

```
In [1]: import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
```

```
In [2]: data = pd.read_csv('q2_dataset.csv', header = None)
data.head()
```

```
Out[2]:
```

	0	1	2	3	4	5
0	Date	Close/Last	Volume	Open	High	Low
1	07/08/20	\$381.37	29272970	376.72	381.50	376.36
2	07/07/20	\$372.69	28106110	375.41	378.62	372.23
3	07/06/20	\$373.85	29663910	370.00	375.78	369.87
4	07/02/20	\$364.11	28510370	367.85	370.47	363.64

```
In [3]: # # Create the dataset by using the latest 3 days as the features
# # and the next day's opening price as the target.
# import pandas as pd
# import numpy as np
# from sklearn.model_selection import train_test_split

# # Load the dataset
# data = pd.read_csv('q2_dataset.csv')

# # Extract values
# values = data.values

# # Initialize lists for targets and features
# targets = []
# features = []
# days = 3

# # Iterate over the dataset to create features and targets
# for i in range(len(values) - days):
#     targets.append(float(str(values[i][1]).replace('$', ''))) # Conver
#     feature = []
#     for j in range(2, 6):
#         for k in range(0, days):
#             feature.append(float(str(values[i + k + 1][j]).replace('$',
#             features.append(feature)

# # Create DataFrame from features and targets
# dataset = pd.DataFrame(features)
# dataset['Target'] = targets

# # Split the dataset into training and testing sets
# train_data, test_data = train_test_split(dataset, test_size=0.3, random

# # Save the training and testing datasets to CSV files
# train_data.to_csv('data/train_data_RNN.csv', index=False, header=False)
# test_data.to_csv('data/test_data_RNN.csv', index=False, header=False)
```

```
In [4]: import pandas as pd
import numpy as np
```

```

import tensorflow as tf
from sklearn.preprocessing import MinMaxScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, LSTM
from tensorflow.keras.callbacks import ModelCheckpoint
import matplotlib.pyplot as plt

# 1. Loading training data
train_data = pd.read_csv('./data/train_data_RNN.csv')
test_data = pd.read_csv('./data/test_data_RNN.csv')

# Extracting the features and target variables from the training data
train_features = train_data.iloc[:, :-1].values
train_target = train_data.iloc[:, -1].values

# Extracting the features and target variables from the testing data
test_features = test_data.iloc[:, :-1].values
test_target = test_data.iloc[:, -1].values

# Performing feature scaling for training and testing data
scaler = MinMaxScaler()
scaled_train_features = scaler.fit_transform(train_features)
scaled_train_target = scaler.fit_transform(train_target.reshape(-1, 1))
scaled_test_features = scaler.fit_transform(test_features)
scaled_test_target = scaler.fit_transform(test_target.reshape(-1, 1))

# Reshaping the features for LSTM input [samples, time steps, features]
reshaped_train_features = np.reshape(scaled_train_features, (scaled_train_target.shape[0], -1))
reshaped_test_features = np.reshape(scaled_test_features, (scaled_test_target.shape[0], -1))

```

2023-07-17 21:41:57.718628: I tensorflow/core/platform/cpu_feature_guard.cc:182] This TensorFlow binary is optimized to use available CPU instructions in performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild TensorFlow with the appropriate compiler flags.

In [5]:

```

# 2. Train network
# Create the RNN model
model = Sequential()
model.add(LSTM(units=50, activation='relu', input_shape=(1, train_features.shape[1])))
model.add(Dense(units=1))
model.compile(optimizer='adam', loss='mean_squared_error')
history = model.fit(reshaped_train_features, scaled_train_target, epochs=100)

# Define the model checkpoint callback to save the best model during training
checkpoint_callback = ModelCheckpoint(filepath='models/20941704.h5', save_best_only=True)

# Train the model on the training data
train_history = model.fit(reshaped_train_features, scaled_train_target, epochs=100, callbacks=[checkpoint_callback])

# Print the final training loss
final_train_loss = train_history.history['loss'][-1]
print(f"Final Training Loss: {final_train_loss}")

```

```
Epoch 1/100
28/28 [=====] - 2s 17ms/step - loss: 0.0760 - val_
_loss: 0.0400
Epoch 2/100
28/28 [=====] - 0s 6ms/step - loss: 0.0142 - val_
_loss: 0.0035
Epoch 3/100
28/28 [=====] - 0s 5ms/step - loss: 0.0020 - val_
_loss: 0.0010
Epoch 4/100
28/28 [=====] - 0s 5ms/step - loss: 5.1340e-04 -
_val_loss: 6.2588e-04
Epoch 5/100
28/28 [=====] - 0s 5ms/step - loss: 4.2866e-04 -
_val_loss: 5.2668e-04
Epoch 6/100
28/28 [=====] - 0s 5ms/step - loss: 4.1051e-04 -
_val_loss: 5.8772e-04
Epoch 7/100
28/28 [=====] - 0s 5ms/step - loss: 3.9854e-04 -
_val_loss: 6.0285e-04
Epoch 8/100
28/28 [=====] - 0s 5ms/step - loss: 3.7352e-04 -
_val_loss: 5.3140e-04
Epoch 9/100
28/28 [=====] - 0s 5ms/step - loss: 3.4908e-04 -
_val_loss: 4.2073e-04
Epoch 10/100
28/28 [=====] - 0s 5ms/step - loss: 3.5216e-04 -
_val_loss: 3.8246e-04
Epoch 11/100
28/28 [=====] - 0s 5ms/step - loss: 3.2164e-04 -
_val_loss: 3.9766e-04
Epoch 12/100
28/28 [=====] - 0s 5ms/step - loss: 3.1202e-04 -
_val_loss: 3.6390e-04
Epoch 13/100
28/28 [=====] - 0s 5ms/step - loss: 3.0276e-04 -
_val_loss: 4.3305e-04
Epoch 14/100
28/28 [=====] - 0s 5ms/step - loss: 3.0083e-04 -
_val_loss: 3.6975e-04
Epoch 15/100
28/28 [=====] - 0s 5ms/step - loss: 2.8903e-04 -
_val_loss: 4.2929e-04
Epoch 16/100
28/28 [=====] - 0s 5ms/step - loss: 2.7889e-04 -
_val_loss: 3.4497e-04
Epoch 17/100
28/28 [=====] - 0s 5ms/step - loss: 2.8228e-04 -
_val_loss: 3.2130e-04
Epoch 18/100
28/28 [=====] - 0s 5ms/step - loss: 2.7667e-04 -
_val_loss: 3.4012e-04
Epoch 19/100
28/28 [=====] - 0s 5ms/step - loss: 2.6911e-04 -
_val_loss: 4.0646e-04
Epoch 20/100
28/28 [=====] - 0s 5ms/step - loss: 2.6261e-04 -
_val_loss: 3.9390e-04
```

```
Epoch 21/100
28/28 [=====] - 0s 5ms/step - loss: 2.5656e-04 -
val_loss: 3.7854e-04
Epoch 22/100
28/28 [=====] - 0s 5ms/step - loss: 2.5985e-04 -
val_loss: 4.0843e-04
Epoch 23/100
28/28 [=====] - 0s 5ms/step - loss: 2.5047e-04 -
val_loss: 3.0749e-04
Epoch 24/100
28/28 [=====] - 0s 5ms/step - loss: 2.6318e-04 -
val_loss: 3.2079e-04
Epoch 25/100
28/28 [=====] - 0s 4ms/step - loss: 2.5699e-04 -
val_loss: 3.3101e-04
Epoch 26/100
28/28 [=====] - 0s 5ms/step - loss: 2.4569e-04 -
val_loss: 3.4218e-04
Epoch 27/100
28/28 [=====] - 0s 5ms/step - loss: 2.4457e-04 -
val_loss: 3.8644e-04
Epoch 28/100
28/28 [=====] - 0s 5ms/step - loss: 2.4435e-04 -
val_loss: 4.0738e-04
Epoch 29/100
28/28 [=====] - 0s 5ms/step - loss: 2.4342e-04 -
val_loss: 3.3447e-04
Epoch 30/100
28/28 [=====] - 0s 7ms/step - loss: 2.4029e-04 -
val_loss: 3.4279e-04
Epoch 31/100
28/28 [=====] - 0s 4ms/step - loss: 2.3873e-04 -
val_loss: 3.8848e-04
Epoch 32/100
28/28 [=====] - 0s 4ms/step - loss: 2.4965e-04 -
val_loss: 2.8518e-04
Epoch 33/100
28/28 [=====] - 0s 5ms/step - loss: 2.4130e-04 -
val_loss: 3.3447e-04
Epoch 34/100
28/28 [=====] - 0s 5ms/step - loss: 2.3428e-04 -
val_loss: 4.1118e-04
Epoch 35/100
28/28 [=====] - 0s 5ms/step - loss: 2.4144e-04 -
val_loss: 2.7559e-04
Epoch 36/100
28/28 [=====] - 0s 5ms/step - loss: 2.5459e-04 -
val_loss: 3.2950e-04
Epoch 37/100
28/28 [=====] - 0s 5ms/step - loss: 2.3407e-04 -
val_loss: 2.9827e-04
Epoch 38/100
28/28 [=====] - 0s 5ms/step - loss: 2.3241e-04 -
val_loss: 3.7621e-04
Epoch 39/100
28/28 [=====] - 0s 5ms/step - loss: 2.2989e-04 -
val_loss: 3.2617e-04
Epoch 40/100
28/28 [=====] - 0s 5ms/step - loss: 2.2897e-04 -
val_loss: 3.1905e-04
```

```
Epoch 41/100
28/28 [=====] - 0s 7ms/step - loss: 2.2907e-04 -
val_loss: 3.0694e-04
Epoch 42/100
28/28 [=====] - 0s 5ms/step - loss: 2.2614e-04 -
val_loss: 3.5292e-04
Epoch 43/100
28/28 [=====] - 0s 6ms/step - loss: 2.2526e-04 -
val_loss: 3.2155e-04
Epoch 44/100
28/28 [=====] - 0s 5ms/step - loss: 2.3504e-04 -
val_loss: 2.7313e-04
Epoch 45/100
28/28 [=====] - 0s 4ms/step - loss: 2.2335e-04 -
val_loss: 4.6582e-04
Epoch 46/100
28/28 [=====] - 0s 4ms/step - loss: 2.3315e-04 -
val_loss: 2.4568e-04
Epoch 47/100
28/28 [=====] - 0s 4ms/step - loss: 2.3165e-04 -
val_loss: 4.6001e-04
Epoch 48/100
28/28 [=====] - 0s 5ms/step - loss: 2.2795e-04 -
val_loss: 2.9752e-04
Epoch 49/100
28/28 [=====] - 0s 5ms/step - loss: 2.2647e-04 -
val_loss: 2.8589e-04
Epoch 50/100
28/28 [=====] - 0s 5ms/step - loss: 2.3390e-04 -
val_loss: 5.7234e-04
Epoch 51/100
28/28 [=====] - 0s 5ms/step - loss: 2.2130e-04 -
val_loss: 2.6201e-04
Epoch 52/100
28/28 [=====] - 0s 5ms/step - loss: 2.4031e-04 -
val_loss: 3.0480e-04
Epoch 53/100
28/28 [=====] - 0s 5ms/step - loss: 2.2687e-04 -
val_loss: 3.3377e-04
Epoch 54/100
28/28 [=====] - 0s 5ms/step - loss: 2.2194e-04 -
val_loss: 2.7634e-04
Epoch 55/100
28/28 [=====] - 0s 5ms/step - loss: 2.1812e-04 -
val_loss: 3.3662e-04
Epoch 56/100
28/28 [=====] - 0s 5ms/step - loss: 2.1548e-04 -
val_loss: 3.6348e-04
Epoch 57/100
28/28 [=====] - 0s 5ms/step - loss: 2.2464e-04 -
val_loss: 2.3518e-04
Epoch 58/100
28/28 [=====] - 0s 5ms/step - loss: 2.2916e-04 -
val_loss: 3.8967e-04
Epoch 59/100
28/28 [=====] - 0s 4ms/step - loss: 2.1526e-04 -
val_loss: 2.6131e-04
Epoch 60/100
28/28 [=====] - 0s 4ms/step - loss: 2.2015e-04 -
val_loss: 4.4999e-04
```

```
Epoch 61/100
28/28 [=====] - 0s 4ms/step - loss: 2.2098e-04 -
val_loss: 2.7551e-04
Epoch 62/100
28/28 [=====] - 0s 5ms/step - loss: 2.1503e-04 -
val_loss: 3.6207e-04
Epoch 63/100
28/28 [=====] - 0s 5ms/step - loss: 2.1712e-04 -
val_loss: 3.5025e-04
Epoch 64/100
28/28 [=====] - 0s 6ms/step - loss: 2.1552e-04 -
val_loss: 2.8263e-04
Epoch 65/100
28/28 [=====] - 0s 5ms/step - loss: 2.1122e-04 -
val_loss: 3.0191e-04
Epoch 66/100
28/28 [=====] - 0s 5ms/step - loss: 2.2083e-04 -
val_loss: 3.2132e-04
Epoch 67/100
28/28 [=====] - 0s 5ms/step - loss: 2.0965e-04 -
val_loss: 2.6603e-04
Epoch 68/100
28/28 [=====] - 0s 5ms/step - loss: 2.3214e-04 -
val_loss: 2.9769e-04
Epoch 69/100
28/28 [=====] - 0s 5ms/step - loss: 2.1350e-04 -
val_loss: 2.8287e-04
Epoch 70/100
28/28 [=====] - 0s 5ms/step - loss: 2.2906e-04 -
val_loss: 2.7891e-04
Epoch 71/100
28/28 [=====] - 0s 5ms/step - loss: 2.0674e-04 -
val_loss: 3.4067e-04
Epoch 72/100
28/28 [=====] - 0s 5ms/step - loss: 2.1377e-04 -
val_loss: 3.2636e-04
Epoch 73/100
28/28 [=====] - 0s 5ms/step - loss: 2.1076e-04 -
val_loss: 3.8530e-04
Epoch 74/100
28/28 [=====] - 0s 4ms/step - loss: 2.1388e-04 -
val_loss: 4.2617e-04
Epoch 75/100
28/28 [=====] - 0s 4ms/step - loss: 2.1005e-04 -
val_loss: 2.3054e-04
Epoch 76/100
28/28 [=====] - 0s 5ms/step - loss: 2.2648e-04 -
val_loss: 2.5032e-04
Epoch 77/100
28/28 [=====] - 0s 5ms/step - loss: 2.1109e-04 -
val_loss: 2.8083e-04
Epoch 78/100
28/28 [=====] - 0s 4ms/step - loss: 2.1858e-04 -
val_loss: 3.5440e-04
Epoch 79/100
28/28 [=====] - 0s 5ms/step - loss: 2.1181e-04 -
val_loss: 3.2875e-04
Epoch 80/100
28/28 [=====] - 0s 5ms/step - loss: 2.1572e-04 -
val_loss: 3.3345e-04
```

```
Epoch 81/100
28/28 [=====] - 0s 5ms/step - loss: 2.2263e-04 -
val_loss: 2.5497e-04
Epoch 82/100
28/28 [=====] - 0s 6ms/step - loss: 2.0800e-04 -
val_loss: 2.3069e-04
Epoch 83/100
28/28 [=====] - 0s 5ms/step - loss: 2.1716e-04 -
val_loss: 2.6337e-04
Epoch 84/100
28/28 [=====] - 0s 5ms/step - loss: 2.0507e-04 -
val_loss: 2.5224e-04
Epoch 85/100
28/28 [=====] - 0s 5ms/step - loss: 2.2846e-04 -
val_loss: 3.0047e-04
Epoch 86/100
28/28 [=====] - 0s 5ms/step - loss: 2.2269e-04 -
val_loss: 3.4192e-04
Epoch 87/100
28/28 [=====] - 0s 5ms/step - loss: 2.0992e-04 -
val_loss: 2.3636e-04
Epoch 88/100
28/28 [=====] - 0s 5ms/step - loss: 2.1292e-04 -
val_loss: 2.6202e-04
Epoch 89/100
28/28 [=====] - 0s 5ms/step - loss: 2.0528e-04 -
val_loss: 2.8297e-04
Epoch 90/100
28/28 [=====] - 0s 5ms/step - loss: 2.0082e-04 -
val_loss: 3.1156e-04
Epoch 91/100
28/28 [=====] - 0s 5ms/step - loss: 2.1589e-04 -
val_loss: 3.3513e-04
Epoch 92/100
28/28 [=====] - 0s 5ms/step - loss: 2.1667e-04 -
val_loss: 3.8113e-04
Epoch 93/100
28/28 [=====] - 0s 5ms/step - loss: 2.0418e-04 -
val_loss: 2.4850e-04
Epoch 94/100
28/28 [=====] - 0s 5ms/step - loss: 2.0609e-04 -
val_loss: 2.4364e-04
Epoch 95/100
28/28 [=====] - 0s 5ms/step - loss: 2.0847e-04 -
val_loss: 2.8263e-04
Epoch 96/100
28/28 [=====] - 0s 5ms/step - loss: 2.0563e-04 -
val_loss: 3.4272e-04
Epoch 97/100
28/28 [=====] - 0s 5ms/step - loss: 2.1323e-04 -
val_loss: 3.6120e-04
Epoch 98/100
28/28 [=====] - 0s 4ms/step - loss: 2.0226e-04 -
val_loss: 3.9144e-04
Epoch 99/100
28/28 [=====] - 0s 5ms/step - loss: 2.0323e-04 -
val_loss: 3.3557e-04
Epoch 100/100
28/28 [=====] - 0s 5ms/step - loss: 2.0018e-04 -
val_loss: 2.6709e-04
```

```
Epoch 1/100
17/28 [=====>.....] - ETA: 0s - loss: 2.1892e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9648e-04
Epoch 2/100
17/28 [=====>.....] - ETA: 0s - loss: 2.3653e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0655e-04
Epoch 3/100
18/28 [=====>.....] - ETA: 0s - loss: 1.9015e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0492e-04
Epoch 4/100
18/28 [=====>.....] - ETA: 0s - loss: 1.9860e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0504e-04
Epoch 5/100
20/28 [=====>.....] - ETA: 0s - loss: 2.2169e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0691e-04
Epoch 6/100
16/28 [=====>.....] - ETA: 0s - loss: 1.7491e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0109e-04
Epoch 7/100
17/28 [=====>.....] - ETA: 0s - loss: 1.9497e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0257e-04
Epoch 8/100
15/28 [=====>.....] - ETA: 0s - loss: 1.5180e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 1.9852e-04
Epoch 9/100
15/28 [=====>.....] - ETA: 0s - loss: 2.2052e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0003e-04
Epoch 10/100
17/28 [=====>.....] - ETA: 0s - loss: 1.9622e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.0115e-04
Epoch 11/100
15/28 [=====>.....] - ETA: 0s - loss: 2.0292e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9664e-04
Epoch 12/100
17/28 [=====>.....] - ETA: 0s - loss: 2.0025e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9899e-04
Epoch 13/100
16/28 [=====>.....] - ETA: 0s - loss: 2.1587e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.0973e-04
Epoch 14/100
14/28 [=====>.....] - ETA: 0s - loss: 1.9964e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.0073e-04
Epoch 15/100
17/28 [=====>.....] - ETA: 0s - loss: 1.8797e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9996e-04
```



```
Epoch 16/100
16/28 [=====>.....] - ETA: 0s - loss: 2.2258e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0368e-04
Epoch 17/100
19/28 [=====>.....] - ETA: 0s - loss: 2.0506e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1092e-04
Epoch 18/100
16/28 [=====>.....] - ETA: 0s - loss: 2.0004e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 8ms/step - loss: 2.0805e-04
Epoch 19/100
17/28 [=====>.....] - ETA: 0s - loss: 2.3242e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1527e-04
Epoch 20/100
13/28 [=====>.....] - ETA: 0s - loss: 2.2006e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.0289e-04
Epoch 21/100
15/28 [=====>.....] - ETA: 0s - loss: 2.9085e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.3709e-04
Epoch 22/100
16/28 [=====>.....] - ETA: 0s - loss: 2.2213e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.0711e-04
Epoch 23/100
17/28 [=====>.....] - ETA: 0s - loss: 1.9462e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9916e-04
Epoch 24/100
17/28 [=====>.....] - ETA: 0s - loss: 2.2722e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1426e-04
Epoch 25/100
18/28 [=====>.....] - ETA: 0s - loss: 2.1268e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9479e-04
Epoch 26/100
18/28 [=====>.....] - ETA: 0s - loss: 1.8646e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9916e-04
Epoch 27/100
17/28 [=====>.....] - ETA: 0s - loss: 2.4007e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0451e-04
Epoch 28/100
17/28 [=====>.....] - ETA: 0s - loss: 2.0628e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1379e-04
Epoch 29/100
16/28 [=====>.....] - ETA: 0s - loss: 1.6569e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9831e-04
Epoch 30/100
15/28 [=====>.....] - ETA: 0s - loss: 1.7284e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0042e-04
```

```
Epoch 31/100
19/28 [=====>.....] - ETA: 0s - loss: 1.8336e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9607e-04
Epoch 32/100
19/28 [=====>.....] - ETA: 0s - loss: 2.1284e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0091e-04
Epoch 33/100
17/28 [=====>.....] - ETA: 0s - loss: 2.1785e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1931e-04
Epoch 34/100
18/28 [=====>.....] - ETA: 0s - loss: 2.0348e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0017e-04
Epoch 35/100
16/28 [=====>.....] - ETA: 0s - loss: 2.1387e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0194e-04
Epoch 36/100
16/28 [=====>.....] - ETA: 0s - loss: 1.7903e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9446e-04
Epoch 37/100
17/28 [=====>.....] - ETA: 0s - loss: 1.9748e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1637e-04
Epoch 38/100
17/28 [=====>.....] - ETA: 0s - loss: 2.0479e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9377e-04
Epoch 39/100
16/28 [=====>.....] - ETA: 0s - loss: 2.2370e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 1.9077e-04
Epoch 40/100
11/28 [=====>.....] - ETA: 0s - loss: 1.8493e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 6ms/step - loss: 2.0735e-04
Epoch 41/100
19/28 [=====>.....] - ETA: 0s - loss: 1.8782e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9566e-04
Epoch 42/100
18/28 [=====>.....] - ETA: 0s - loss: 2.1559e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9323e-04
Epoch 43/100
17/28 [=====>.....] - ETA: 0s - loss: 1.8986e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9124e-04
Epoch 44/100
16/28 [=====>.....] - ETA: 0s - loss: 2.1400e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0281e-04
Epoch 45/100
19/28 [=====>.....] - ETA: 0s - loss: 2.3982e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1299e-04
```

```
Epoch 46/100
18/28 [=====>.....] - ETA: 0s - loss: 1.6346e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9451e-04
Epoch 47/100
15/28 [=====>.....] - ETA: 0s - loss: 1.7195e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9496e-04
Epoch 48/100
17/28 [=====>.....] - ETA: 0s - loss: 1.9948e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9280e-04
Epoch 49/100
17/28 [=====>.....] - ETA: 0s - loss: 1.8432e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.0038e-04
Epoch 50/100
15/28 [=====>.....] - ETA: 0s - loss: 2.3352e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 4ms/step - loss: 2.1174e-04
Epoch 51/100
16/28 [=====>.....] - ETA: 0s - loss: 1.6598e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0344e-04
Epoch 52/100
20/28 [=====>.....] - ETA: 0s - loss: 1.9530e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1219e-04
Epoch 53/100
15/28 [=====>.....] - ETA: 0s - loss: 1.9894e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0414e-04
Epoch 54/100
16/28 [=====>.....] - ETA: 0s - loss: 1.8336e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9996e-04
Epoch 55/100
19/28 [=====>.....] - ETA: 0s - loss: 2.0776e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0025e-04
Epoch 56/100
18/28 [=====>.....] - ETA: 0s - loss: 1.8014e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9398e-04
Epoch 57/100
16/28 [=====>.....] - ETA: 0s - loss: 1.4454e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8922e-04
Epoch 58/100
16/28 [=====>.....] - ETA: 0s - loss: 1.6895e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9114e-04
Epoch 59/100
16/28 [=====>.....] - ETA: 0s - loss: 2.0876e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9007e-04
Epoch 60/100
18/28 [=====>.....] - ETA: 0s - loss: 1.7475e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9455e-04
```

```
Epoch 61/100
19/28 [=====>.....] - ETA: 0s - loss: 1.8506e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9379e-04
Epoch 62/100
19/28 [=====>.....] - ETA: 0s - loss: 1.9647e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0066e-04
Epoch 63/100
20/28 [=====>.....] - ETA: 0s - loss: 2.0253e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0196e-04
Epoch 64/100
21/28 [=====>.....] - ETA: 0s - loss: 2.1538e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0945e-04
Epoch 65/100
19/28 [=====>.....] - ETA: 0s - loss: 2.1657e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0739e-04
Epoch 66/100
21/28 [=====>.....] - ETA: 0s - loss: 1.8134e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1183e-04
Epoch 67/100
20/28 [=====>.....] - ETA: 0s - loss: 1.9015e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8576e-04
Epoch 68/100
20/28 [=====>.....] - ETA: 0s - loss: 1.9707e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9496e-04
Epoch 69/100
19/28 [=====>.....] - ETA: 0s - loss: 1.9509e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9711e-04
Epoch 70/100
21/28 [=====>.....] - ETA: 0s - loss: 1.7907e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9037e-04
Epoch 71/100
19/28 [=====>.....] - ETA: 0s - loss: 1.8375e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1276e-04
Epoch 72/100
18/28 [=====>.....] - ETA: 0s - loss: 1.9261e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9455e-04
Epoch 73/100
17/28 [=====>.....] - ETA: 0s - loss: 1.8653e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9844e-04
Epoch 74/100
20/28 [=====>.....] - ETA: 0s - loss: 2.0120e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9763e-04
Epoch 75/100
19/28 [=====>.....] - ETA: 0s - loss: 2.1190e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8738e-04
```

```
Epoch 76/100
19/28 [=====>.....] - ETA: 0s - loss: 1.8847e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9916e-04
Epoch 77/100
20/28 [=====>.....] - ETA: 0s - loss: 1.9203e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0201e-04
Epoch 78/100
21/28 [=====>.....] - ETA: 0s - loss: 2.1255e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0407e-04
Epoch 79/100
18/28 [=====>.....] - ETA: 0s - loss: 1.5564e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8645e-04
Epoch 80/100
19/28 [=====>.....] - ETA: 0s - loss: 1.9306e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8789e-04
Epoch 81/100
17/28 [=====>.....] - ETA: 0s - loss: 1.9910e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9368e-04
Epoch 82/100
19/28 [=====>.....] - ETA: 0s - loss: 1.9235e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9699e-04
Epoch 83/100
19/28 [=====>.....] - ETA: 0s - loss: 1.7663e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8776e-04
Epoch 84/100
14/28 [=====>.....] - ETA: 0s - loss: 2.0031e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9201e-04
Epoch 85/100
17/28 [=====>.....] - ETA: 0s - loss: 2.3077e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0996e-04
Epoch 86/100
20/28 [=====>.....] - ETA: 0s - loss: 1.8124e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0213e-04
Epoch 87/100
18/28 [=====>.....] - ETA: 0s - loss: 1.8370e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9228e-04
Epoch 88/100
16/28 [=====>.....] - ETA: 0s - loss: 1.6726e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9497e-04
Epoch 89/100
20/28 [=====>.....] - ETA: 0s - loss: 1.6278e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8729e-04
Epoch 90/100
17/28 [=====>.....] - ETA: 0s - loss: 1.9393e-04WARNIN
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 5ms/step - loss: 1.9024e-04
```

```

Epoch 91/100
21/28 [=====>.....] - ETA: 0s - loss: 2.0189e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9405e-04
Epoch 92/100
18/28 [=====>.....] - ETA: 0s - loss: 2.1685e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.0998e-04
Epoch 93/100
20/28 [=====>.....] - ETA: 0s - loss: 2.0683e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1012e-04
Epoch 94/100
17/28 [=====>.....] - ETA: 0s - loss: 2.4059e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1849e-04
Epoch 95/100
21/28 [=====>.....] - ETA: 0s - loss: 2.3150e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.2206e-04
Epoch 96/100
17/28 [=====>.....] - ETA: 0s - loss: 1.7016e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8799e-04
Epoch 97/100
20/28 [=====>.....] - ETA: 0s - loss: 2.0110e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9889e-04
Epoch 98/100
20/28 [=====>.....] - ETA: 0s - loss: 2.0656e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.9945e-04
Epoch 99/100
20/28 [=====>.....] - ETA: 0s - loss: 1.6756e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 1.8882e-04
Epoch 100/100
19/28 [=====>.....] - ETA: 0s - loss: 2.1266e-04WARNING
G:tensorflow:Can save best model only with val_loss available, skipping.
28/28 [=====] - 0s 3ms/step - loss: 2.1059e-04
Final Training Loss: 0.00021058919082861394

```

```

In [6]: # 3. Saving the trained model for training data
        model.save('models/20941704_train.h5')

```

```

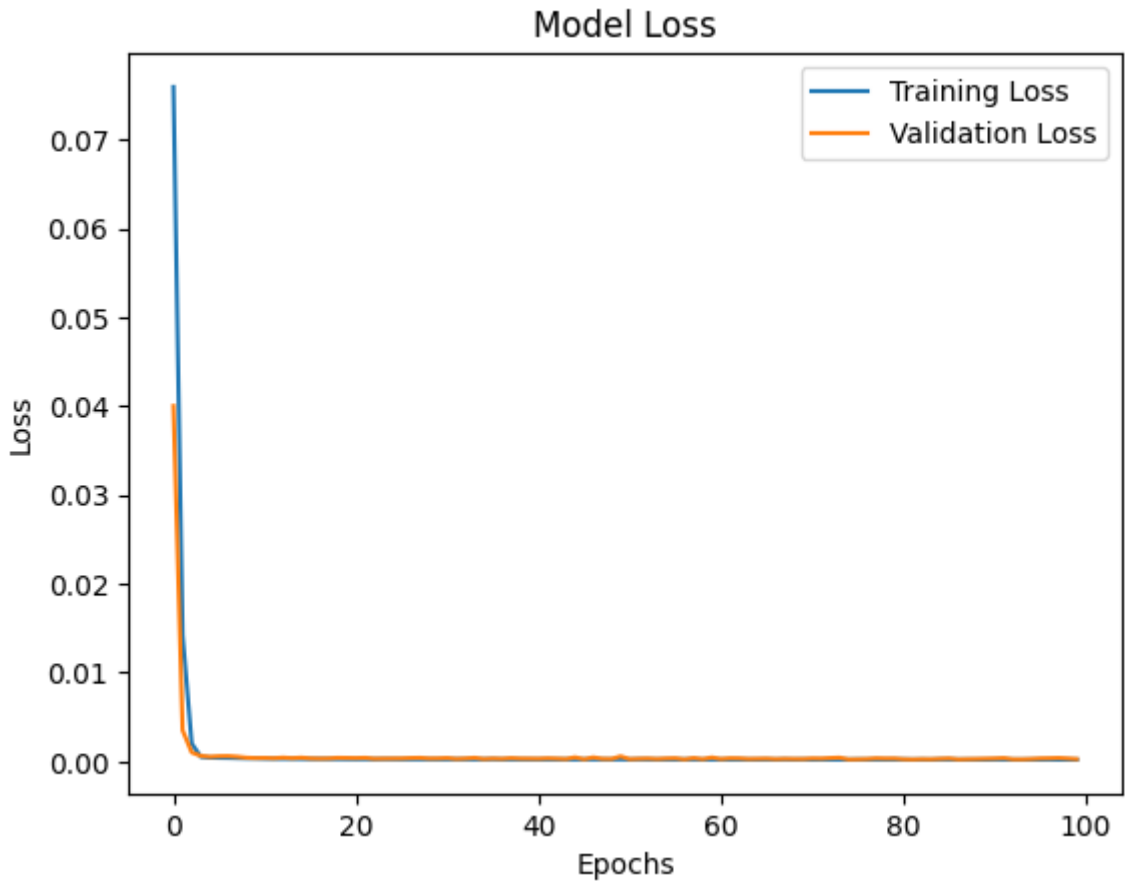
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site-packa
ges/keras/src/engine/training.py:3000: UserWarning: You are saving your mo
del as an HDF5 file via `model.save()`. This file format is considered leg
acy. We recommend using instead the native Keras format, e.g. `model.save
('my_model.keras')`.
  saving_api.save_model(

```

```

In [7]: # 4. Plotting the loss during training
        plt.plot(history.history['loss'], label='Training Loss')
        plt.plot(history.history['val_loss'], label='Validation Loss')
        plt.title('Model Loss')
        plt.xlabel('Epochs')
        plt.ylabel('Loss')
        plt.legend()
        plt.show()

```



```
In [ ]:
```