Lab-1

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LAB 1

AIDI 2000

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Import Libraries

[ ]:
```
import pandas as pd
import numpy as np
from tensorflow import keras
from sklearn.preprocessing import StandardScaler, LabelEncoder
from tensorflow.keras import layers, Sequential
from sklearn.model_selection import train_test_split
from matplotlib import pyplot as plt
```

Import Dataset

[ ]:
```
data = pd.read_csv('spotify_data_12_20_2023.csv', dtype="object")
data.dropna(inplace=True)
print(data.columns)
```

```
Index(['album_id', 'album_name', 'album_popularity', 'album_type', 'artists',
       'artist_0', 'artist_1', 'artist_2', 'artist_3', 'artist_4', 'artist_id',
       'duration_sec', 'label', 'release_date', 'total_tracks', 'track_id',
       'track_name', 'track_number', 'artist_genres', 'artist_popularity',
       'followers', 'name', 'genre_0', 'genre_1', 'genre_2', 'genre_3',
       'genre_4', 'acousticness', 'analysis_url', 'danceability',
       'duration_ms', 'energy', 'instrumentalness', 'key', 'liveness',
       'loudness', 'mode', 'speechiness', 'tempo', 'time_signature',
       'track_href', 'type', 'uri', 'valence', 'explicit', 'track_popularity',
       'release_year', 'release_month', 'rn'],
      dtype='object')
```

Describe Dataset

[ ]:
```
print(data.describe())
```

```
                       album_id                album_name album_popularity  \
count                       583                       583              583
unique                      181                       156               71
top     6Mzrj457wfDueNk3eZJ3Z8  Handel: St. John Passion                6
```

```
freq                        39                             39                40

       album_type                                                    artists  \
count         583                                                       583
unique          2                                                       348
top         album  ['George Frideric Handel', 'Martin Kleitmann',…
freq          460                                                        39

                     artist_0                                  artist_1  \
count                     583                                       583
unique                    107                                       183
top     George Frideric Handel  Choir of St. John's College, Cambridge
freq                      128                                        68

                 artist_2      artist_3      artist_4  … time_signature  \
count                 583           583           583  …            583
unique                187           204           244  …              4
top     Andrew Nethsingha  Mária Zádori  Judit Nemeth  …              4
freq                   41            39            39  …            416

                                                 track_href            type  \
count                                                   583             583
unique                                                  583               1
top     https://api.spotify.com/v1/tracks/6fEJ0p0zapwJ…  audio_features
freq                                                      1             583

                                      uri valence explicit  \
count                                 583     583      583
unique                                583     427        2
top     spotify:track:6fEJ0p0zapwJn7gpfekiBY  0.0354    false
freq                                    1       5      494

       track_popularity release_year release_month   rn
count               583          583           583  583
unique               65           44            12    1
top                   0         2014       January    1
freq                111           53           136  583

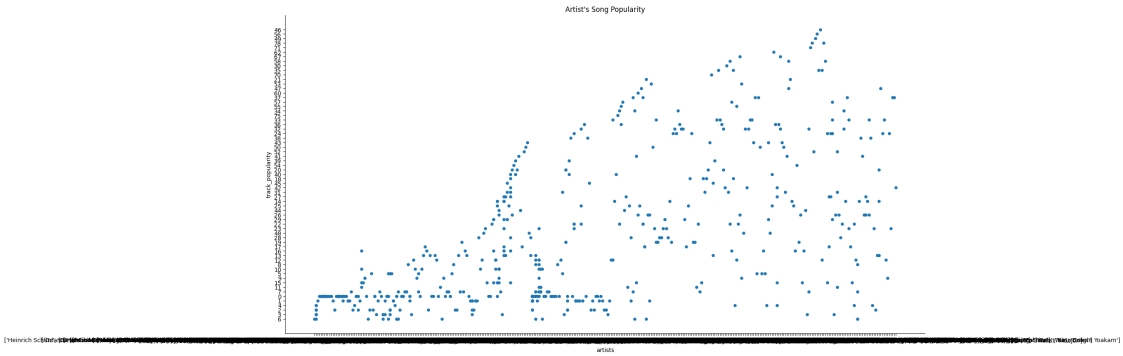
[4 rows x 49 columns]
```

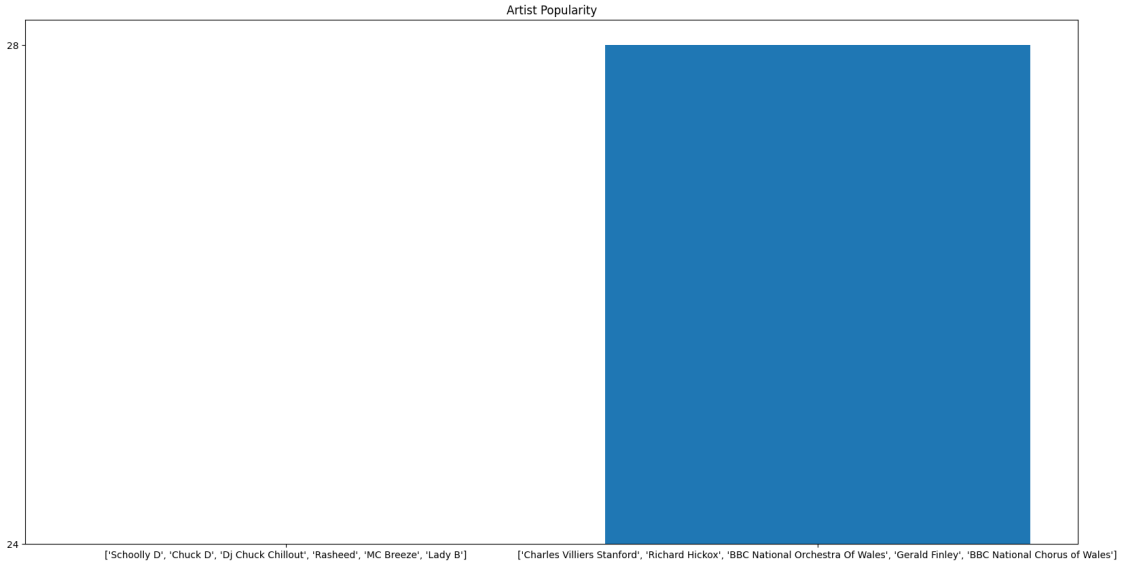
Plot Graphs

[ ]:
```
df = pd.DataFrame(data)

df.plot(kind='scatter', x='artists', y='track_popularity', figsize=(20, 10),
        title="Artist's Song Popularity")
plt.gca().spines[['top', 'right']].set_visible(False)
```

```
x1 = df['artists']
y1 = df['artist_popularity']
plt.figure(figsize =(20, 10))
plt.bar(x1[0:10], y1[0:10])
plt.title('Artist Popularity')
plt.show()
```





Select Fields for data processing

[ ]:
```
numeric_features = ['artist_popularity','acousticness', 'danceability',␣
↪'energy', 'instrumentalness', 'liveness',
                    'loudness', 'speechiness', 'tempo', 'track_popularity',␣
↪'followers', 'album_popularity',
                    'instrumentalness']
categorical_features = ['artists','label','artist_genres']
```

```
X_categorical = df[categorical_features]
X_numeric = df[numeric_features]
```

Prepare the Data for Processing

[ ]:
```
scaler = StandardScaler()
X_numeric_scaled = scaler.fit_transform(X_numeric)

label_encoders = {}
X_categorical_encoded = pd.DataFrame()

for feature in categorical_features:
    label_encoder = LabelEncoder()
    X_categorical_encoded[feature] = label_encoder.fit_transform(df[feature])
    label_encoders[feature] = label_encoder
```

Split the data

[ ]:
```
X = pd.concat([pd.DataFrame(X_numeric_scaled, columns=numeric_features),␣
 ↪X_categorical_encoded], axis=1)
y = df['artist_popularity']

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=42)
```

Analyse Model Shape

[ ]:
```
# View the Model Shape
print(X_train.shape)
print(y_train.shape)
```

```
(466, 16)
(466,)
```

[ ]:
```
print(X_test.shape)
print(y_test.shape)
```

```
(117, 16)
(117,)
```

Reshape the data

[ ]:
```
X_train = X_train.to_numpy().reshape(-1, 16, 1)
X_test = X_test.to_numpy().reshape(-1, 16, 1)

# Preprocess y_test data
y_test = y_test.to_numpy().reshape(-1, 1)  # Reshape to a column vector
```

```
placeholder_features_test = np.zeros((len(y_test), 3))  # Create placeholder␣
 ↪features
y_test_categorical = keras.utils.to_categorical(y_test)
y_test = np.concatenate((y_test_categorical, placeholder_features_test),␣
 ↪axis=1)  # Concatenate features
y_test = y_test.flatten()  # Flatten back to a 1D array if necessary

y_train = keras.utils.to_categorical(y_train)
y_test = np.concatenate((y_test_categorical, placeholder_features_test),␣
 ↪axis=1)  # Concatenate features
```

Analyse Model Shape

[ ]:
```
# View the Model Shape
print(X_train.shape)
print(y_train.shape)
```

```
(466, 16, 1)
(466, 89)
```

[ ]:
```
print(X_test.shape)
print(y_test.shape)
```

```
(117, 16, 1)
(117, 89)
```

Build and execute the model.

[ ]:
```
# Defining the model
model = Sequential([
        layers.Input(shape=(16, 1)),
    layers.Conv1D(32, kernel_size=3, activation='relu'),
    layers.Dense(32, activation='relu'),
    layers.MaxPooling1D(pool_size=2),
    layers.Conv1D(32, kernel_size=3, activation='relu'),
    layers.Dense(32, activation='relu'),
    layers.Flatten(),
    layers.Dense(32, activation='relu'),
    layers.Dense(y_test.shape[1], activation='softmax')
])


# Compiling the model
model.compile(optimizer='adam', loss='categorical_crossentropy',␣
 ↪metrics=['accuracy'])

# fitting the model
h = model.fit(X_train, y_train, epochs=300, verbose=1, validation_data=(X_test,␣
 ↪y_test), batch_size=8)
```

```
Epoch 1/300
59/59 [==============================] - 2s 7ms/step - loss: 4.0688 - accuracy:
0.1288 - val_loss: 3.2983 - val_accuracy: 0.2051
Epoch 2/300
59/59 [==============================] - 0s 3ms/step - loss: 3.0851 - accuracy:
0.2189 - val_loss: 2.6972 - val_accuracy: 0.3846
Epoch 3/300
59/59 [==============================] - 0s 3ms/step - loss: 2.5378 - accuracy:
0.3820 - val_loss: 2.3969 - val_accuracy: 0.4359
Epoch 4/300
59/59 [==============================] - 0s 3ms/step - loss: 2.2103 - accuracy:
0.4163 - val_loss: 2.0498 - val_accuracy: 0.5128
Epoch 5/300
59/59 [==============================] - 0s 3ms/step - loss: 1.9167 - accuracy:
0.4785 - val_loss: 1.7567 - val_accuracy: 0.5556
Epoch 6/300
59/59 [==============================] - 0s 2ms/step - loss: 1.6094 - accuracy:
0.5365 - val_loss: 1.5064 - val_accuracy: 0.5983
Epoch 7/300
59/59 [==============================] - 0s 3ms/step - loss: 1.4202 - accuracy:
0.5880 - val_loss: 1.3573 - val_accuracy: 0.6496
Epoch 8/300
59/59 [==============================] - 0s 3ms/step - loss: 1.2390 - accuracy:
0.6288 - val_loss: 1.3341 - val_accuracy: 0.6325
Epoch 9/300
59/59 [==============================] - 0s 3ms/step - loss: 1.0744 - accuracy:
0.6674 - val_loss: 1.0380 - val_accuracy: 0.7265
Epoch 10/300
59/59 [==============================] - 0s 3ms/step - loss: 0.9634 - accuracy:
0.7039 - val_loss: 0.9401 - val_accuracy: 0.7863
Epoch 11/300
59/59 [==============================] - 0s 3ms/step - loss: 0.7776 - accuracy:
0.7725 - val_loss: 0.8784 - val_accuracy: 0.7949
Epoch 12/300
59/59 [==============================] - 0s 3ms/step - loss: 0.7193 - accuracy:
0.7918 - val_loss: 0.9157 - val_accuracy: 0.7863
Epoch 13/300
59/59 [==============================] - 0s 3ms/step - loss: 0.6543 - accuracy:
0.8133 - val_loss: 0.7984 - val_accuracy: 0.8034
Epoch 14/300
59/59 [==============================] - 0s 3ms/step - loss: 0.6007 - accuracy:
0.7961 - val_loss: 0.7147 - val_accuracy: 0.8205
Epoch 15/300
59/59 [==============================] - 0s 3ms/step - loss: 0.5602 - accuracy:
0.8004 - val_loss: 0.6583 - val_accuracy: 0.8632
Epoch 16/300
59/59 [==============================] - 0s 3ms/step - loss: 0.4361 - accuracy:
```

```
0.8627 - val_loss: 0.7933 - val_accuracy: 0.8120
Epoch 17/300
59/59 [==============================] - 0s 3ms/step - loss: 0.4521 - accuracy:
0.8627 - val_loss: 0.6721 - val_accuracy: 0.8718
Epoch 18/300
59/59 [==============================] - 0s 3ms/step - loss: 0.3753 - accuracy:
0.8755 - val_loss: 0.5871 - val_accuracy: 0.9145
Epoch 19/300
59/59 [==============================] - 0s 3ms/step - loss: 0.3310 - accuracy:
0.8991 - val_loss: 0.5320 - val_accuracy: 0.9231
Epoch 20/300
59/59 [==============================] - 0s 3ms/step - loss: 0.2875 - accuracy:
0.9206 - val_loss: 0.4754 - val_accuracy: 0.9402
Epoch 21/300
59/59 [==============================] - 0s 3ms/step - loss: 0.2840 - accuracy:
0.9142 - val_loss: 0.5949 - val_accuracy: 0.8803
Epoch 22/300
59/59 [==============================] - 0s 4ms/step - loss: 0.2536 - accuracy:
0.9099 - val_loss: 0.5156 - val_accuracy: 0.9316
Epoch 23/300
59/59 [==============================] - 0s 3ms/step - loss: 0.2326 - accuracy:
0.9313 - val_loss: 0.5772 - val_accuracy: 0.9231
Epoch 24/300
59/59 [==============================] - 0s 2ms/step - loss: 0.2588 - accuracy:
0.9206 - val_loss: 0.6225 - val_accuracy: 0.8974
Epoch 25/300
59/59 [==============================] - 0s 2ms/step - loss: 0.2503 - accuracy:
0.9077 - val_loss: 0.6196 - val_accuracy: 0.8974
Epoch 26/300
59/59 [==============================] - 0s 3ms/step - loss: 0.2417 - accuracy:
0.9120 - val_loss: 0.5494 - val_accuracy: 0.9316
Epoch 27/300
59/59 [==============================] - 0s 3ms/step - loss: 0.3208 - accuracy:
0.8798 - val_loss: 0.5647 - val_accuracy: 0.9060
Epoch 28/300
59/59 [==============================] - 0s 4ms/step - loss: 0.2123 - accuracy:
0.9270 - val_loss: 0.4522 - val_accuracy: 0.9316
Epoch 29/300
59/59 [==============================] - 0s 2ms/step - loss: 0.1652 - accuracy:
0.9399 - val_loss: 0.4864 - val_accuracy: 0.9316
Epoch 30/300
59/59 [==============================] - 0s 2ms/step - loss: 0.2306 - accuracy:
0.9142 - val_loss: 0.6544 - val_accuracy: 0.9231
Epoch 31/300
59/59 [==============================] - 0s 3ms/step - loss: 0.1522 - accuracy:
0.9506 - val_loss: 0.4736 - val_accuracy: 0.9402
Epoch 32/300
59/59 [==============================] - 0s 2ms/step - loss: 0.1742 - accuracy:
```

```
0.9335 - val_loss: 0.5243 - val_accuracy: 0.8889
Epoch 33/300
59/59 [==============================] - 0s 2ms/step - loss: 0.2580 - accuracy:
0.9120 - val_loss: 0.4540 - val_accuracy: 0.9487
Epoch 34/300
59/59 [==============================] - 0s 3ms/step - loss: 0.1305 - accuracy:
0.9485 - val_loss: 0.5130 - val_accuracy: 0.9402
Epoch 35/300
59/59 [==============================] - 0s 3ms/step - loss: 0.1003 - accuracy:
0.9657 - val_loss: 0.5079 - val_accuracy: 0.9573
Epoch 36/300
59/59 [==============================] - 0s 2ms/step - loss: 0.1137 - accuracy:
0.9635 - val_loss: 0.5151 - val_accuracy: 0.9316
Epoch 37/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0782 - accuracy:
0.9700 - val_loss: 0.5057 - val_accuracy: 0.9573
Epoch 38/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0607 - accuracy:
0.9807 - val_loss: 0.5822 - val_accuracy: 0.9231
Epoch 39/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0892 - accuracy:
0.9635 - val_loss: 0.5383 - val_accuracy: 0.9487
Epoch 40/300
59/59 [==============================] - 0s 2ms/step - loss: 0.1085 - accuracy:
0.9592 - val_loss: 0.7079 - val_accuracy: 0.9060
Epoch 41/300
59/59 [==============================] - 0s 3ms/step - loss: 0.1296 - accuracy:
0.9592 - val_loss: 0.5337 - val_accuracy: 0.9316
Epoch 42/300
59/59 [==============================] - 0s 3ms/step - loss: 0.1117 - accuracy:
0.9700 - val_loss: 0.4902 - val_accuracy: 0.9573
Epoch 43/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0486 - accuracy:
0.9871 - val_loss: 0.5305 - val_accuracy: 0.9487
Epoch 44/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0648 - accuracy:
0.9785 - val_loss: 0.5598 - val_accuracy: 0.9145
Epoch 45/300
59/59 [==============================] - 0s 4ms/step - loss: 0.1889 - accuracy:
0.9485 - val_loss: 0.5869 - val_accuracy: 0.9316
Epoch 46/300
59/59 [==============================] - 0s 3ms/step - loss: 0.1308 - accuracy:
0.9549 - val_loss: 0.5730 - val_accuracy: 0.9145
Epoch 47/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0739 - accuracy:
0.9700 - val_loss: 0.4340 - val_accuracy: 0.9487
Epoch 48/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0446 - accuracy:
```

```
0.9871 - val_loss: 0.4636 - val_accuracy: 0.9573
Epoch 49/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0366 - accuracy:
0.9871 - val_loss: 0.4811 - val_accuracy: 0.9487
Epoch 50/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0210 - accuracy:
0.9957 - val_loss: 0.4861 - val_accuracy: 0.9487
Epoch 51/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0187 - accuracy:
0.9979 - val_loss: 0.4646 - val_accuracy: 0.9658
Epoch 52/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0180 - accuracy:
0.9936 - val_loss: 0.5197 - val_accuracy: 0.9573
Epoch 53/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0156 - accuracy:
0.9957 - val_loss: 0.4859 - val_accuracy: 0.9658
Epoch 54/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0214 - accuracy:
0.9936 - val_loss: 0.5163 - val_accuracy: 0.9487
Epoch 55/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0317 - accuracy:
0.9893 - val_loss: 0.5437 - val_accuracy: 0.9487
Epoch 56/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0273 - accuracy:
0.9957 - val_loss: 0.4782 - val_accuracy: 0.9658
Epoch 57/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0259 - accuracy:
0.9936 - val_loss: 0.5027 - val_accuracy: 0.9487
Epoch 58/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0206 - accuracy:
0.9957 - val_loss: 0.5084 - val_accuracy: 0.9573
Epoch 59/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0557 - accuracy:
0.9785 - val_loss: 0.7465 - val_accuracy: 0.8803
Epoch 60/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0808 - accuracy:
0.9785 - val_loss: 0.5636 - val_accuracy: 0.9231
Epoch 61/300
59/59 [==============================] - 0s 2ms/step - loss: 0.1387 - accuracy:
0.9421 - val_loss: 0.7919 - val_accuracy: 0.8889
Epoch 62/300
59/59 [==============================] - 0s 2ms/step - loss: 0.1983 - accuracy:
0.9249 - val_loss: 0.5340 - val_accuracy: 0.9060
Epoch 63/300
59/59 [==============================] - 0s 4ms/step - loss: 0.1170 - accuracy:
0.9700 - val_loss: 0.5884 - val_accuracy: 0.9231
Epoch 64/300
59/59 [==============================] - 0s 2ms/step - loss: 0.2966 - accuracy:
```

```
0.9313 - val_loss: 0.5691 - val_accuracy: 0.9316
Epoch 65/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0778 - accuracy:
0.9721 - val_loss: 0.6544 - val_accuracy: 0.8974
Epoch 66/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0380 - accuracy:
0.9893 - val_loss: 0.4850 - val_accuracy: 0.9402
Epoch 67/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0206 - accuracy:
0.9957 - val_loss: 0.5634 - val_accuracy: 0.9487
Epoch 68/300
59/59 [==============================] - 0s 5ms/step - loss: 0.0234 - accuracy:
0.9936 - val_loss: 0.4615 - val_accuracy: 0.9658
Epoch 69/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0125 - accuracy:
0.9979 - val_loss: 0.4745 - val_accuracy: 0.9658
Epoch 70/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0068 - accuracy:
1.0000 - val_loss: 0.5375 - val_accuracy: 0.9573
Epoch 71/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0055 - accuracy:
1.0000 - val_loss: 0.5168 - val_accuracy: 0.9658
Epoch 72/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0047 - accuracy:
1.0000 - val_loss: 0.5321 - val_accuracy: 0.9658
Epoch 73/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0038 - accuracy:
1.0000 - val_loss: 0.5583 - val_accuracy: 0.9573
Epoch 74/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0043 - accuracy:
1.0000 - val_loss: 0.5616 - val_accuracy: 0.9573
Epoch 75/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0037 - accuracy:
1.0000 - val_loss: 0.5588 - val_accuracy: 0.9487
Epoch 76/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0032 - accuracy:
1.0000 - val_loss: 0.5721 - val_accuracy: 0.9573
Epoch 77/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0029 - accuracy:
1.0000 - val_loss: 0.5511 - val_accuracy: 0.9658
Epoch 78/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0028 - accuracy:
1.0000 - val_loss: 0.5609 - val_accuracy: 0.9573
Epoch 79/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0026 - accuracy:
1.0000 - val_loss: 0.5742 - val_accuracy: 0.9487
Epoch 80/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0024 - accuracy:
```

```
1.0000 - val_loss: 0.5678 - val_accuracy: 0.9573
Epoch 81/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0021 - accuracy:
1.0000 - val_loss: 0.5799 - val_accuracy: 0.9573
Epoch 82/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0020 - accuracy:
1.0000 - val_loss: 0.5784 - val_accuracy: 0.9573
Epoch 83/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0020 - accuracy:
1.0000 - val_loss: 0.5858 - val_accuracy: 0.9487
Epoch 84/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0024 - accuracy:
1.0000 - val_loss: 0.6049 - val_accuracy: 0.9487
Epoch 85/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0019 - accuracy:
1.0000 - val_loss: 0.6101 - val_accuracy: 0.9402
Epoch 86/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0016 - accuracy:
1.0000 - val_loss: 0.5848 - val_accuracy: 0.9487
Epoch 87/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0015 - accuracy:
1.0000 - val_loss: 0.5802 - val_accuracy: 0.9487
Epoch 88/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0013 - accuracy:
1.0000 - val_loss: 0.6003 - val_accuracy: 0.9573
Epoch 89/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0013 - accuracy:
1.0000 - val_loss: 0.6019 - val_accuracy: 0.9573
Epoch 90/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0012 - accuracy:
1.0000 - val_loss: 0.5951 - val_accuracy: 0.9658
Epoch 91/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0013 - accuracy:
1.0000 - val_loss: 0.5959 - val_accuracy: 0.9573
Epoch 92/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0012 - accuracy:
1.0000 - val_loss: 0.6064 - val_accuracy: 0.9573
Epoch 93/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0011 - accuracy:
1.0000 - val_loss: 0.6090 - val_accuracy: 0.9573
Epoch 94/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0012 - accuracy:
1.0000 - val_loss: 0.6321 - val_accuracy: 0.9487
Epoch 95/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0013 - accuracy:
1.0000 - val_loss: 0.6149 - val_accuracy: 0.9487
Epoch 96/300
59/59 [==============================] - 0s 4ms/step - loss: 9.5568e-04 -
```

```
accuracy: 1.0000 - val_loss: 0.6139 - val_accuracy: 0.9487
Epoch 97/300
59/59 [==============================] - 0s 3ms/step - loss: 9.6176e-04 -
accuracy: 1.0000 - val_loss: 0.6227 - val_accuracy: 0.9573
Epoch 98/300
59/59 [==============================] - 0s 3ms/step - loss: 9.6761e-04 -
accuracy: 1.0000 - val_loss: 0.6276 - val_accuracy: 0.9573
Epoch 99/300
59/59 [==============================] - 0s 3ms/step - loss: 8.1724e-04 -
accuracy: 1.0000 - val_loss: 0.6295 - val_accuracy: 0.9573
Epoch 100/300
59/59 [==============================] - 0s 3ms/step - loss: 7.5687e-04 -
accuracy: 1.0000 - val_loss: 0.6288 - val_accuracy: 0.9573
Epoch 101/300
59/59 [==============================] - 0s 3ms/step - loss: 7.4797e-04 -
accuracy: 1.0000 - val_loss: 0.6291 - val_accuracy: 0.9573
Epoch 102/300
59/59 [==============================] - 0s 3ms/step - loss: 7.0932e-04 -
accuracy: 1.0000 - val_loss: 0.6216 - val_accuracy: 0.9573
Epoch 103/300
59/59 [==============================] - 0s 3ms/step - loss: 7.2240e-04 -
accuracy: 1.0000 - val_loss: 0.6437 - val_accuracy: 0.9402
Epoch 104/300
59/59 [==============================] - 0s 3ms/step - loss: 6.4751e-04 -
accuracy: 1.0000 - val_loss: 0.6403 - val_accuracy: 0.9487
Epoch 105/300
59/59 [==============================] - 0s 3ms/step - loss: 6.9134e-04 -
accuracy: 1.0000 - val_loss: 0.6358 - val_accuracy: 0.9573
Epoch 106/300
59/59 [==============================] - 0s 5ms/step - loss: 6.4818e-04 -
accuracy: 1.0000 - val_loss: 0.6480 - val_accuracy: 0.9487
Epoch 107/300
59/59 [==============================] - 0s 3ms/step - loss: 6.0035e-04 -
accuracy: 1.0000 - val_loss: 0.6507 - val_accuracy: 0.9487
Epoch 108/300
59/59 [==============================] - 0s 3ms/step - loss: 5.5155e-04 -
accuracy: 1.0000 - val_loss: 0.6602 - val_accuracy: 0.9487
Epoch 109/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0016 - accuracy:
1.0000 - val_loss: 0.6101 - val_accuracy: 0.9487
Epoch 110/300
59/59 [==============================] - 0s 3ms/step - loss: 0.2606 - accuracy:
0.9614 - val_loss: 5.0929 - val_accuracy: 0.6923
Epoch 111/300
59/59 [==============================] - 0s 3ms/step - loss: 1.3991 - accuracy:
0.7361 - val_loss: 0.5261 - val_accuracy: 0.8632
Epoch 112/300
59/59 [==============================] - 0s 3ms/step - loss: 0.2119 - accuracy:
```

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0.9335 - val_loss: 0.4882 - val_accuracy: 0.9060
Epoch 113/300
59/59 [==============================] - 0s 3ms/step - loss: 0.1255 - accuracy:
0.9506 - val_loss: 0.3923 - val_accuracy: 0.9231
Epoch 114/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0439 - accuracy:
0.9957 - val_loss: 0.3869 - val_accuracy: 0.9573
Epoch 115/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0300 - accuracy:
0.9936 - val_loss: 0.4074 - val_accuracy: 0.9487
Epoch 116/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0233 - accuracy:
0.9979 - val_loss: 0.4007 - val_accuracy: 0.9573
Epoch 117/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0181 - accuracy:
0.9979 - val_loss: 0.4143 - val_accuracy: 0.9573
Epoch 118/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0116 - accuracy:
1.0000 - val_loss: 0.4112 - val_accuracy: 0.9658
Epoch 119/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0100 - accuracy:
1.0000 - val_loss: 0.4429 - val_accuracy: 0.9402
Epoch 120/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0111 - accuracy:
0.9979 - val_loss: 0.4387 - val_accuracy: 0.9487
Epoch 121/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0093 - accuracy:
0.9979 - val_loss: 0.4431 - val_accuracy: 0.9487
Epoch 122/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0072 - accuracy:
1.0000 - val_loss: 0.4338 - val_accuracy: 0.9487
Epoch 123/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0052 - accuracy:
1.0000 - val_loss: 0.4569 - val_accuracy: 0.9487
Epoch 124/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0047 - accuracy:
1.0000 - val_loss: 0.4568 - val_accuracy: 0.9487
Epoch 125/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0053 - accuracy:
1.0000 - val_loss: 0.4549 - val_accuracy: 0.9487
Epoch 126/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0039 - accuracy:
1.0000 - val_loss: 0.4811 - val_accuracy: 0.9487
Epoch 127/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0036 - accuracy:
1.0000 - val_loss: 0.4913 - val_accuracy: 0.9487
Epoch 128/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0031 - accuracy:
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1.0000 - val_loss: 0.5162 - val_accuracy: 0.9487
Epoch 129/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0030 - accuracy:
1.0000 - val_loss: 0.5041 - val_accuracy: 0.9573
Epoch 130/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0029 - accuracy:
1.0000 - val_loss: 0.5165 - val_accuracy: 0.9487
Epoch 131/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0024 - accuracy:
1.0000 - val_loss: 0.5167 - val_accuracy: 0.9487
Epoch 132/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0022 - accuracy:
1.0000 - val_loss: 0.5312 - val_accuracy: 0.9573
Epoch 133/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0022 - accuracy:
1.0000 - val_loss: 0.5339 - val_accuracy: 0.9573
Epoch 134/300
59/59 [==============================] - 0s 4ms/step - loss: 0.0019 - accuracy:
1.0000 - val_loss: 0.5412 - val_accuracy: 0.9487
Epoch 135/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0018 - accuracy:
1.0000 - val_loss: 0.5352 - val_accuracy: 0.9487
Epoch 136/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0017 - accuracy:
1.0000 - val_loss: 0.5492 - val_accuracy: 0.9402
Epoch 137/300
59/59 [==============================] - 0s 5ms/step - loss: 0.0016 - accuracy:
1.0000 - val_loss: 0.5590 - val_accuracy: 0.9402
Epoch 138/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0015 - accuracy:
1.0000 - val_loss: 0.5585 - val_accuracy: 0.9402
Epoch 139/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0014 - accuracy:
1.0000 - val_loss: 0.5592 - val_accuracy: 0.9402
Epoch 140/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0012 - accuracy:
1.0000 - val_loss: 0.5558 - val_accuracy: 0.9487
Epoch 141/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0012 - accuracy:
1.0000 - val_loss: 0.5788 - val_accuracy: 0.9487
Epoch 142/300
59/59 [==============================] - 0s 2ms/step - loss: 0.0011 - accuracy:
1.0000 - val_loss: 0.5722 - val_accuracy: 0.9402
Epoch 143/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0010 - accuracy:
1.0000 - val_loss: 0.5716 - val_accuracy: 0.9402
Epoch 144/300
59/59 [==============================] - 0s 3ms/step - loss: 9.7921e-04 -
```

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accuracy: 1.0000 - val_loss: 0.5765 - val_accuracy: 0.9573
Epoch 145/300
59/59 [==============================] - 0s 3ms/step - loss: 0.0010 - accuracy:
1.0000 - val_loss: 0.5874 - val_accuracy: 0.9487
Epoch 146/300
59/59 [==============================] - 0s 4ms/step - loss: 8.9194e-04 -
accuracy: 1.0000 - val_loss: 0.5915 - val_accuracy: 0.9402
Epoch 147/300
59/59 [==============================] - 0s 3ms/step - loss: 9.0571e-04 -
accuracy: 1.0000 - val_loss: 0.5771 - val_accuracy: 0.9487
Epoch 148/300
59/59 [==============================] - 0s 3ms/step - loss: 7.8802e-04 -
accuracy: 1.0000 - val_loss: 0.5919 - val_accuracy: 0.9402
Epoch 149/300
59/59 [==============================] - 0s 3ms/step - loss: 7.6733e-04 -
accuracy: 1.0000 - val_loss: 0.5971 - val_accuracy: 0.9402
Epoch 150/300
59/59 [==============================] - 0s 2ms/step - loss: 7.0436e-04 -
accuracy: 1.0000 - val_loss: 0.5865 - val_accuracy: 0.9487
Epoch 151/300
59/59 [==============================] - 0s 4ms/step - loss: 7.2566e-04 -
accuracy: 1.0000 - val_loss: 0.6053 - val_accuracy: 0.9487
Epoch 152/300
59/59 [==============================] - 0s 4ms/step - loss: 6.6622e-04 -
accuracy: 1.0000 - val_loss: 0.6088 - val_accuracy: 0.9402
Epoch 153/300
59/59 [==============================] - 0s 3ms/step - loss: 6.2435e-04 -
accuracy: 1.0000 - val_loss: 0.6038 - val_accuracy: 0.9402
Epoch 154/300
59/59 [==============================] - 0s 4ms/step - loss: 6.1674e-04 -
accuracy: 1.0000 - val_loss: 0.6011 - val_accuracy: 0.9402
Epoch 155/300
59/59 [==============================] - 0s 3ms/step - loss: 5.7622e-04 -
accuracy: 1.0000 - val_loss: 0.6026 - val_accuracy: 0.9402
Epoch 156/300
59/59 [==============================] - 0s 2ms/step - loss: 5.4689e-04 -
accuracy: 1.0000 - val_loss: 0.6157 - val_accuracy: 0.9402
Epoch 157/300
59/59 [==============================] - 0s 3ms/step - loss: 5.0248e-04 -
accuracy: 1.0000 - val_loss: 0.6118 - val_accuracy: 0.9402
Epoch 158/300
59/59 [==============================] - 0s 3ms/step - loss: 4.9661e-04 -
accuracy: 1.0000 - val_loss: 0.6251 - val_accuracy: 0.9402
Epoch 159/300
59/59 [==============================] - 0s 3ms/step - loss: 4.6517e-04 -
accuracy: 1.0000 - val_loss: 0.6189 - val_accuracy: 0.9402
Epoch 160/300
59/59 [==============================] - 0s 3ms/step - loss: 4.8997e-04 -
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accuracy: 1.0000 - val_loss: 0.6340 - val_accuracy: 0.9402
Epoch 161/300
59/59 [==============================] - 0s 4ms/step - loss: 4.2753e-04 -
accuracy: 1.0000 - val_loss: 0.6270 - val_accuracy: 0.9402
Epoch 162/300
59/59 [==============================] - 0s 4ms/step - loss: 4.3009e-04 -
accuracy: 1.0000 - val_loss: 0.6316 - val_accuracy: 0.9402
Epoch 163/300
59/59 [==============================] - 0s 5ms/step - loss: 3.9423e-04 -
accuracy: 1.0000 - val_loss: 0.6336 - val_accuracy: 0.9402
Epoch 164/300
59/59 [==============================] - 0s 2ms/step - loss: 3.9202e-04 -
accuracy: 1.0000 - val_loss: 0.6348 - val_accuracy: 0.9402
Epoch 165/300
59/59 [==============================] - 0s 4ms/step - loss: 3.5065e-04 -
accuracy: 1.0000 - val_loss: 0.6405 - val_accuracy: 0.9402
Epoch 166/300
59/59 [==============================] - 0s 3ms/step - loss: 3.6087e-04 -
accuracy: 1.0000 - val_loss: 0.6348 - val_accuracy: 0.9402
Epoch 167/300
59/59 [==============================] - 0s 3ms/step - loss: 3.2651e-04 -
accuracy: 1.0000 - val_loss: 0.6378 - val_accuracy: 0.9402
Epoch 168/300
59/59 [==============================] - 0s 4ms/step - loss: 3.2025e-04 -
accuracy: 1.0000 - val_loss: 0.6610 - val_accuracy: 0.9402
Epoch 169/300
59/59 [==============================] - 0s 2ms/step - loss: 3.4102e-04 -
accuracy: 1.0000 - val_loss: 0.6420 - val_accuracy: 0.9402
Epoch 170/300
59/59 [==============================] - 0s 3ms/step - loss: 2.8525e-04 -
accuracy: 1.0000 - val_loss: 0.6563 - val_accuracy: 0.9402
Epoch 171/300
59/59 [==============================] - 0s 2ms/step - loss: 2.7725e-04 -
accuracy: 1.0000 - val_loss: 0.6508 - val_accuracy: 0.9402
Epoch 172/300
59/59 [==============================] - 0s 3ms/step - loss: 2.6683e-04 -
accuracy: 1.0000 - val_loss: 0.6577 - val_accuracy: 0.9402
Epoch 173/300
59/59 [==============================] - 0s 3ms/step - loss: 2.5491e-04 -
accuracy: 1.0000 - val_loss: 0.6550 - val_accuracy: 0.9402
Epoch 174/300
59/59 [==============================] - 0s 2ms/step - loss: 2.4735e-04 -
accuracy: 1.0000 - val_loss: 0.6652 - val_accuracy: 0.9402
Epoch 175/300
59/59 [==============================] - 0s 2ms/step - loss: 2.3381e-04 -
accuracy: 1.0000 - val_loss: 0.6610 - val_accuracy: 0.9402
Epoch 176/300
59/59 [==============================] - 0s 3ms/step - loss: 2.2649e-04 -
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accuracy: 1.0000 - val_loss: 0.6649 - val_accuracy: 0.9402
Epoch 177/300
59/59 [==============================] - 0s 2ms/step - loss: 2.2373e-04 -
accuracy: 1.0000 - val_loss: 0.6682 - val_accuracy: 0.9402
Epoch 178/300
59/59 [==============================] - 0s 3ms/step - loss: 2.0488e-04 -
accuracy: 1.0000 - val_loss: 0.6710 - val_accuracy: 0.9402
Epoch 179/300
59/59 [==============================] - 0s 2ms/step - loss: 2.1458e-04 -
accuracy: 1.0000 - val_loss: 0.6747 - val_accuracy: 0.9402
Epoch 180/300
59/59 [==============================] - 0s 3ms/step - loss: 1.8727e-04 -
accuracy: 1.0000 - val_loss: 0.6788 - val_accuracy: 0.9402
Epoch 181/300
59/59 [==============================] - 0s 3ms/step - loss: 1.8154e-04 -
accuracy: 1.0000 - val_loss: 0.6728 - val_accuracy: 0.9402
Epoch 182/300
59/59 [==============================] - 0s 4ms/step - loss: 1.8920e-04 -
accuracy: 1.0000 - val_loss: 0.6849 - val_accuracy: 0.9402
Epoch 183/300
59/59 [==============================] - 0s 4ms/step - loss: 1.8959e-04 -
accuracy: 1.0000 - val_loss: 0.6791 - val_accuracy: 0.9402
Epoch 184/300
59/59 [==============================] - 0s 3ms/step - loss: 1.6976e-04 -
accuracy: 1.0000 - val_loss: 0.6858 - val_accuracy: 0.9402
Epoch 185/300
59/59 [==============================] - 0s 4ms/step - loss: 1.6545e-04 -
accuracy: 1.0000 - val_loss: 0.6863 - val_accuracy: 0.9402
Epoch 186/300
59/59 [==============================] - 0s 3ms/step - loss: 1.5353e-04 -
accuracy: 1.0000 - val_loss: 0.6952 - val_accuracy: 0.9402
Epoch 187/300
59/59 [==============================] - 0s 3ms/step - loss: 1.5428e-04 -
accuracy: 1.0000 - val_loss: 0.6854 - val_accuracy: 0.9402
Epoch 188/300
59/59 [==============================] - 0s 4ms/step - loss: 1.4558e-04 -
accuracy: 1.0000 - val_loss: 0.6992 - val_accuracy: 0.9402
Epoch 189/300
59/59 [==============================] - 0s 5ms/step - loss: 1.3048e-04 -
accuracy: 1.0000 - val_loss: 0.6892 - val_accuracy: 0.9402
Epoch 190/300
59/59 [==============================] - 0s 5ms/step - loss: 1.4407e-04 -
accuracy: 1.0000 - val_loss: 0.6868 - val_accuracy: 0.9402
Epoch 191/300
59/59 [==============================] - 0s 4ms/step - loss: 1.2741e-04 -
accuracy: 1.0000 - val_loss: 0.7118 - val_accuracy: 0.9402
Epoch 192/300
59/59 [==============================] - 0s 4ms/step - loss: 1.2091e-04 -
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accuracy: 1.0000 - val_loss: 0.6945 - val_accuracy: 0.9402
Epoch 193/300
59/59 [==============================] - 0s 5ms/step - loss: 1.1420e-04 -
accuracy: 1.0000 - val_loss: 0.7119 - val_accuracy: 0.9402
Epoch 194/300
59/59 [==============================] - 0s 5ms/step - loss: 1.1413e-04 -
accuracy: 1.0000 - val_loss: 0.7010 - val_accuracy: 0.9402
Epoch 195/300
59/59 [==============================] - 0s 4ms/step - loss: 1.0558e-04 -
accuracy: 1.0000 - val_loss: 0.7159 - val_accuracy: 0.9402
Epoch 196/300
59/59 [==============================] - 0s 4ms/step - loss: 1.0023e-04 -
accuracy: 1.0000 - val_loss: 0.7137 - val_accuracy: 0.9402
Epoch 197/300
59/59 [==============================] - 0s 3ms/step - loss: 9.5609e-05 -
accuracy: 1.0000 - val_loss: 0.7138 - val_accuracy: 0.9402
Epoch 198/300
59/59 [==============================] - 0s 3ms/step - loss: 9.4929e-05 -
accuracy: 1.0000 - val_loss: 0.7114 - val_accuracy: 0.9402
Epoch 199/300
59/59 [==============================] - 0s 4ms/step - loss: 9.1386e-05 -
accuracy: 1.0000 - val_loss: 0.7200 - val_accuracy: 0.9402
Epoch 200/300
59/59 [==============================] - 0s 4ms/step - loss: 9.0240e-05 -
accuracy: 1.0000 - val_loss: 0.7185 - val_accuracy: 0.9402
Epoch 201/300
59/59 [==============================] - 0s 4ms/step - loss: 8.4512e-05 -
accuracy: 1.0000 - val_loss: 0.7208 - val_accuracy: 0.9402
Epoch 202/300
59/59 [==============================] - 0s 4ms/step - loss: 8.8762e-05 -
accuracy: 1.0000 - val_loss: 0.7153 - val_accuracy: 0.9402
Epoch 203/300
59/59 [==============================] - 0s 4ms/step - loss: 7.9066e-05 -
accuracy: 1.0000 - val_loss: 0.7331 - val_accuracy: 0.9402
Epoch 204/300
59/59 [==============================] - 0s 4ms/step - loss: 7.7397e-05 -
accuracy: 1.0000 - val_loss: 0.7315 - val_accuracy: 0.9402
Epoch 205/300
59/59 [==============================] - 0s 4ms/step - loss: 7.1418e-05 -
accuracy: 1.0000 - val_loss: 0.7298 - val_accuracy: 0.9402
Epoch 206/300
59/59 [==============================] - 0s 4ms/step - loss: 7.9990e-05 -
accuracy: 1.0000 - val_loss: 0.7386 - val_accuracy: 0.9487
Epoch 207/300
59/59 [==============================] - 0s 4ms/step - loss: 7.0942e-05 -
accuracy: 1.0000 - val_loss: 0.7391 - val_accuracy: 0.9487
Epoch 208/300
59/59 [==============================] - 0s 5ms/step - loss: 7.0117e-05 -
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accuracy: 1.0000 - val_loss: 0.7372 - val_accuracy: 0.9487
Epoch 209/300
59/59 [==============================] - 0s 3ms/step - loss: 6.1465e-05 -
accuracy: 1.0000 - val_loss: 0.7456 - val_accuracy: 0.9402
Epoch 210/300
59/59 [==============================] - 0s 3ms/step - loss: 5.9632e-05 -
accuracy: 1.0000 - val_loss: 0.7457 - val_accuracy: 0.9402
Epoch 211/300
59/59 [==============================] - 0s 4ms/step - loss: 6.0883e-05 -
accuracy: 1.0000 - val_loss: 0.7416 - val_accuracy: 0.9487
Epoch 212/300
59/59 [==============================] - 0s 3ms/step - loss: 5.4056e-05 -
accuracy: 1.0000 - val_loss: 0.7459 - val_accuracy: 0.9487
Epoch 213/300
59/59 [==============================] - 0s 5ms/step - loss: 5.4185e-05 -
accuracy: 1.0000 - val_loss: 0.7521 - val_accuracy: 0.9487
Epoch 214/300
59/59 [==============================] - 0s 4ms/step - loss: 5.1621e-05 -
accuracy: 1.0000 - val_loss: 0.7404 - val_accuracy: 0.9487
Epoch 215/300
59/59 [==============================] - 0s 2ms/step - loss: 5.1640e-05 -
accuracy: 1.0000 - val_loss: 0.7553 - val_accuracy: 0.9487
Epoch 216/300
59/59 [==============================] - 0s 2ms/step - loss: 4.7877e-05 -
accuracy: 1.0000 - val_loss: 0.7451 - val_accuracy: 0.9402
Epoch 217/300
59/59 [==============================] - 0s 4ms/step - loss: 4.7758e-05 -
accuracy: 1.0000 - val_loss: 0.7630 - val_accuracy: 0.9487
Epoch 218/300
59/59 [==============================] - 0s 3ms/step - loss: 4.5935e-05 -
accuracy: 1.0000 - val_loss: 0.7625 - val_accuracy: 0.9487
Epoch 219/300
59/59 [==============================] - 0s 2ms/step - loss: 4.5008e-05 -
accuracy: 1.0000 - val_loss: 0.7517 - val_accuracy: 0.9487
Epoch 220/300
59/59 [==============================] - 0s 2ms/step - loss: 4.3609e-05 -
accuracy: 1.0000 - val_loss: 0.7674 - val_accuracy: 0.9487
Epoch 221/300
59/59 [==============================] - 0s 3ms/step - loss: 4.3308e-05 -
accuracy: 1.0000 - val_loss: 0.7739 - val_accuracy: 0.9487
Epoch 222/300
59/59 [==============================] - 0s 3ms/step - loss: 4.0557e-05 -
accuracy: 1.0000 - val_loss: 0.7641 - val_accuracy: 0.9487
Epoch 223/300
59/59 [==============================] - 0s 3ms/step - loss: 4.1311e-05 -
accuracy: 1.0000 - val_loss: 0.7792 - val_accuracy: 0.9487
Epoch 224/300
59/59 [==============================] - 0s 4ms/step - loss: 3.5765e-05 -
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accuracy: 1.0000 - val_loss: 0.7724 - val_accuracy: 0.9487
Epoch 225/300
59/59 [==============================] - 0s 2ms/step - loss: 3.4321e-05 -
accuracy: 1.0000 - val_loss: 0.7791 - val_accuracy: 0.9487
Epoch 226/300
59/59 [==============================] - 0s 3ms/step - loss: 3.5602e-05 -
accuracy: 1.0000 - val_loss: 0.7847 - val_accuracy: 0.9487
Epoch 227/300
59/59 [==============================] - 0s 3ms/step - loss: 3.4415e-05 -
accuracy: 1.0000 - val_loss: 0.7788 - val_accuracy: 0.9487
Epoch 228/300
59/59 [==============================] - 0s 3ms/step - loss: 3.1673e-05 -
accuracy: 1.0000 - val_loss: 0.7886 - val_accuracy: 0.9487
Epoch 229/300
59/59 [==============================] - 0s 3ms/step - loss: 3.4159e-05 -
accuracy: 1.0000 - val_loss: 0.7952 - val_accuracy: 0.9487
Epoch 230/300
59/59 [==============================] - 0s 4ms/step - loss: 2.9556e-05 -
accuracy: 1.0000 - val_loss: 0.7791 - val_accuracy: 0.9487
Epoch 231/300
59/59 [==============================] - 0s 3ms/step - loss: 2.8505e-05 -
accuracy: 1.0000 - val_loss: 0.7870 - val_accuracy: 0.9487
Epoch 232/300
59/59 [==============================] - 0s 3ms/step - loss: 2.6740e-05 -
accuracy: 1.0000 - val_loss: 0.7895 - val_accuracy: 0.9487
Epoch 233/300
59/59 [==============================] - 0s 3ms/step - loss: 2.5778e-05 -
accuracy: 1.0000 - val_loss: 0.7868 - val_accuracy: 0.9487
Epoch 234/300
59/59 [==============================] - 0s 4ms/step - loss: 2.5134e-05 -
accuracy: 1.0000 - val_loss: 0.7902 - val_accuracy: 0.9487
Epoch 235/300
59/59 [==============================] - 0s 2ms/step - loss: 2.3675e-05 -
accuracy: 1.0000 - val_loss: 0.7978 - val_accuracy: 0.9487
Epoch 236/300
59/59 [==============================] - 0s 3ms/step - loss: 2.3049e-05 -
accuracy: 1.0000 - val_loss: 0.7940 - val_accuracy: 0.9487
Epoch 237/300
59/59 [==============================] - 0s 3ms/step - loss: 2.2367e-05 -
accuracy: 1.0000 - val_loss: 0.7952 - val_accuracy: 0.9487
Epoch 238/300
59/59 [==============================] - 0s 5ms/step - loss: 2.1885e-05 -
accuracy: 1.0000 - val_loss: 0.7997 - val_accuracy: 0.9487
Epoch 239/300
59/59 [==============================] - 0s 3ms/step - loss: 2.1572e-05 -
accuracy: 1.0000 - val_loss: 0.7968 - val_accuracy: 0.9487
Epoch 240/300
59/59 [==============================] - 0s 3ms/step - loss: 2.0466e-05 -
```

```
accuracy: 1.0000 - val_loss: 0.8083 - val_accuracy: 0.9487
Epoch 241/300
59/59 [==============================] - 0s 2ms/step - loss: 1.9763e-05 -
accuracy: 1.0000 - val_loss: 0.8072 - val_accuracy: 0.9487
Epoch 242/300
59/59 [==============================] - 0s 2ms/step - loss: 1.9712e-05 -
accuracy: 1.0000 - val_loss: 0.8155 - val_accuracy: 0.9487
Epoch 243/300
59/59 [==============================] - 0s 3ms/step - loss: 1.8557e-05 -
accuracy: 1.0000 - val_loss: 0.8072 - val_accuracy: 0.9487
Epoch 244/300
59/59 [==============================] - 0s 3ms/step - loss: 1.7848e-05 -
accuracy: 1.0000 - val_loss: 0.8175 - val_accuracy: 0.9487
Epoch 245/300
59/59 [==============================] - 0s 3ms/step - loss: 1.7412e-05 -
accuracy: 1.0000 - val_loss: 0.8194 - val_accuracy: 0.9487
Epoch 246/300
59/59 [==============================] - 0s 4ms/step - loss: 1.6715e-05 -
accuracy: 1.0000 - val_loss: 0.8189 - val_accuracy: 0.9487
Epoch 247/300
59/59 [==============================] - 0s 2ms/step - loss: 1.6331e-05 -
accuracy: 1.0000 - val_loss: 0.8178 - val_accuracy: 0.9487
Epoch 248/300
59/59 [==============================] - 0s 2ms/step - loss: 1.5324e-05 -
accuracy: 1.0000 - val_loss: 0.8193 - val_accuracy: 0.9487
Epoch 249/300
59/59 [==============================] - 0s 3ms/step - loss: 1.5173e-05 -
accuracy: 1.0000 - val_loss: 0.8308 - val_accuracy: 0.9487
Epoch 250/300
59/59 [==============================] - 0s 5ms/step - loss: 1.4523e-05 -
accuracy: 1.0000 - val_loss: 0.8170 - val_accuracy: 0.9487
Epoch 251/300
59/59 [==============================] - 0s 3ms/step - loss: 1.4498e-05 -
accuracy: 1.0000 - val_loss: 0.8319 - val_accuracy: 0.9487
Epoch 252/300
59/59 [==============================] - 0s 4ms/step - loss: 1.3789e-05 -
accuracy: 1.0000 - val_loss: 0.8236 - val_accuracy: 0.9487
Epoch 253/300
59/59 [==============================] - 0s 2ms/step - loss: 1.3438e-05 -
accuracy: 1.0000 - val_loss: 0.8312 - val_accuracy: 0.9487
Epoch 254/300
59/59 [==============================] - 0s 3ms/step - loss: 1.2720e-05 -
accuracy: 1.0000 - val_loss: 0.8396 - val_accuracy: 0.9487
Epoch 255/300
59/59 [==============================] - 0s 3ms/step - loss: 1.2348e-05 -
accuracy: 1.0000 - val_loss: 0.8318 - val_accuracy: 0.9487
Epoch 256/300
59/59 [==============================] - 0s 3ms/step - loss: 1.2505e-05 -
```

```
accuracy: 1.0000 - val_loss: 0.8421 - val_accuracy: 0.9487
Epoch 257/300
59/59 [==============================] - 0s 3ms/step - loss: 1.1618e-05 -
accuracy: 1.0000 - val_loss: 0.8455 - val_accuracy: 0.9487
Epoch 258/300
59/59 [==============================] - 0s 3ms/step - loss: 1.0966e-05 -
accuracy: 1.0000 - val_loss: 0.8436 - val_accuracy: 0.9487
Epoch 259/300
59/59 [==============================] - 0s 2ms/step - loss: 1.0756e-05 -
accuracy: 1.0000 - val_loss: 0.8441 - val_accuracy: 0.9487
Epoch 260/300
59/59 [==============================] - 0s 3ms/step - loss: 1.0923e-05 -
accuracy: 1.0000 - val_loss: 0.8478 - val_accuracy: 0.9487
Epoch 261/300
59/59 [==============================] - 0s 3ms/step - loss: 9.8826e-06 -
accuracy: 1.0000 - val_loss: 0.8479 - val_accuracy: 0.9487
Epoch 262/300
59/59 [==============================] - 0s 3ms/step - loss: 9.6836e-06 -
accuracy: 1.0000 - val_loss: 0.8484 - val_accuracy: 0.9487
Epoch 263/300
59/59 [==============================] - 0s 4ms/step - loss: 9.0691e-06 -
accuracy: 1.0000 - val_loss: 0.8470 - val_accuracy: 0.9487
Epoch 264/300
59/59 [==============================] - 0s 3ms/step - loss: 9.5725e-06 -
accuracy: 1.0000 - val_loss: 0.8495 - val_accuracy: 0.9487
Epoch 265/300
59/59 [==============================] - 0s 3ms/step - loss: 8.6718e-06 -
accuracy: 1.0000 - val_loss: 0.8689 - val_accuracy: 0.9487
Epoch 266/300
59/59 [==============================] - 0s 2ms/step - loss: 9.3892e-06 -
accuracy: 1.0000 - val_loss: 0.8588 - val_accuracy: 0.9487
Epoch 267/300
59/59 [==============================] - 0s 3ms/step - loss: 7.9909e-06 -
accuracy: 1.0000 - val_loss: 0.8616 - val_accuracy: 0.9487
Epoch 268/300
59/59 [==============================] - 0s 4ms/step - loss: 7.7837e-06 -
accuracy: 1.0000 - val_loss: 0.8617 - val_accuracy: 0.9487
Epoch 269/300
59/59 [==============================] - 0s 3ms/step - loss: 7.3499e-06 -
accuracy: 1.0000 - val_loss: 0.8654 - val_accuracy: 0.9487
Epoch 270/300
59/59 [==============================] - 0s 6ms/step - loss: 7.0212e-06 -
accuracy: 1.0000 - val_loss: 0.8656 - val_accuracy: 0.9487
Epoch 271/300
59/59 [==============================] - 0s 4ms/step - loss: 7.0086e-06 -
accuracy: 1.0000 - val_loss: 0.8627 - val_accuracy: 0.9487
Epoch 272/300
59/59 [==============================] - 0s 2ms/step - loss: 6.7167e-06 -
```

```
accuracy: 1.0000 - val_loss: 0.8690 - val_accuracy: 0.9487
Epoch 273/300
59/59 [==============================] - 0s 3ms/step - loss: 7.0825e-06 -
accuracy: 1.0000 - val_loss: 0.8707 - val_accuracy: 0.9487
Epoch 274/300
59/59 [==============================] - 0s 3ms/step - loss: 6.1867e-06 -
accuracy: 1.0000 - val_loss: 0.8705 - val_accuracy: 0.9487
Epoch 275/300
59/59 [==============================] - 0s 3ms/step - loss: 6.1511e-06 -
accuracy: 1.0000 - val_loss: 0.8679 - val_accuracy: 0.9487
Epoch 276/300
59/59 [==============================] - 0s 3ms/step - loss: 5.8151e-06 -
accuracy: 1.0000 - val_loss: 0.8673 - val_accuracy: 0.9487
Epoch 277/300
59/59 [==============================] - 0s 2ms/step - loss: 6.0250e-06 -
accuracy: 1.0000 - val_loss: 0.8757 - val_accuracy: 0.9487
Epoch 278/300
59/59 [==============================] - 0s 3ms/step - loss: 5.7073e-06 -
accuracy: 1.0000 - val_loss: 0.8683 - val_accuracy: 0.9487
Epoch 279/300
59/59 [==============================] - 0s 3ms/step - loss: 5.2428e-06 -
accuracy: 1.0000 - val_loss: 0.8779 - val_accuracy: 0.9487
Epoch 280/300
59/59 [==============================] - 0s 3ms/step - loss: 5.2201e-06 -
accuracy: 1.0000 - val_loss: 0.8888 - val_accuracy: 0.9487
Epoch 281/300
59/59 [==============================] - 0s 3ms/step - loss: 4.8138e-06 -
accuracy: 1.0000 - val_loss: 0.8785 - val_accuracy: 0.9487
Epoch 282/300
59/59 [==============================] - 0s 3ms/step - loss: 4.6798e-06 -
accuracy: 1.0000 - val_loss: 0.8954 - val_accuracy: 0.9487
Epoch 283/300
59/59 [==============================] - 0s 3ms/step - loss: 4.7192e-06 -
accuracy: 1.0000 - val_loss: 0.8910 - val_accuracy: 0.9487
Epoch 284/300
59/59 [==============================] - 0s 3ms/step - loss: 4.4680e-06 -
accuracy: 1.0000 - val_loss: 0.8865 - val_accuracy: 0.9487
Epoch 285/300
59/59 [==============================] - 0s 3ms/step - loss: 4.2025e-06 -
accuracy: 1.0000 - val_loss: 0.8908 - val_accuracy: 0.9487
Epoch 286/300
59/59 [==============================] - 0s 3ms/step - loss: 4.0748e-06 -
accuracy: 1.0000 - val_loss: 0.8883 - val_accuracy: 0.9487
Epoch 287/300
59/59 [==============================] - 0s 4ms/step - loss: 3.9970e-06 -
accuracy: 1.0000 - val_loss: 0.9022 - val_accuracy: 0.9487
Epoch 288/300
59/59 [==============================] - 0s 6ms/step - loss: 3.8594e-06 -
```

```
accuracy: 1.0000 - val_loss: 0.8904 - val_accuracy: 0.9487
Epoch 289/300
59/59 [==============================] - 0s 3ms/step - loss: 3.8778e-06 -
accuracy: 1.0000 - val_loss: 0.9022 - val_accuracy: 0.9573
Epoch 290/300
59/59 [==============================] - 0s 3ms/step - loss: 3.5977e-06 -
accuracy: 1.0000 - val_loss: 0.8995 - val_accuracy: 0.9487
Epoch 291/300
59/59 [==============================] - 0s 3ms/step - loss: 3.4540e-06 -
accuracy: 1.0000 - val_loss: 0.9011 - val_accuracy: 0.9487
Epoch 292/300
59/59 [==============================] - 0s 3ms/step - loss: 3.8034e-06 -
accuracy: 1.0000 - val_loss: 0.8888 - val_accuracy: 0.9487
Epoch 293/300
59/59 [==============================] - 0s 4ms/step - loss: 3.6778e-06 -
accuracy: 1.0000 - val_loss: 0.9016 - val_accuracy: 0.9487
Epoch 294/300
59/59 [==============================] - 0s 4ms/step - loss: 3.1810e-06 -
accuracy: 1.0000 - val_loss: 0.9014 - val_accuracy: 0.9487
Epoch 295/300
59/59 [==============================] - 0s 3ms/step - loss: 3.0718e-06 -
accuracy: 1.0000 - val_loss: 0.9035 - val_accuracy: 0.9487
Epoch 296/300
59/59 [==============================] - 0s 4ms/step - loss: 3.0396e-06 -
accuracy: 1.0000 - val_loss: 0.9143 - val_accuracy: 0.9487
Epoch 297/300
59/59 [==============================] - 0s 4ms/step - loss: 2.9219e-06 -
accuracy: 1.0000 - val_loss: 0.9043 - val_accuracy: 0.9487
Epoch 298/300
59/59 [==============================] - 0s 3ms/step - loss: 2.7710e-06 -
accuracy: 1.0000 - val_loss: 0.9167 - val_accuracy: 0.9487
Epoch 299/300
59/59 [==============================] - 0s 4ms/step - loss: 2.6121e-06 -
accuracy: 1.0000 - val_loss: 0.9112 - val_accuracy: 0.9487
Epoch 300/300
59/59 [==============================] - 0s 4ms/step - loss: 2.5645e-06 -
accuracy: 1.0000 - val_loss: 0.9179 - val_accuracy: 0.9487
```

[ ]:
```
model.summary()
```

```
Model: "sequential_69"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv1d_109 (Conv1D)         (None, 14, 32)            128


_________________________________________________________________
 Layer (type)                Output Shape              Param #
```

```
=================================================================
 conv1d_109 (Conv1D)         (None, 14, 32)            128

 dense_286 (Dense)           (None, 14, 32)            1056

 max_pooling1d_77 (MaxPooli  (None, 7, 32)             0
 ng1D)

 conv1d_110 (Conv1D)         (None, 5, 32)             3104

 dense_287 (Dense)           (None, 5, 32)             1056

 flatten_71 (Flatten)        (None, 160)               0

 dense_288 (Dense)           (None, 32)                5152

 dense_289 (Dense)           (None, 89)                2937

=================================================================
Total params: 13433 (52.47 KB)
Trainable params: 13433 (52.47 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Evaluate the model

[ ]:
```
score=model.evaluate(X_test, y_test)
print("Test loss:",score[0])
print("Test accuracy",score[1])
```

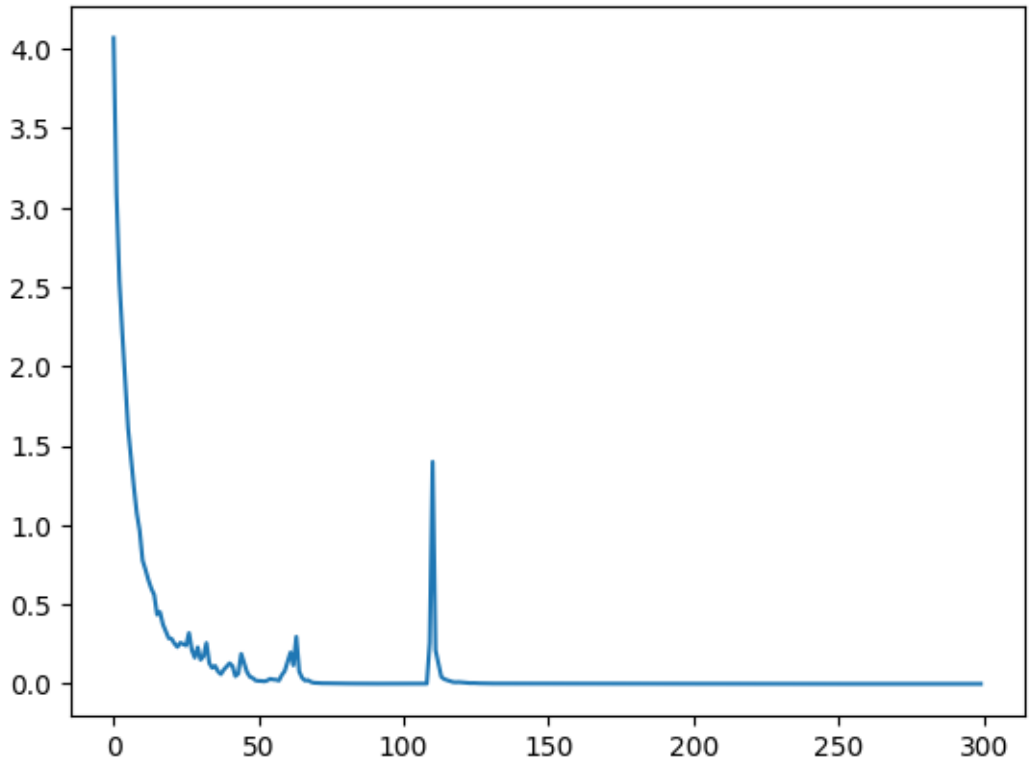
```
1/4 [======>…] - ETA: 0s - loss: 0.2138 - accuracy: 0.9375

4/4 [==============================] - 0s 4ms/step - loss: 0.9179 - accuracy:
0.9487
Test loss: 0.9179329872131348
Test accuracy 0.9487179517745972
Test loss: 0.9179329872131348
Test accuracy 0.9487179517745972
```

Plot the model performance

[ ]:
```
plt.plot(h.history['loss'])
```

[ ]:
```
[<matplotlib.lines.Line2D at 0x2d2d028a310>]
```



Make Prediction

[ ]:
```
result = model.predict(X_test[:7])
```

```
1/1 [==============================] - 0s 180ms/step
1/1 [==============================] - 0s 180ms/step
```

Compare Prediction against test value

[ ]:
```
result[:7].argmax(axis=1)
```

[ ]:
```
array([66, 80, 38, 73, 65, 66, 38], dtype=int64)
```

[ ]:
```
y_test[:7].argmax(axis=1)
```

[ ]:
```
array([66, 73, 38, 73, 65, 66, 38], dtype=int64)
```

[ ]:
```
result
```

[ ]:
```
array([[1.89866194e-29, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        5.69825823e-35, 7.81600583e-28, 1.93848942e-29, 4.45189004e-31,
        1.10324277e-35, 8.11767999e-31, 1.61683253e-32, 1.23624127e-30,
        0.00000000e+00, 1.05047862e-36, 0.00000000e+00, 1.10588053e-35,
        1.89874048e-30, 8.48238836e-34, 8.78467429e-31, 2.46712809e-37,
```

```
 1.21756200e-31, 1.08824546e-35, 5.97217307e-37, 0.00000000e+00,
 1.45048533e-26, 1.11941866e-30, 0.00000000e+00, 0.00000000e+00,
 2.39625993e-32, 8.38856701e-24, 2.27189861e-36, 4.21633749e-21,
 6.61542093e-34, 0.00000000e+00, 1.15919161e-35, 1.38811175e-35,
 8.99209226e-19, 0.00000000e+00, 6.37342662e-20, 3.31173346e-32,
 1.82945727e-32, 0.00000000e+00, 0.00000000e+00, 1.99557907e-23,
 0.00000000e+00, 1.08655881e-17, 0.00000000e+00, 0.00000000e+00,
 0.00000000e+00, 4.34141092e-20, 0.00000000e+00, 0.00000000e+00,
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 4.33652809e-35, 3.22795399e-02, 9.67719734e-01, 1.55260436e-25,
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 3.30745209e-33, 0.00000000e+00, 5.34195565e-30, 6.03916709e-35,
 3.47663110e-24],
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 1.78098160e-29, 9.99317714e-24, 2.37014707e-26, 6.27048418e-31,
 1.45873693e-24, 3.30388397e-24, 6.72234480e-32, 9.24230977e-26,
 5.23651271e-22, 4.01233287e-33, 1.47842915e-23, 2.72903444e-32,
 1.43507007e-31, 2.20065294e-30, 2.19579092e-21, 6.60490880e-32,
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 9.39122347e-33, 1.26270677e-23, 4.63804357e-19, 1.89420615e-12,
 2.05478031e-07, 4.90319507e-21, 2.22318162e-30, 1.12966180e-15,
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 2.33357500e-11, 1.44033493e-07, 7.32095115e-19, 1.62782869e-32,
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 4.80285403e-23],
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```

```
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 0.00000000e+00],
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