 [==============================] - 0s 322us/step - loss: 15.5758
Epoch 63/500
80/80 [==============================] - 0s 334us/step - loss: 15.3994
Epoch 64/500
80/80 [==============================] - 0s 337us/step - loss: 15.2484
```

```
Epoch 65/500
80/80 [==============================] - 0s 332us/step - loss: 15.0546
Epoch 66/500
80/80 [==============================] - 0s 331us/step - loss: 14.9342
Epoch 67/500
80/80 [==============================] - 0s 322us/step - loss: 14.7656
Epoch 68/500
80/80 [==============================] - 0s 324us/step - loss: 14.6631
Epoch 69/500
80/80 [==============================] - 0s 325us/step - loss: 14.4947
Epoch 70/500
80/80 [==============================] - 0s 328us/step - loss: 14.3812
Epoch 71/500
80/80 [==============================] - 0s 324us/step - loss: 14.1612
Epoch 72/500
80/80 [==============================] - 0s 322us/step - loss: 14.0431
Epoch 73/500
80/80 [==============================] - 0s 339us/step - loss: 13.9011
Epoch 74/500
80/80 [==============================] - 0s 339us/step - loss: 13.7629
Epoch 75/500
80/80 [==============================] - 0s 344us/step - loss: 13.6369
Epoch 76/500
80/80 [==============================] - 0s 356us/step - loss: 13.4874
Epoch 77/500
80/80 [==============================] - 0s 327us/step - loss: 13.3465
Epoch 78/500
80/80 [==============================] - 0s 326us/step - loss: 13.2344
Epoch 79/500
80/80 [==============================] - 0s 324us/step - loss: 13.1002
Epoch 80/500
80/80 [==============================] - 0s 334us/step - loss: 12.9516
Epoch 81/500
80/80 [==============================] - 0s 336us/step - loss: 12.8526
Epoch 82/500
80/80 [==============================] - 0s 345us/step - loss: 12.6866
Epoch 83/500
80/80 [==============================] - 0s 344us/step - loss: 12.5675
Epoch 84/500
80/80 [==============================] - 0s 373us/step - loss: 12.4422
Epoch 85/500
80/80 [==============================] - 0s 339us/step - loss: 12.2893
Epoch 86/500
80/80 [==============================] - 0s 344us/step - loss: 12.1821
Epoch 87/500
80/80 [==============================] - 0s 335us/step - loss: 12.0816
Epoch 88/500
80/80 [==============================] - 0s 363us/step - loss: 11.9201
Epoch 89/500
80/80 [==============================] - 0s 327us/step - loss: 11.8248
Epoch 90/500
80/80 [==============================] - 0s 321us/step - loss: 11.7064
Epoch 91/500
80/80 [==============================] - 0s 340us/step - loss: 11.5569
Epoch 92/500
80/80 [==============================] - 0s 331us/step - loss: 11.4474
Epoch 93/500
80/80 [==============================] - 0s 336us/step - loss: 11.3332
Epoch 94/500
80/80 [==============================] - 0s 332us/step - loss: 11.2180
Epoch 95/500
80/80 [==============================] - 0s 329us/step - loss: 11.1583
Epoch 96/500
80/80 [==============================] - 0s 338us/step - loss: 10.9920
```

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```
Epoch 97/500
80/80 [==============================] - 0s 329us/step - loss: 10.9128
Epoch 98/500
80/80 [==============================] - 0s 445us/step - loss: 10.7596
Epoch 99/500
80/80 [==============================] - 0s 452us/step - loss: 10.6684
Epoch 100/500
80/80 [==============================] - 0s 392us/step - loss: 10.5582
Epoch 101/500
80/80 [==============================] - 0s 346us/step - loss: 10.4534
Epoch 102/500
80/80 [==============================] - 0s 313us/step - loss: 10.3488
Epoch 103/500
80/80 [==============================] - 0s 320us/step - loss: 10.2601
Epoch 104/500
80/80 [==============================] - 0s 351us/step - loss: 10.1173
Epoch 105/500
80/80 [==============================] - 0s 330us/step - loss: 10.0285
Epoch 106/500
80/80 [==============================] - 0s 329us/step - loss: 9.9287
Epoch 107/500
80/80 [==============================] - 0s 344us/step - loss: 9.8196
Epoch 108/500
80/80 [==============================] - 0s 335us/step - loss: 9.7287
Epoch 109/500
80/80 [==============================] - 0s 331us/step - loss: 9.6440
Epoch 110/500
80/80 [==============================] - 0s 323us/step - loss: 9.5548
Epoch 111/500
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Epoch 112/500
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Epoch 113/500
80/80 [==============================] - 0s 334us/step - loss: 9.2399
Epoch 114/500
80/80 [==============================] - 0s 329us/step - loss: 9.1974
Epoch 115/500
80/80 [==============================] - 0s 533us/step - loss: 9.0562
Epoch 116/500
80/80 [==============================] - 0s 420us/step - loss: 9.0023
Epoch 117/500
80/80 [==============================] - 0s 339us/step - loss: 8.8921
Epoch 118/500
80/80 [==============================] - 0s 338us/step - loss: 8.8244
Epoch 119/500
80/80 [==============================] - 0s 344us/step - loss: 8.7095
Epoch 120/500
80/80 [==============================] - 0s 328us/step - loss: 8.6378
Epoch 121/500
80/80 [==============================] - 0s 389us/step - loss: 8.5784
Epoch 122/500
80/80 [==============================] - 0s 333us/step - loss: 8.4509
Epoch 123/500
80/80 [==============================] - 0s 339us/step - loss: 8.4006
Epoch 124/500
80/80 [==============================] - 0s 344us/step - loss: 8.3273
Epoch 125/500
80/80 [==============================] - 0s 335us/step - loss: 8.2317
Epoch 126/500
80/80 [==============================] - 0s 342us/step - loss: 8.1676
Epoch 127/500
80/80 [==============================] - 0s 327us/step - loss: 8.0622
Epoch 128/500
80/80 [==============================] - 0s 325us/step - loss: 8.0151
```

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```
Epoch 129/500
80/80 [==============================] - 0s 343us/step - loss: 7.9064
Epoch 130/500
80/80 [==============================] - 0s 323us/step - loss: 7.8371
Epoch 131/500
80/80 [==============================] - 0s 329us/step - loss: 7.7680
Epoch 132/500
80/80 [==============================] - 0s 332us/step - loss: 7.6891
Epoch 133/500
80/80 [==============================] - 0s 324us/step - loss: 7.7059
Epoch 134/500
80/80 [==============================] - 0s 321us/step - loss: 7.5387
Epoch 135/500
80/80 [==============================] - 0s 328us/step - loss: 7.4896
Epoch 136/500
80/80 [==============================] - 0s 327us/step - loss: 7.4315
Epoch 137/500
80/80 [==============================] - 0s 320us/step - loss: 7.3352
Epoch 138/500
80/80 [==============================] - 0s 327us/step - loss: 7.3030
Epoch 139/500
80/80 [==============================] - 0s 331us/step - loss: 7.2135
Epoch 140/500
80/80 [==============================] - 0s 329us/step - loss: 7.1275
Epoch 141/500
80/80 [==============================] - 0s 335us/step - loss: 7.0884
Epoch 142/500
80/80 [==============================] - 0s 342us/step - loss: 7.0518
Epoch 143/500
80/80 [==============================] - 0s 337us/step - loss: 6.9523
Epoch 144/500
80/80 [==============================] - 0s 340us/step - loss: 6.8845
Epoch 145/500
80/80 [==============================] - 0s 348us/step - loss: 6.8810
Epoch 146/500
80/80 [==============================] - 0s 353us/step - loss: 6.8023
Epoch 147/500
80/80 [==============================] - 0s 385us/step - loss: 6.7061
Epoch 148/500
80/80 [==============================] - 0s 386us/step - loss: 6.6604
Epoch 149/500
80/80 [==============================] - 0s 338us/step - loss: 6.6116
Epoch 150/500
80/80 [==============================] - 0s 327us/step - loss: 6.5314
Epoch 151/500
80/80 [==============================] - 0s 328us/step - loss: 6.4995
Epoch 152/500
80/80 [==============================] - 0s 332us/step - loss: 6.4631
Epoch 153/500
80/80 [==============================] - 0s 321us/step - loss: 6.3779
Epoch 154/500
80/80 [==============================] - 0s 465us/step - loss: 6.3130
Epoch 155/500
80/80 [==============================] - 0s 371us/step - loss: 6.2742
Epoch 156/500
80/80 [==============================] - 0s 351us/step - loss: 6.2515
Epoch 157/500
80/80 [==============================] - 0s 343us/step - loss: 6.1539
Epoch 158/500
80/80 [==============================] - 0s 380us/step - loss: 6.1170
Epoch 159/500
80/80 [==============================] - 0s 372us/step - loss: 6.0901
Epoch 160/500
80/80 [==============================] - 0s 343us/step - loss: 6.0468
```

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```
Epoch 161/500
80/80 [==============================] - 0s 358us/step - loss: 5.9881
Epoch 162/500
80/80 [==============================] - 0s 334us/step - loss: 5.9488
Epoch 163/500
80/80 [==============================] - 0s 348us/step - loss: 5.8900
Epoch 164/500
80/80 [==============================] - 0s 338us/step - loss: 5.8673
Epoch 165/500
80/80 [==============================] - 0s 343us/step - loss: 5.8042
Epoch 166/500
80/80 [==============================] - 0s 351us/step - loss: 5.7565
Epoch 167/500
80/80 [==============================] - 0s 339us/step - loss: 5.7313
Epoch 168/500
80/80 [==============================] - 0s 348us/step - loss: 5.7003
Epoch 169/500
80/80 [==============================] - 0s 334us/step - loss: 5.6254
Epoch 170/500
80/80 [==============================] - 0s 328us/step - loss: 5.5990
Epoch 171/500
80/80 [==============================] - 0s 332us/step - loss: 5.5643
Epoch 172/500
80/80 [==============================] - 0s 325us/step - loss: 5.5143
Epoch 173/500
80/80 [==============================] - 0s 329us/step - loss: 5.4618
Epoch 174/500
80/80 [==============================] - 0s 336us/step - loss: 5.4548
Epoch 175/500
80/80 [==============================] - 0s 324us/step - loss: 5.4074
Epoch 176/500
80/80 [==============================] - 0s 333us/step - loss: 5.3700
Epoch 177/500
80/80 [==============================] - 0s 322us/step - loss: 5.3355
Epoch 178/500
80/80 [==============================] - 0s 322us/step - loss: 5.3262
Epoch 179/500
80/80 [==============================] - 0s 322us/step - loss: 5.2762
Epoch 180/500
80/80 [==============================] - 0s 319us/step - loss: 5.2595
Epoch 181/500
80/80 [==============================] - 0s 329us/step - loss: 5.2129
Epoch 182/500
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Epoch 183/500
80/80 [==============================] - 0s 332us/step - loss: 5.1545
Epoch 184/500
80/80 [==============================] - 0s 362us/step - loss: 5.0959
Epoch 185/500
80/80 [==============================] - 0s 650us/step - loss: 5.0867
Epoch 186/500
80/80 [==============================] - 0s 332us/step - loss: 5.0699
Epoch 187/500
80/80 [==============================] - 0s 327us/step - loss: 5.0121
Epoch 188/500
80/80 [==============================] - 0s 342us/step - loss: 5.0059
Epoch 189/500
80/80 [==============================] - 0s 333us/step - loss: 4.9488
Epoch 190/500
80/80 [==============================] - 0s 345us/step - loss: 4.9454
Epoch 191/500
80/80 [==============================] - 0s 342us/step - loss: 4.8970
Epoch 192/500
80/80 [==============================] - 0s 328us/step - loss: 4.8521
```

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```
Epoch 193/500
80/80 [==============================] - 0s 337us/step - loss: 4.8655
Epoch 194/500
80/80 [==============================] - 0s 347us/step - loss: 4.8146
Epoch 195/500
80/80 [==============================] - 0s 334us/step - loss: 4.7736
Epoch 196/500
80/80 [==============================] - 0s 326us/step - loss: 4.7604
Epoch 197/500
80/80 [==============================] - 0s 324us/step - loss: 4.7456
Epoch 198/500
80/80 [==============================] - 0s 334us/step - loss: 4.7132
Epoch 199/500
80/80 [==============================] - 0s 325us/step - loss: 4.6981
Epoch 200/500
80/80 [==============================] - 0s 331us/step - loss: 4.6662
Epoch 201/500
80/80 [==============================] - 0s 326us/step - loss: 4.6417
Epoch 202/500
80/80 [==============================] - 0s 323us/step - loss: 4.6266
Epoch 203/500
80/80 [==============================] - 0s 321us/step - loss: 4.5979
Epoch 204/500
80/80 [==============================] - 0s 328us/step - loss: 4.6352
Epoch 205/500
80/80 [==============================] - 0s 321us/step - loss: 4.5774
Epoch 206/500
80/80 [==============================] - 0s 317us/step - loss: 4.5514
Epoch 207/500
80/80 [==============================] - 0s 328us/step - loss: 4.5226
Epoch 208/500
80/80 [==============================] - 0s 318us/step - loss: 4.5296
Epoch 209/500
80/80 [==============================] - 0s 318us/step - loss: 4.4774
Epoch 210/500
80/80 [==============================] - 0s 308us/step - loss: 4.4678
Epoch 211/500
80/80 [==============================] - 0s 319us/step - loss: 4.4531
Epoch 212/500
80/80 [==============================] - 0s 323us/step - loss: 4.4256
Epoch 213/500
80/80 [==============================] - 0s 319us/step - loss: 4.4270
Epoch 214/500
80/80 [==============================] - 0s 316us/step - loss: 4.3969
Epoch 215/500
80/80 [==============================] - 0s 330us/step - loss: 4.3799
Epoch 216/500
80/80 [==============================] - 0s 322us/step - loss: 4.3553
Epoch 217/500
80/80 [==============================] - 0s 339us/step - loss: 4.3546
Epoch 218/500
80/80 [==============================] - 0s 329us/step - loss: 4.3266
Epoch 219/500
80/80 [==============================] - 0s 306us/step - loss: 4.3234
Epoch 220/500
80/80 [==============================] - 0s 334us/step - loss: 4.3067
Epoch 221/500
80/80 [==============================] - 0s 324us/step - loss: 4.2928
Epoch 222/500
80/80 [==============================] - 0s 321us/step - loss: 4.2710
Epoch 223/500
80/80 [==============================] - 0s 319us/step - loss: 4.2558
Epoch 224/500
80/80 [==============================] - 0s 311us/step - loss: 4.2287
```

```
Epoch 225/500
80/80 [==============================] - 0s 310us/step - loss: 4.2315
Epoch 226/500
80/80 [==============================] - 0s 318us/step - loss: 4.2076
Epoch 227/500
80/80 [==============================] - 0s 316us/step - loss: 4.1853
Epoch 228/500
80/80 [==============================] - 0s 302us/step - loss: 4.1811
Epoch 229/500
80/80 [==============================] - 0s 314us/step - loss: 4.1893
Epoch 230/500
80/80 [==============================] - 0s 323us/step - loss: 4.1486
Epoch 231/500
80/80 [==============================] - 0s 335us/step - loss: 4.1365
Epoch 232/500
80/80 [==============================] - 0s 315us/step - loss: 4.1223
Epoch 233/500
80/80 [==============================] - 0s 322us/step - loss: 4.1368
Epoch 234/500
80/80 [==============================] - 0s 318us/step - loss: 4.1466
Epoch 235/500
80/80 [==============================] - 0s 307us/step - loss: 4.1068
Epoch 236/500
80/80 [==============================] - 0s 330us/step - loss: 4.0966
Epoch 237/500
80/80 [==============================] - 0s 319us/step - loss: 4.0796
Epoch 238/500
80/80 [==============================] - 0s 314us/step - loss: 4.0695
Epoch 239/500
80/80 [==============================] - 0s 322us/step - loss: 4.0514
Epoch 240/500
80/80 [==============================] - 0s 313us/step - loss: 4.0552
Epoch 241/500
80/80 [==============================] - 0s 430us/step - loss: 4.0274
Epoch 242/500
80/80 [==============================] - 0s 328us/step - loss: 4.0335
Epoch 243/500
80/80 [==============================] - 0s 318us/step - loss: 4.0143
Epoch 244/500
80/80 [==============================] - 0s 327us/step - loss: 4.0086
Epoch 245/500
80/80 [==============================] - 0s 332us/step - loss: 4.0597
Epoch 246/500
80/80 [==============================] - 0s 328us/step - loss: 3.9825
Epoch 247/500
80/80 [==============================] - 0s 329us/step - loss: 3.9871
Epoch 248/500
80/80 [==============================] - 0s 331us/step - loss: 3.9726
Epoch 249/500
80/80 [==============================] - 0s 332us/step - loss: 3.9738
Epoch 250/500
80/80 [==============================] - 0s 315us/step - loss: 3.9596
Epoch 251/500
80/80 [==============================] - 0s 320us/step - loss: 3.9553
Epoch 252/500
80/80 [==============================] - 0s 329us/step - loss: 3.9258
Epoch 253/500
80/80 [==============================] - 0s 326us/step - loss: 3.9756
Epoch 254/500
80/80 [==============================] - 0s 314us/step - loss: 3.9181
Epoch 255/500
80/80 [==============================] - 0s 325us/step - loss: 3.9231
Epoch 256/500
80/80 [==============================] - 0s 310us/step - loss: 3.8978
```

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```
Epoch 257/500
80/80 [==============================] - 0s 595us/step - loss: 3.9000
Epoch 258/500
80/80 [==============================] - 0s 385us/step - loss: 3.8832
Epoch 259/500
80/80 [==============================] - 0s 320us/step - loss: 3.8819
Epoch 260/500
80/80 [==============================] - 0s 316us/step - loss: 3.8592
Epoch 261/500
80/80 [==============================] - 0s 329us/step - loss: 3.8558
Epoch 262/500
80/80 [==============================] - 0s 324us/step - loss: 3.8600
Epoch 263/500
80/80 [==============================] - 0s 332us/step - loss: 3.8659
Epoch 264/500
80/80 [==============================] - 0s 326us/step - loss: 3.8369
Epoch 265/500
80/80 [==============================] - 0s 334us/step - loss: 3.8344
Epoch 266/500
80/80 [==============================] - 0s 333us/step - loss: 3.8329
Epoch 267/500
80/80 [==============================] - 0s 328us/step - loss: 3.8542
Epoch 268/500
80/80 [==============================] - 0s 347us/step - loss: 3.8208
Epoch 269/500
80/80 [==============================] - 0s 313us/step - loss: 3.8149
Epoch 270/500
80/80 [==============================] - 0s 320us/step - loss: 3.8309
Epoch 271/500
80/80 [==============================] - 0s 332us/step - loss: 3.8211
Epoch 272/500
80/80 [==============================] - 0s 318us/step - loss: 3.8113
Epoch 273/500
80/80 [==============================] - 0s 320us/step - loss: 3.8051
Epoch 274/500
80/80 [==============================] - 0s 333us/step - loss: 3.7773
Epoch 275/500
80/80 [==============================] - 0s 333us/step - loss: 3.7714
Epoch 276/500
80/80 [==============================] - 0s 320us/step - loss: 3.7759
Epoch 277/500
80/80 [==============================] - 0s 317us/step - loss: 3.7793
Epoch 278/500
80/80 [==============================] - 0s 334us/step - loss: 3.7626
Epoch 279/500
80/80 [==============================] - 0s 332us/step - loss: 3.7666
Epoch 280/500
80/80 [==============================] - 0s 318us/step - loss: 3.7669
Epoch 281/500
80/80 [==============================] - 0s 321us/step - loss: 3.7440
Epoch 282/500
80/80 [==============================] - 0s 320us/step - loss: 3.7483
Epoch 283/500
80/80 [==============================] - 0s 333us/step - loss: 3.7658
Epoch 284/500
80/80 [==============================] - 0s 320us/step - loss: 3.7313
Epoch 285/500
80/80 [==============================] - 0s 319us/step - loss: 3.7238
Epoch 286/500
80/80 [==============================] - 0s 331us/step - loss: 3.7513
Epoch 287/500
80/80 [==============================] - 0s 321us/step - loss: 3.7112
Epoch 288/500
80/80 [==============================] - 0s 317us/step - loss: 3.7225
```
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```
Epoch 289/500
80/80 [==============================] - 0s 312us/step - loss: 3.7409
Epoch 290/500
80/80 [==============================] - 0s 317us/step - loss: 3.7065
Epoch 291/500
80/80 [==============================] - 0s 321us/step - loss: 3.7286
Epoch 292/500
80/80 [==============================] - 0s 321us/step - loss: 3.6889
Epoch 293/500
80/80 [==============================] - 0s 316us/step - loss: 3.7074
Epoch 294/500
80/80 [==============================] - 0s 313us/step - loss: 3.6974
Epoch 295/500
80/80 [==============================] - 0s 304us/step - loss: 3.7051
Epoch 296/500
80/80 [==============================] - 0s 315us/step - loss: 3.7093
Epoch 297/500
80/80 [==============================] - 0s 316us/step - loss: 3.6809
Epoch 298/500
80/80 [==============================] - 0s 314us/step - loss: 3.6894
Epoch 299/500
80/80 [==============================] - 0s 320us/step - loss: 3.6984
Epoch 300/500
80/80 [==============================] - 0s 306us/step - loss: 3.6973
Epoch 301/500
80/80 [==============================] - 0s 308us/step - loss: 3.7049
Epoch 302/500
80/80 [==============================] - 0s 311us/step - loss: 3.6739
Epoch 303/500
80/80 [==============================] - 0s 318us/step - loss: 3.6579
Epoch 304/500
80/80 [==============================] - 0s 312us/step - loss: 3.6560
Epoch 305/500
80/80 [==============================] - 0s 320us/step - loss: 3.6717
Epoch 306/500
80/80 [==============================] - 0s 323us/step - loss: 3.6724
Epoch 307/500
80/80 [==============================] - 0s 319us/step - loss: 3.6826
Epoch 308/500
80/80 [==============================] - 0s 315us/step - loss: 3.6616
Epoch 309/500
80/80 [==============================] - 0s 315us/step - loss: 3.6727
Epoch 310/500
80/80 [==============================] - 0s 315us/step - loss: 3.6488
Epoch 311/500
80/80 [==============================] - 0s 416us/step - loss: 3.6353
Epoch 312/500
80/80 [==============================] - 0s 329us/step - loss: 3.6233
Epoch 313/500
80/80 [==============================] - 0s 319us/step - loss: 3.6433
Epoch 314/500
80/80 [==============================] - 0s 314us/step - loss: 3.6208
Epoch 315/500
80/80 [==============================] - 0s 316us/step - loss: 3.6283
Epoch 316/500
80/80 [==============================] - 0s 322us/step - loss: 3.6195
Epoch 317/500
80/80 [==============================] - 0s 326us/step - loss: 3.6235
Epoch 318/500
80/80 [==============================] - 0s 310us/step - loss: 3.6097
Epoch 319/500
80/80 [==============================] - 0s 323us/step - loss: 3.6137
Epoch 320/500
80/80 [==============================] - 0s 321us/step - loss: 3.6157
```

```
Epoch 321/500
80/80 [==============================] - 0s 326us/step - loss: 3.6435
Epoch 322/500
80/80 [==============================] - 0s 322us/step - loss: 3.6306
Epoch 323/500
80/80 [==============================] - 0s 322us/step - loss: 3.6145
Epoch 324/500
80/80 [==============================] - 0s 310us/step - loss: 3.6014
Epoch 325/500
80/80 [==============================] - 0s 312us/step - loss: 3.5965
Epoch 326/500
80/80 [==============================] - 0s 315us/step - loss: 3.5899
Epoch 327/500
80/80 [==============================] - 0s 317us/step - loss: 3.6027
Epoch 328/500
80/80 [==============================] - 0s 325us/step - loss: 3.5906
Epoch 329/500
80/80 [==============================] - 0s 325us/step - loss: 3.5874
Epoch 330/500
80/80 [==============================] - 0s 415us/step - loss: 3.6069
Epoch 331/500
80/80 [==============================] - 0s 502us/step - loss: 3.6074
Epoch 332/500
80/80 [==============================] - 0s 315us/step - loss: 3.6006
Epoch 333/500
80/80 [==============================] - 0s 316us/step - loss: 3.5961
Epoch 334/500
80/80 [==============================] - 0s 337us/step - loss: 3.5883
Epoch 335/500
80/80 [==============================] - 0s 317us/step - loss: 3.6020
Epoch 336/500
80/80 [==============================] - 0s 325us/step - loss: 3.5606
Epoch 337/500
80/80 [==============================] - 0s 331us/step - loss: 3.5752
Epoch 338/500
80/80 [==============================] - 0s 320us/step - loss: 3.5686
Epoch 339/500
80/80 [==============================] - 0s 442us/step - loss: 3.5853
Epoch 340/500
80/80 [==============================] - 0s 336us/step - loss: 3.5620
Epoch 341/500
80/80 [==============================] - 0s 328us/step - loss: 3.5645
Epoch 342/500
80/80 [==============================] - 0s 342us/step - loss: 3.5627
Epoch 343/500
80/80 [==============================] - 0s 364us/step - loss: 3.5679
Epoch 344/500
80/80 [==============================] - 0s 377us/step - loss: 3.5686
Epoch 345/500
80/80 [==============================] - 0s 369us/step - loss: 3.5569
Epoch 346/500
80/80 [==============================] - 0s 391us/step - loss: 3.5579
Epoch 347/500
80/80 [==============================] - 0s 397us/step - loss: 3.5554
Epoch 348/500
80/80 [==============================] - 0s 542us/step - loss: 3.5766
Epoch 349/500
80/80 [==============================] - 0s 395us/step - loss: 3.5780
Epoch 350/500
80/80 [==============================] - 0s 341us/step - loss: 3.5681
Epoch 351/500
80/80 [==============================] - 0s 350us/step - loss: 3.5530
Epoch 352/500
80/80 [==============================] - 0s 337us/step - loss: 3.5665
```

```
Epoch 353/500
80/80 [==============================] - 0s 325us/step - loss: 3.5346
Epoch 354/500
80/80 [==============================] - 0s 338us/step - loss: 3.5548
Epoch 355/500
80/80 [==============================] - 0s 336us/step - loss: 3.5507
Epoch 356/500
80/80 [==============================] - 0s 336us/step - loss: 3.5347
Epoch 357/500
80/80 [==============================] - 0s 340us/step - loss: 3.5601
Epoch 358/500
80/80 [==============================] - 0s 327us/step - loss: 3.5560
Epoch 359/500
80/80 [==============================] - 0s 335us/step - loss: 3.5375
Epoch 360/500
80/80 [==============================] - 0s 364us/step - loss: 3.5265
Epoch 361/500
80/80 [==============================] - 0s 329us/step - loss: 3.5497
Epoch 362/500
80/80 [==============================] - 0s 343us/step - loss: 3.5213
Epoch 363/500
80/80 [==============================] - 0s 326us/step - loss: 3.5218
Epoch 364/500
80/80 [==============================] - 0s 335us/step - loss: 3.5369
Epoch 365/500
80/80 [==============================] - 0s 331us/step - loss: 3.5133
Epoch 366/500
80/80 [==============================] - 0s 332us/step - loss: 3.5344
Epoch 367/500
80/80 [==============================] - 0s 313us/step - loss: 3.5358
Epoch 368/500
80/80 [==============================] - 0s 308us/step - loss: 3.5130
Epoch 369/500
80/80 [==============================] - 0s 326us/step - loss: 3.5481
Epoch 370/500
80/80 [==============================] - 0s 327us/step - loss: 3.5333
Epoch 371/500
80/80 [==============================] - 0s 318us/step - loss: 3.5075
Epoch 372/500
80/80 [==============================] - 0s 324us/step - loss: 3.5189
Epoch 373/500
80/80 [==============================] - 0s 327us/step - loss: 3.5285
Epoch 374/500
80/80 [==============================] - 0s 329us/step - loss: 3.5239
Epoch 375/500
80/80 [==============================] - 0s 322us/step - loss: 3.5185
Epoch 376/500
80/80 [==============================] - 0s 317us/step - loss: 3.4991
Epoch 377/500
80/80 [==============================] - 0s 317us/step - loss: 3.5017
Epoch 378/500
80/80 [==============================] - 0s 323us/step - loss: 3.5043
Epoch 379/500
80/80 [==============================] - 0s 306us/step - loss: 3.5182
Epoch 380/500
80/80 [==============================] - 0s 331us/step - loss: 3.5195
Epoch 381/500
80/80 [==============================] - 0s 327us/step - loss: 3.5129
Epoch 382/500
80/80 [==============================] - 0s 332us/step - loss: 3.4868
Epoch 383/500
80/80 [==============================] - 0s 315us/step - loss: 3.5368
Epoch 384/500
80/80 [==============================] - 0s 320us/step - loss: 3.5096
```

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```
Epoch 385/500
80/80 [==============================] - 0s 322us/step - loss: 3.5281
Epoch 386/500
80/80 [==============================] - 0s 407us/step - loss: 3.5034
Epoch 387/500
80/80 [==============================] - 0s 340us/step - loss: 3.4909
Epoch 388/500
80/80 [==============================] - 0s 315us/step - loss: 3.5108
Epoch 389/500
80/80 [==============================] - 0s 324us/step - loss: 3.4815
Epoch 390/500
80/80 [==============================] - 0s 317us/step - loss: 3.4846
Epoch 391/500
80/80 [==============================] - 0s 337us/step - loss: 3.5112
Epoch 392/500
80/80 [==============================] - 0s 318us/step - loss: 3.4864
Epoch 393/500
80/80 [==============================] - 0s 340us/step - loss: 3.4974
Epoch 394/500
80/80 [==============================] - 0s 315us/step - loss: 3.4965
Epoch 395/500
80/80 [==============================] - 0s 320us/step - loss: 3.4812
Epoch 396/500
80/80 [==============================] - 0s 315us/step - loss: 3.4771
Epoch 397/500
80/80 [==============================] - 0s 311us/step - loss: 3.5079
Epoch 398/500
80/80 [==============================] - 0s 320us/step - loss: 3.4940
Epoch 399/500
80/80 [==============================] - 0s 328us/step - loss: 3.4715
Epoch 400/500
80/80 [==============================] - 0s 343us/step - loss: 3.5037
Epoch 401/500
80/80 [==============================] - 0s 571us/step - loss: 3.4955
Epoch 402/500
80/80 [==============================] - 0s 315us/step - loss: 3.4959
Epoch 403/500
80/80 [==============================] - 0s 324us/step - loss: 3.4848
Epoch 404/500
80/80 [==============================] - 0s 323us/step - loss: 3.4814
Epoch 405/500
80/80 [==============================] - 0s 322us/step - loss: 3.4910
Epoch 406/500
80/80 [==============================] - 0s 307us/step - loss: 3.4825
Epoch 407/500
80/80 [==============================] - 0s 325us/step - loss: 3.4788
Epoch 408/500
80/80 [==============================] - 0s 333us/step - loss: 3.4858
Epoch 409/500
80/80 [==============================] - 0s 329us/step - loss: 3.4801
Epoch 410/500
80/80 [==============================] - 0s 315us/step - loss: 3.4641
Epoch 411/500
80/80 [==============================] - 0s 322us/step - loss: 3.4720
Epoch 412/500
80/80 [==============================] - 0s 336us/step - loss: 3.4854
Epoch 413/500
80/80 [==============================] - 0s 333us/step - loss: 3.4822
Epoch 414/500
80/80 [==============================] - 0s 334us/step - loss: 3.4851
Epoch 415/500
80/80 [==============================] - 0s 329us/step - loss: 3.4773
Epoch 416/500
80/80 [==============================] - 0s 317us/step - loss: 3.4912
```
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```
Epoch 417/500
80/80 [==============================] - 0s 316us/step - loss: 3.4699
Epoch 418/500
80/80 [==============================] - 0s 318us/step - loss: 3.5069
Epoch 419/500
80/80 [==============================] - 0s 313us/step - loss: 3.5000
Epoch 420/500
80/80 [==============================] - 0s 331us/step - loss: 3.4631
Epoch 421/500
80/80 [==============================] - 0s 319us/step - loss: 3.4680
Epoch 422/500
80/80 [==============================] - 0s 310us/step - loss: 3.4692
Epoch 423/500
80/80 [==============================] - 0s 306us/step - loss: 3.4539
Epoch 424/500
80/80 [==============================] - 0s 321us/step - loss: 3.4606
Epoch 425/500
80/80 [==============================] - 0s 314us/step - loss: 3.4699
Epoch 426/500
80/80 [==============================] - 0s 315us/step - loss: 3.4677
Epoch 427/500
80/80 [==============================] - 0s 320us/step - loss: 3.4899
Epoch 428/500
80/80 [==============================] - 0s 312us/step - loss: 3.4806
Epoch 429/500
80/80 [==============================] - 0s 313us/step - loss: 3.4466
Epoch 430/500
80/80 [==============================] - 0s 320us/step - loss: 3.4573
Epoch 431/500
80/80 [==============================] - 0s 307us/step - loss: 3.4512
Epoch 432/500
80/80 [==============================] - 0s 305us/step - loss: 3.4490
Epoch 433/500
80/80 [==============================] - 0s 313us/step - loss: 3.4659
Epoch 434/500
80/80 [==============================] - 0s 326us/step - loss: 3.4612
Epoch 435/500
80/80 [==============================] - 0s 311us/step - loss: 3.4721
Epoch 436/500
80/80 [==============================] - 0s 319us/step - loss: 3.4625
Epoch 437/500
80/80 [==============================] - 0s 317us/step - loss: 3.4482
Epoch 438/500
80/80 [==============================] - 0s 305us/step - loss: 3.4826
Epoch 439/500
80/80 [==============================] - 0s 309us/step - loss: 3.4523
Epoch 440/500
80/80 [==============================] - 0s 318us/step - loss: 3.4549
Epoch 441/500
80/80 [==============================] - 0s 307us/step - loss: 3.4475
Epoch 442/500
80/80 [==============================] - 0s 317us/step - loss: 3.4615
Epoch 443/500
80/80 [==============================] - 0s 307us/step - loss: 3.4382
Epoch 444/500
80/80 [==============================] - 0s 322us/step - loss: 3.4451
Epoch 445/500
80/80 [==============================] - 0s 308us/step - loss: 3.4979
Epoch 446/500
80/80 [==============================] - 0s 310us/step - loss: 3.4532
Epoch 447/500
80/80 [==============================] - 0s 332us/step - loss: 3.4581
Epoch 448/500
80/80 [==============================] - 0s 317us/step - loss: 3.4334
```
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```
Epoch 449/500
80/80 [==============================] - 0s 316us/step - loss: 3.4492
Epoch 450/500
80/80 [==============================] - 0s 323us/step - loss: 3.4717
Epoch 451/500
80/80 [==============================] - 0s 297us/step - loss: 3.4476
Epoch 452/500
80/80 [==============================] - 0s 318us/step - loss: 3.4557
Epoch 453/500
80/80 [==============================] - 0s 323us/step - loss: 3.4799
Epoch 454/500
80/80 [==============================] - 0s 319us/step - loss: 3.4396
Epoch 455/500
80/80 [==============================] - 0s 316us/step - loss: 3.4488
Epoch 456/500
80/80 [==============================] - 0s 305us/step - loss: 3.4428
Epoch 457/500
80/80 [==============================] - 0s 314us/step - loss: 3.4527
Epoch 458/500
80/80 [==============================] - 0s 327us/step - loss: 3.4265
Epoch 459/500
80/80 [==============================] - 0s 327us/step - loss: 3.4667
Epoch 460/500
80/80 [==============================] - 0s 310us/step - loss: 3.4392
Epoch 461/500
80/80 [==============================] - 0s 333us/step - loss: 3.4508
Epoch 462/500
80/80 [==============================] - 0s 320us/step - loss: 3.4316
Epoch 463/500
80/80 [==============================] - 0s 331us/step - loss: 3.4355
Epoch 464/500
80/80 [==============================] - 0s 332us/step - loss: 3.4474
Epoch 465/500
80/80 [==============================] - 0s 328us/step - loss: 3.4316
Epoch 466/500
80/80 [==============================] - 0s 334us/step - loss: 3.4356
Epoch 467/500
80/80 [==============================] - 0s 318us/step - loss: 3.4319
Epoch 468/500
80/80 [==============================] - 0s 327us/step - loss: 3.4495
Epoch 469/500
80/80 [==============================] - 0s 328us/step - loss: 3.4392
Epoch 470/500
80/80 [==============================] - 0s 304us/step - loss: 3.4521
Epoch 471/500
80/80 [==============================] - 0s 318us/step - loss: 3.4234
Epoch 472/500
80/80 [==============================] - 0s 312us/step - loss: 3.4453
Epoch 473/500
80/80 [==============================] - 0s 321us/step - loss: 3.4391
Epoch 474/500
80/80 [==============================] - 0s 324us/step - loss: 3.4318
Epoch 475/500
80/80 [==============================] - 0s 584us/step - loss: 3.4357
Epoch 476/500
80/80 [==============================] - 0s 338us/step - loss: 3.4336
Epoch 477/500
80/80 [==============================] - 0s 337us/step - loss: 3.4244
Epoch 478/500
80/80 [==============================] - 0s 319us/step - loss: 3.4334
Epoch 479/500
80/80 [==============================] - 0s 326us/step - loss: 3.4623
Epoch 480/500
80/80 [==============================] - 0s 329us/step - loss: 3.4365
```

```
Epoch 481/500
80/80 [==============================] - 0s 329us/step - loss: 3.4444
Epoch 482/500
80/80 [==============================] - 0s 320us/step - loss: 3.4348
Epoch 483/500
80/80 [==============================] - 0s 316us/step - loss: 3.5030
Epoch 484/500
80/80 [==============================] - 0s 344us/step - loss: 3.4520
Epoch 485/500
80/80 [==============================] - 0s 309us/step - loss: 3.4257
Epoch 486/500
80/80 [==============================] - 0s 319us/step - loss: 3.4347
Epoch 487/500
80/80 [==============================] - 0s 326us/step - loss: 3.4228
Epoch 488/500
80/80 [==============================] - 0s 323us/step - loss: 3.4372
Epoch 489/500
80/80 [==============================] - 0s 318us/step - loss: 3.4280
Epoch 490/500
80/80 [==============================] - 0s 327us/step - loss: 3.4513
Epoch 491/500
80/80 [==============================] - 0s 312us/step - loss: 3.4384
Epoch 492/500
80/80 [==============================] - 0s 320us/step - loss: 3.4441
Epoch 493/500
80/80 [==============================] - 0s 318us/step - loss: 3.4202
Epoch 494/500
80/80 [==============================] - 0s 332us/step - loss: 3.4579
Epoch 495/500
80/80 [==============================] - 0s 308us/step - loss: 3.4340
Epoch 496/500
80/80 [==============================] - 0s 318us/step - loss: 3.4309
Epoch 497/500
80/80 [==============================] - 0s 310us/step - loss: 3.4244
Epoch 498/500
80/80 [==============================] - 0s 318us/step - loss: 3.4343
Epoch 499/500
80/80 [==============================] - 0s 313us/step - loss: 3.4414
Epoch 500/500
80/80 [==============================] - 0s 313us/step - loss: 3.4154
```

Question 16

Use the training history to plot how the loss function changed over each training epoch.

```
In [30]:  # put your answer here
          plt.plot(history.history['loss'])
```

```
Out[30]:  [<matplotlib.lines.Line2D at 0x2879f4d00>]
```
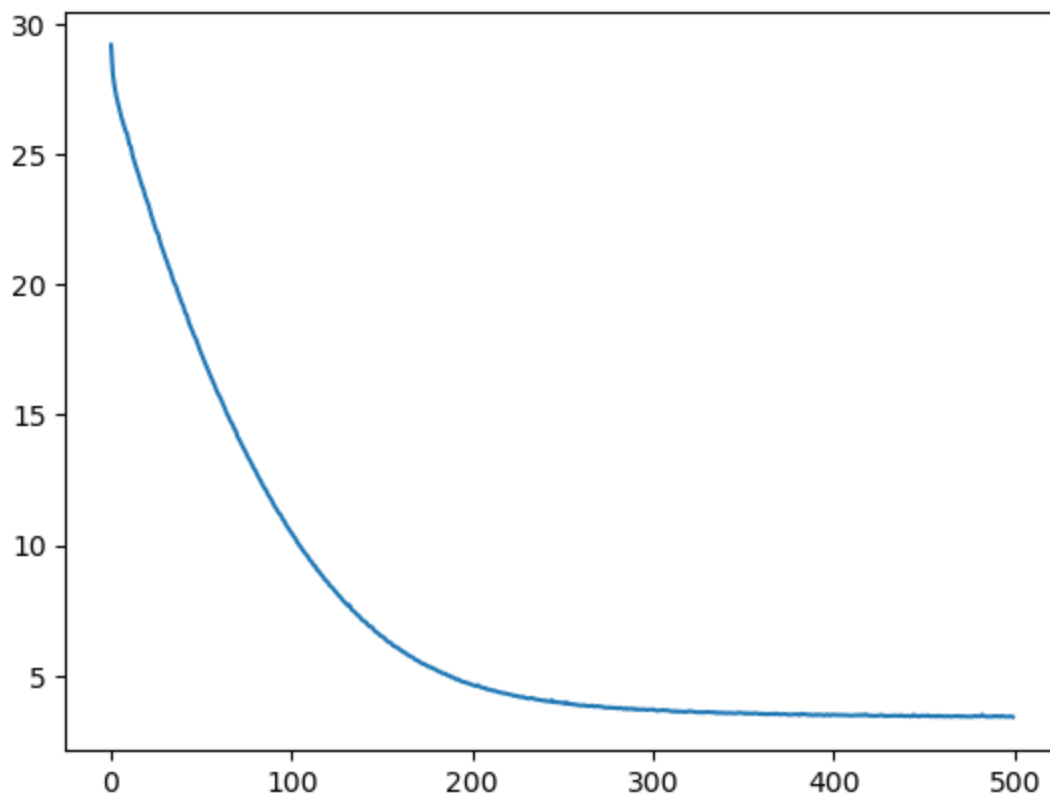
Question 17

What equation does the model provide for predicting open rate?

```
In [31]: model.get_weights()
```

```
Out[31]: [array([[0.6849418],
                [5.620405 ]], dtype=float32),
          array([5.9561067], dtype=float32)]
```

```
In [32]: w0 = model.get_weights()[1]
         w1 = model.get_weights()[0][0]
         w2 = model.get_weights()[0][1]
```

```
In [33]: print(" equation: open_rate = %.2f + %.2f * savings_pct + %.2f * coupon_or_discount"%(w0

          equation: open_rate = 5.96 + 0.68 * savings_pct + 5.62 * coupon_or_discount
```

```
In [34]: y_pred = w0 + np.dot(x, [w1, w2])
```

```
In [35]: np.mean((y-y_pred)**2)
```

```
Out[35]: 3.399910798139473
```

put your answer here