Question 1

Iris Dataset

```
# Import required libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import sklearn

# Import necessary modules
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
from math import sqrt

# Keras specific
import keras
from keras.models import Sequential
from keras.layers import Dense
from keras.utils import to_categorical
```

```
df = pd.read_csv('sample_data/iris.data')
print(df.shape)
df.describe()
```

```
(150, 5)

            s_len       s_wid       p_len       p_wid
count  150.000000  150.000000  150.000000  150.000000
mean     5.843333    3.054000    3.758667    1.198667
std      0.828066    0.433594    1.764420    0.763161
min      4.300000    2.000000    1.000000    0.100000
25%      5.100000    2.800000    1.600000    0.300000
50%      5.800000    3.000000    4.350000    1.300000
75%      6.400000    3.300000    5.100000    1.800000
max      7.900000    4.400000    6.900000    2.500000
```

```
target_column = ['class']
predictors = list(set(list(df.columns))-set(target_column))
df[predictors] = df[predictors]/df[predictors].max()
df.describe()
```

```
            s_len       s_wid       p_len       p_wid
count  150.000000  150.000000  150.000000  150.000000
mean     0.739662    0.694091    0.544734    0.479467
std      0.104818    0.098544    0.255713    0.305264
min      0.544304    0.454545    0.144928    0.040000
25%      0.645570    0.636364    0.231884    0.120000
50%      0.734177    0.681818    0.630435    0.520000
```

```
75%      0.810127    0.750000    0.739130    0.720000
max      1.000000    1.000000    1.000000    1.000000
```

```
X = df[predictors].values
df['class'].replace(['Iris-setosa', 'Iris-virginica', 'Iris-
versicolor'],
                        [0, 1, 2], inplace=True)
y = df[target_column].values

X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.30, random_state=40)
print(X_train.shape); print(X_test.shape)
```

```
(105, 4)
(45, 4)
```

```
# one hot encode outputs
y_train = to_categorical(y_train)
y_test = to_categorical(y_test)

count_classes = y_test.shape[1]
print(count_classes)
```

```
3
```

```
model = Sequential()
model.add(Dense(500, activation='relu', input_dim=4))
model.add(Dense(100, activation='sigmoid'))
model.add(Dense(50, activation='sigmoid'))
model.add(Dense(3, activation='softmax'))

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

# build the model
md = model.fit(X_train, y_train, epochs=100, validation_split=0.2)
```

```
Epoch 1/100
3/3 [==============================] - 1s 120ms/step - loss: 1.2794 -
accuracy: 0.3214 - val_loss: 1.1312 - val_accuracy: 0.4286
Epoch 2/100
3/3 [==============================] - 0s 15ms/step - loss: 1.1508 -
accuracy: 0.3214 - val_loss: 1.1135 - val_accuracy: 0.5238
Epoch 3/100
3/3 [==============================] - 0s 15ms/step - loss: 1.1018 -
accuracy: 0.4405 - val_loss: 1.1298 - val_accuracy: 0.2381
Epoch 4/100
3/3 [==============================] - 0s 14ms/step - loss: 1.0955 -
accuracy: 0.3571 - val_loss: 1.1418 - val_accuracy: 0.2381
```

```
Epoch 5/100
3/3 [==============================] - 0s 14ms/step - loss: 1.0856 -
accuracy: 0.4286 - val_loss: 1.1305 - val_accuracy: 0.5714
Epoch 6/100
3/3 [==============================] - 0s 20ms/step - loss: 1.0806 -
accuracy: 0.6667 - val_loss: 1.1117 - val_accuracy: 0.5714
Epoch 7/100
3/3 [==============================] - 0s 14ms/step - loss: 1.0676 -
accuracy: 0.6310 - val_loss: 1.0889 - val_accuracy: 0.5714
Epoch 8/100
3/3 [==============================] - 0s 15ms/step - loss: 1.0524 -
accuracy: 0.6786 - val_loss: 1.0623 - val_accuracy: 0.5714
Epoch 9/100
3/3 [==============================] - 0s 15ms/step - loss: 1.0365 -
accuracy: 0.6786 - val_loss: 1.0429 - val_accuracy: 0.5714
Epoch 10/100
3/3 [==============================] - 0s 15ms/step - loss: 1.0214 -
accuracy: 0.6786 - val_loss: 1.0245 - val_accuracy: 0.4762
Epoch 11/100
3/3 [==============================] - 0s 14ms/step - loss: 1.0084 -
accuracy: 0.5000 - val_loss: 1.0026 - val_accuracy: 0.4762
Epoch 12/100
3/3 [==============================] - 0s 16ms/step - loss: 0.9936 -
accuracy: 0.5595 - val_loss: 0.9812 - val_accuracy: 0.7619
Epoch 13/100
3/3 [==============================] - 0s 17ms/step - loss: 0.9726 -
accuracy: 0.7024 - val_loss: 0.9641 - val_accuracy: 0.5714
Epoch 14/100
3/3 [==============================] - 0s 20ms/step - loss: 0.9467 -
accuracy: 0.7500 - val_loss: 0.9453 - val_accuracy: 0.5714
Epoch 15/100
3/3 [==============================] - 0s 21ms/step - loss: 0.9192 -
accuracy: 0.6786 - val_loss: 0.9303 - val_accuracy: 0.5714
Epoch 16/100
3/3 [==============================] - 0s 15ms/step - loss: 0.8919 -
accuracy: 0.6786 - val_loss: 0.9090 - val_accuracy: 0.5714
Epoch 17/100
3/3 [==============================] - 0s 17ms/step - loss: 0.8628 -
accuracy: 0.6786 - val_loss: 0.8809 - val_accuracy: 0.5714
Epoch 18/100
3/3 [==============================] - 0s 16ms/step - loss: 0.8327 -
accuracy: 0.6786 - val_loss: 0.8455 - val_accuracy: 0.5714
Epoch 19/100
3/3 [==============================] - 0s 17ms/step - loss: 0.7965 -
accuracy: 0.6786 - val_loss: 0.8048 - val_accuracy: 0.5714
Epoch 20/100
3/3 [==============================] - 0s 16ms/step - loss: 0.7596 -
accuracy: 0.6905 - val_loss: 0.7572 - val_accuracy: 0.5714
Epoch 21/100
3/3 [==============================] - 0s 16ms/step - loss: 0.7235 -
```

```
accuracy: 0.7500 - val_loss: 0.7150 - val_accuracy: 0.5714
Epoch 22/100
3/3 [==============================] - 0s 16ms/step - loss: 0.6883 -
accuracy: 0.7857 - val_loss: 0.6795 - val_accuracy: 0.6667
Epoch 23/100
3/3 [==============================] - 0s 16ms/step - loss: 0.6547 -
accuracy: 0.7976 - val_loss: 0.6496 - val_accuracy: 0.6190
Epoch 24/100
3/3 [==============================] - 0s 16ms/step - loss: 0.6245 -
accuracy: 0.7976 - val_loss: 0.6229 - val_accuracy: 0.6190
Epoch 25/100
3/3 [==============================] - 0s 18ms/step - loss: 0.5973 -
accuracy: 0.7976 - val_loss: 0.5995 - val_accuracy: 0.6190
Epoch 26/100
3/3 [==============================] - 0s 16ms/step - loss: 0.5715 -
accuracy: 0.8214 - val_loss: 0.5724 - val_accuracy: 0.7619
Epoch 27/100
3/3 [==============================] - 0s 15ms/step - loss: 0.5497 -
accuracy: 0.8214 - val_loss: 0.5499 - val_accuracy: 0.8095
Epoch 28/100
3/3 [==============================] - 0s 16ms/step - loss: 0.5293 -
accuracy: 0.8571 - val_loss: 0.5252 - val_accuracy: 0.9524
Epoch 29/100
3/3 [==============================] - 0s 16ms/step - loss: 0.5137 -
accuracy: 0.9167 - val_loss: 0.5024 - val_accuracy: 0.9524
Epoch 30/100
3/3 [==============================] - 0s 17ms/step - loss: 0.4956 -
accuracy: 0.9167 - val_loss: 0.4904 - val_accuracy: 0.9524
Epoch 31/100
3/3 [==============================] - 0s 19ms/step - loss: 0.4816 -
accuracy: 0.8929 - val_loss: 0.4826 - val_accuracy: 0.9524
Epoch 32/100
3/3 [==============================] - 0s 16ms/step - loss: 0.4665 -
accuracy: 0.8810 - val_loss: 0.4635 - val_accuracy: 0.9524
Epoch 33/100
3/3 [==============================] - 0s 16ms/step - loss: 0.4534 -
accuracy: 0.9405 - val_loss: 0.4407 - val_accuracy: 0.9524
Epoch 34/100
3/3 [==============================] - 0s 15ms/step - loss: 0.4407 -
accuracy: 0.9643 - val_loss: 0.4232 - val_accuracy: 0.9524
Epoch 35/100
3/3 [==============================] - 0s 16ms/step - loss: 0.4281 -
accuracy: 0.9643 - val_loss: 0.4131 - val_accuracy: 0.9524
Epoch 36/100
3/3 [==============================] - 0s 15ms/step - loss: 0.4155 -
accuracy: 0.9643 - val_loss: 0.4003 - val_accuracy: 0.9524
Epoch 37/100
3/3 [==============================] - 0s 24ms/step - loss: 0.4040 -
accuracy: 0.9643 - val_loss: 0.3821 - val_accuracy: 0.9524
Epoch 38/100
```

```
3/3 [==============================] - 0s 16ms/step - loss: 0.3924 -
accuracy: 0.9643 - val_loss: 0.3698 - val_accuracy: 0.9524
Epoch 39/100
3/3 [==============================] - 0s 17ms/step - loss: 0.3799 -
accuracy: 0.9643 - val_loss: 0.3637 - val_accuracy: 0.9524
Epoch 40/100
3/3 [==============================] - 0s 17ms/step - loss: 0.3698 -
accuracy: 0.9643 - val_loss: 0.3537 - val_accuracy: 0.9524
Epoch 41/100
3/3 [==============================] - 0s 19ms/step - loss: 0.3595 -
accuracy: 0.9643 - val_loss: 0.3333 - val_accuracy: 0.9524
Epoch 42/100
3/3 [==============================] - 0s 16ms/step - loss: 0.3474 -
accuracy: 0.9643 - val_loss: 0.3256 - val_accuracy: 0.9524
Epoch 43/100
3/3 [==============================] - 0s 16ms/step - loss: 0.3373 -
accuracy: 0.9643 - val_loss: 0.3107 - val_accuracy: 0.9524
Epoch 44/100
3/3 [==============================] - 0s 18ms/step - loss: 0.3263 -
accuracy: 0.9643 - val_loss: 0.3034 - val_accuracy: 0.9524
Epoch 45/100
3/3 [==============================] - 0s 17ms/step - loss: 0.3174 -
accuracy: 0.9643 - val_loss: 0.2918 - val_accuracy: 0.9524
Epoch 46/100
3/3 [==============================] - 0s 17ms/step - loss: 0.3064 -
accuracy: 0.9643 - val_loss: 0.2771 - val_accuracy: 0.9524
Epoch 47/100
3/3 [==============================] - 0s 19ms/step - loss: 0.2972 -
accuracy: 0.9643 - val_loss: 0.2684 - val_accuracy: 0.9524
Epoch 48/100
3/3 [==============================] - 0s 16ms/step - loss: 0.2893 -
accuracy: 0.9643 - val_loss: 0.2612 - val_accuracy: 0.9524
Epoch 49/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2798 -
accuracy: 0.9643 - val_loss: 0.2433 - val_accuracy: 0.9524
Epoch 50/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2717 -
accuracy: 0.9524 - val_loss: 0.2364 - val_accuracy: 0.9524
Epoch 51/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2629 -
accuracy: 0.9643 - val_loss: 0.2307 - val_accuracy: 0.9524
Epoch 52/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2544 -
accuracy: 0.9643 - val_loss: 0.2268 - val_accuracy: 0.9524
Epoch 53/100
3/3 [==============================] - 0s 22ms/step - loss: 0.2480 -
accuracy: 0.9643 - val_loss: 0.2164 - val_accuracy: 0.9524
Epoch 54/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2389 -
accuracy: 0.9643 - val_loss: 0.2030 - val_accuracy: 0.9524
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Epoch 55/100
3/3 [==============================] - 0s 16ms/step - loss: 0.2321 -
accuracy: 0.9524 - val_loss: 0.1953 - val_accuracy: 0.9524
Epoch 56/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2253 -
accuracy: 0.9524 - val_loss: 0.1918 - val_accuracy: 0.9524
Epoch 57/100
3/3 [==============================] - 0s 18ms/step - loss: 0.2170 -
accuracy: 0.9643 - val_loss: 0.1971 - val_accuracy: 0.9524
Epoch 58/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2149 -
accuracy: 0.9643 - val_loss: 0.1914 - val_accuracy: 0.9524
Epoch 59/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2061 -
accuracy: 0.9643 - val_loss: 0.1735 - val_accuracy: 0.9524
Epoch 60/100
3/3 [==============================] - 0s 17ms/step - loss: 0.2022 -
accuracy: 0.9643 - val_loss: 0.1599 - val_accuracy: 1.0000
Epoch 61/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1990 -
accuracy: 0.9762 - val_loss: 0.1587 - val_accuracy: 0.9524
Epoch 62/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1916 -
accuracy: 0.9524 - val_loss: 0.1735 - val_accuracy: 0.9524
Epoch 63/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1883 -
accuracy: 0.9643 - val_loss: 0.1661 - val_accuracy: 0.9524
Epoch 64/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1824 -
accuracy: 0.9643 - val_loss: 0.1487 - val_accuracy: 0.9524
Epoch 65/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1737 -
accuracy: 0.9524 - val_loss: 0.1367 - val_accuracy: 1.0000
Epoch 66/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1766 -
accuracy: 0.9762 - val_loss: 0.1322 - val_accuracy: 1.0000
Epoch 67/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1703 -
accuracy: 0.9643 - val_loss: 0.1389 - val_accuracy: 0.9524
Epoch 68/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1661 -
accuracy: 0.9643 - val_loss: 0.1448 - val_accuracy: 0.9524
Epoch 69/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1615 -
accuracy: 0.9643 - val_loss: 0.1296 - val_accuracy: 0.9524
Epoch 70/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1574 -
accuracy: 0.9524 - val_loss: 0.1214 - val_accuracy: 0.9524
Epoch 71/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1533 -
```

```
accuracy: 0.9643 - val_loss: 0.1231 - val_accuracy: 0.9524
Epoch 72/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1505 -
accuracy: 0.9524 - val_loss: 0.1297 - val_accuracy: 0.9524
Epoch 73/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1484 -
accuracy: 0.9643 - val_loss: 0.1225 - val_accuracy: 0.9524
Epoch 74/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1450 -
accuracy: 0.9524 - val_loss: 0.1139 - val_accuracy: 0.9524
Epoch 75/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1425 -
accuracy: 0.9524 - val_loss: 0.1142 - val_accuracy: 0.9524
Epoch 76/100
3/3 [==============================] - 0s 20ms/step - loss: 0.1380 -
accuracy: 0.9524 - val_loss: 0.1062 - val_accuracy: 0.9524
Epoch 77/100
3/3 [==============================] - 0s 15ms/step - loss: 0.1364 -
accuracy: 0.9643 - val_loss: 0.1051 - val_accuracy: 0.9524
Epoch 78/100
3/3 [==============================] - 0s 20ms/step - loss: 0.1351 -
accuracy: 0.9643 - val_loss: 0.1058 - val_accuracy: 0.9524
Epoch 79/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1364 -
accuracy: 0.9524 - val_loss: 0.1172 - val_accuracy: 0.9524
Epoch 80/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1333 -
accuracy: 0.9643 - val_loss: 0.1086 - val_accuracy: 0.9524
Epoch 81/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1274 -
accuracy: 0.9524 - val_loss: 0.1023 - val_accuracy: 0.9524
Epoch 82/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1251 -
accuracy: 0.9524 - val_loss: 0.0980 - val_accuracy: 0.9524
Epoch 83/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1229 -
accuracy: 0.9524 - val_loss: 0.0957 - val_accuracy: 0.9524
Epoch 84/100
3/3 [==============================] - 0s 15ms/step - loss: 0.1208 -
accuracy: 0.9524 - val_loss: 0.0929 - val_accuracy: 0.9524
Epoch 85/100
3/3 [==============================] - 0s 15ms/step - loss: 0.1211 -
accuracy: 0.9643 - val_loss: 0.0912 - val_accuracy: 0.9524
Epoch 86/100
3/3 [==============================] - 0s 21ms/step - loss: 0.1175 -
accuracy: 0.9643 - val_loss: 0.0933 - val_accuracy: 0.9524
Epoch 87/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1162 -
accuracy: 0.9524 - val_loss: 0.0931 - val_accuracy: 0.9524
Epoch 88/100
```

```
3/3 [==============================] - 0s 17ms/step - loss: 0.1147 -
accuracy: 0.9524 - val_loss: 0.0913 - val_accuracy: 0.9524
Epoch 89/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1144 -
accuracy: 0.9643 - val_loss: 0.0868 - val_accuracy: 0.9524
Epoch 90/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1118 -
accuracy: 0.9643 - val_loss: 0.0902 - val_accuracy: 0.9524
Epoch 91/100
3/3 [==============================] - 0s 15ms/step - loss: 0.1106 -
accuracy: 0.9524 - val_loss: 0.0875 - val_accuracy: 0.9524
Epoch 92/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1134 -
accuracy: 0.9643 - val_loss: 0.0824 - val_accuracy: 0.9524
Epoch 93/100
3/3 [==============================] - 0s 26ms/step - loss: 0.1095 -
accuracy: 0.9643 - val_loss: 0.0938 - val_accuracy: 0.9524
Epoch 94/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1111 -
accuracy: 0.9524 - val_loss: 0.0867 - val_accuracy: 0.9524
Epoch 95/100
3/3 [==============================] - 0s 18ms/step - loss: 0.1064 -
accuracy: 0.9524 - val_loss: 0.0842 - val_accuracy: 0.9524
Epoch 96/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1095 -
accuracy: 0.9524 - val_loss: 0.0787 - val_accuracy: 0.9524
Epoch 97/100
3/3 [==============================] - 0s 16ms/step - loss: 0.1045 -
accuracy: 0.9524 - val_loss: 0.0811 - val_accuracy: 0.9524
Epoch 98/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1033 -
accuracy: 0.9524 - val_loss: 0.0778 - val_accuracy: 0.9524
Epoch 99/100
3/3 [==============================] - 0s 20ms/step - loss: 0.1148 -
accuracy: 0.9643 - val_loss: 0.0690 - val_accuracy: 1.0000
Epoch 100/100
3/3 [==============================] - 0s 17ms/step - loss: 0.1013 -
accuracy: 0.9762 - val_loss: 0.0870 - val_accuracy: 0.9524
```

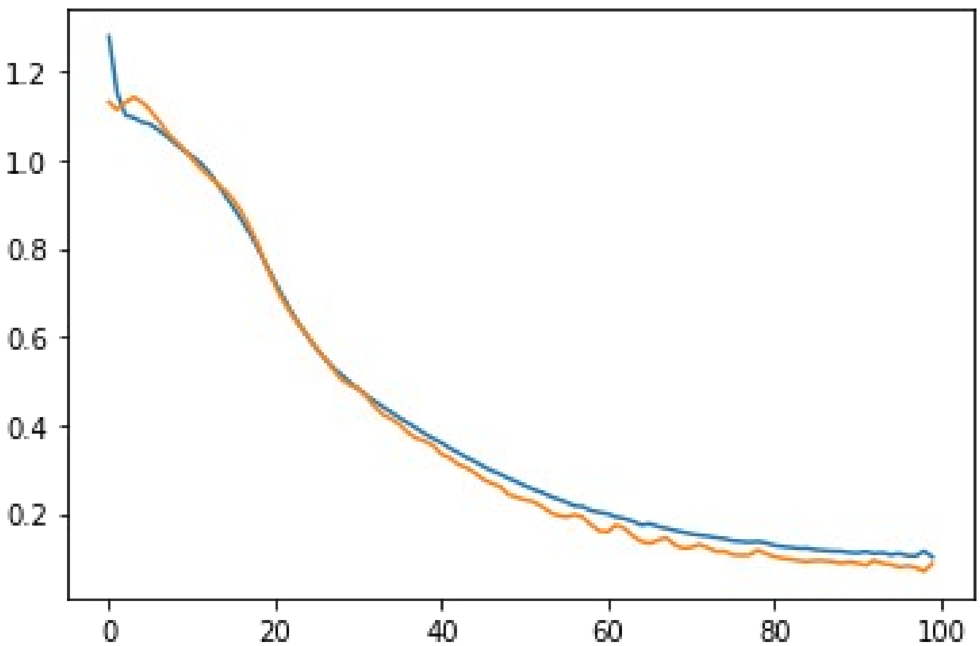
```python
pred_train= model.predict(X_train)
scores = model.evaluate(X_train, y_train, verbose=0)
print('Accuracy on training data: {}% \n Error on training data:
{}'.format(scores[1], 1 - scores[1]))

pred_test= model.predict(X_test)
scores2 = model.evaluate(X_test, y_test, verbose=0)
print('Accuracy on test data: {}% \n Error on test data:
{}'.format(scores2[1], 1 - scores2[1]))
```

```
4/4 [==============================] - 0s 4ms/step
Accuracy on training data: 0.9523809552192688%
```

```
 Error on training data: 0.0476190447807312
2/2 [==============================] - 0s 5ms/step
Accuracy on test data: 0.9777777791023254%
 Error on test data: 0.02222222089767456
```

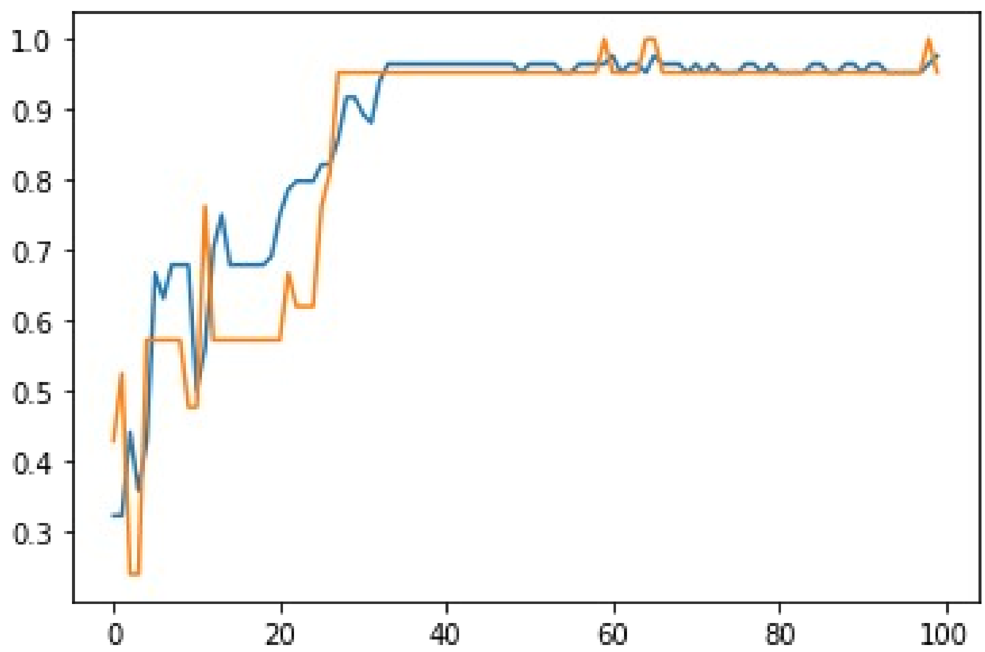
```python
import matplotlib.pyplot as plt

plt.plot(md.history['loss'])
plt.plot(md.history['val_loss'])
```

```
[<matplotlib.lines.Line2D at 0x7fdbf596b9d0>]
```




```python
plt.plot(md.history['accuracy'])
plt.plot(md.history['val_accuracy'])
```

```
[<matplotlib.lines.Line2D at 0x7fdbf59ea340>]
```



Question 2

Breast Cancer Dataset

```
df2 = pd.read_csv('sample_data/wdbc.data', header=None)
print(df2.shape)
df2.drop(df2.columns[0], axis=1, inplace=True)
df2.replace(('M', 'B'), (1, 0), inplace=True)
df2.head()
df2.describe()
```

```
(569, 32)

              1           2           3           4            5   \
count  569.000000  569.000000  569.000000  569.000000   569.000000
mean     0.372583   14.127292   19.289649   91.969033   654.889104
std      0.483918    3.524049    4.301036   24.298981   351.914129
min      0.000000    6.981000    9.710000   43.790000   143.500000
25%      0.000000   11.700000   16.170000   75.170000   420.300000
50%      0.000000   13.370000   18.840000   86.240000   551.100000
75%      1.000000   15.780000   21.800000  104.100000   782.700000
max      1.000000   28.110000   39.280000  188.500000  2501.000000

              6           7           8           9           10  ...
\
count  569.000000  569.000000  569.000000  569.000000  569.000000  ...

mean     0.096360    0.104341    0.088799    0.048919    0.181162  ...
```

```
std      0.014064    0.052813    0.079720    0.038803    0.027414  ...

min      0.052630    0.019380    0.000000    0.000000    0.106000  ...

25%      0.086370    0.064920    0.029560    0.020310    0.161900  ...

50%      0.095870    0.092630    0.061540    0.033500    0.179200  ...

75%      0.105300    0.130400    0.130700    0.074000    0.195700  ...

max      0.163400    0.345400    0.426800    0.201200    0.304000  ...


               22          23          24           25          26  \
count  569.000000  569.000000  569.000000   569.000000  569.000000
mean    16.269190   25.677223  107.261213   880.583128    0.132369
std      4.833242    6.146258   33.602542   569.356993    0.022832
min      7.930000   12.020000   50.410000   185.200000    0.071170
25%     13.010000   21.080000   84.110000   515.300000    0.116600
50%     14.970000   25.410000   97.660000   686.500000    0.131300
75%     18.790000   29.720000  125.400000  1084.000000    0.146000
max     36.040000   49.540000  251.200000  4254.000000    0.222600

               27          28          29          30          31
count  569.000000  569.000000  569.000000  569.000000  569.000000
mean     0.254265    0.272188    0.114606    0.290076    0.083946
std      0.157336    0.208624    0.065732    0.061867    0.018061
min      0.027290    0.000000    0.000000    0.156500    0.055040
25%      0.147200    0.114500    0.064930    0.250400    0.071460
50%      0.211900    0.226700    0.099930    0.282200    0.080040
75%      0.339100    0.382900    0.161400    0.317900    0.092080
max      1.058000    1.252000    0.291000    0.663800    0.207500

[8 rows x 31 columns]
```

```
X = df2.drop(df2.columns[[0]],axis = 1)
y = df2.iloc[:,0].values
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test =
train_test_split(X,y,test_size=0.3,random_state=0)
print(X_train.shape); print(X_test.shape)
```

```
(398, 30)
(171, 30)
```

```
model = Sequential()
model.add(Dense(500, activation='sigmoid', input_dim=30))
model.add(Dense(100, activation='sigmoid'))
model.add(Dense(50, activation='sigmoid'))
model.add(Dense(1, activation='sigmoid'))
```

```python
# Compile the model
model.compile(optimizer='adam',
              loss='binary_crossentropy',
              metrics=['accuracy'])

# build the model
md = model.fit(X_train, y_train, epochs=100, validation_split=0.2)
```

```
Epoch 1/100
10/10 [==============================] - 1s 29ms/step - loss: 0.6520 -
accuracy: 0.6006 - val_loss: 0.6463 - val_accuracy: 0.6000
Epoch 2/100
10/10 [==============================] - 0s 6ms/step - loss: 0.5852 -
accuracy: 0.7107 - val_loss: 0.5563 - val_accuracy: 0.8125
Epoch 3/100
10/10 [==============================] - 0s 7ms/step - loss: 0.4965 -
accuracy: 0.8711 - val_loss: 0.4555 - val_accuracy: 0.8750
Epoch 4/100
10/10 [==============================] - 0s 8ms/step - loss: 0.3883 -
accuracy: 0.8931 - val_loss: 0.3644 - val_accuracy: 0.8875
Epoch 5/100
10/10 [==============================] - 0s 7ms/step - loss: 0.3131 -
accuracy: 0.9025 - val_loss: 0.3162 - val_accuracy: 0.9125
Epoch 6/100
10/10 [==============================] - 0s 6ms/step - loss: 0.2665 -
accuracy: 0.9088 - val_loss: 0.3011 - val_accuracy: 0.8875
Epoch 7/100
10/10 [==============================] - 0s 7ms/step - loss: 0.2448 -
accuracy: 0.9088 - val_loss: 0.2756 - val_accuracy: 0.9000
Epoch 8/100
10/10 [==============================] - 0s 8ms/step - loss: 0.2317 -
accuracy: 0.9182 - val_loss: 0.3355 - val_accuracy: 0.8750
Epoch 9/100
10/10 [==============================] - 0s 6ms/step - loss: 0.2486 -
accuracy: 0.9119 - val_loss: 0.2995 - val_accuracy: 0.8750
Epoch 10/100
10/10 [==============================] - 0s 7ms/step - loss: 0.2398 -
accuracy: 0.9151 - val_loss: 0.2790 - val_accuracy: 0.8875
Epoch 11/100
10/10 [==============================] - 0s 9ms/step - loss: 0.2517 -
accuracy: 0.9088 - val_loss: 0.2960 - val_accuracy: 0.8875
Epoch 12/100
10/10 [==============================] - 0s 6ms/step - loss: 0.2325 -
accuracy: 0.9182 - val_loss: 0.3129 - val_accuracy: 0.8750
Epoch 13/100
10/10 [==============================] - 0s 8ms/step - loss: 0.2084 -
accuracy: 0.9214 - val_loss: 0.2570 - val_accuracy: 0.9250
Epoch 14/100
10/10 [==============================] - 0s 7ms/step - loss: 0.2172 -
```

```
accuracy: 0.9214 - val_loss: 0.2444 - val_accuracy: 0.9125
Epoch 15/100
10/10 [==============================] - 0s 7ms/step - loss: 0.2098 -
accuracy: 0.9182 - val_loss: 0.3122 - val_accuracy: 0.8875
Epoch 16/100
10/10 [==============================] - 0s 8ms/step - loss: 0.2144 -
accuracy: 0.9057 - val_loss: 0.2554 - val_accuracy: 0.9250
Epoch 17/100
10/10 [==============================] - 0s 7ms/step - loss: 0.2072 -
accuracy: 0.9182 - val_loss: 0.2439 - val_accuracy: 0.9000
Epoch 18/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1861 -
accuracy: 0.9277 - val_loss: 0.2600 - val_accuracy: 0.9000
Epoch 19/100
10/10 [==============================] - 0s 6ms/step - loss: 0.2054 -
accuracy: 0.9214 - val_loss: 0.2612 - val_accuracy: 0.9000
Epoch 20/100
10/10 [==============================] - 0s 7ms/step - loss: 0.2015 -
accuracy: 0.9151 - val_loss: 0.2528 - val_accuracy: 0.9000
Epoch 21/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1938 -
accuracy: 0.9245 - val_loss: 0.2421 - val_accuracy: 0.9125
Epoch 22/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1872 -
accuracy: 0.9245 - val_loss: 0.2625 - val_accuracy: 0.8875
Epoch 23/100
10/10 [==============================] - 0s 9ms/step - loss: 0.2103 -
accuracy: 0.9277 - val_loss: 0.2730 - val_accuracy: 0.8875
Epoch 24/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1901 -
accuracy: 0.9214 - val_loss: 0.2851 - val_accuracy: 0.9000
Epoch 25/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1981 -
accuracy: 0.9308 - val_loss: 0.2333 - val_accuracy: 0.9125
Epoch 26/100
10/10 [==============================] - 0s 9ms/step - loss: 0.1844 -
accuracy: 0.9182 - val_loss: 0.2562 - val_accuracy: 0.9125
Epoch 27/100
10/10 [==============================] - 0s 6ms/step - loss: 0.2202 -
accuracy: 0.9088 - val_loss: 0.2779 - val_accuracy: 0.9000
Epoch 28/100
10/10 [==============================] - 0s 9ms/step - loss: 0.1824 -
accuracy: 0.9151 - val_loss: 0.2384 - val_accuracy: 0.9125
Epoch 29/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1736 -
accuracy: 0.9214 - val_loss: 0.2309 - val_accuracy: 0.9125
Epoch 30/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1803 -
accuracy: 0.9088 - val_loss: 0.2359 - val_accuracy: 0.9250
Epoch 31/100
```

```
10/10 [==============================] - 0s 6ms/step - loss: 0.1978 -
accuracy: 0.9214 - val_loss: 0.2946 - val_accuracy: 0.9000
Epoch 32/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1847 -
accuracy: 0.9277 - val_loss: 0.2586 - val_accuracy: 0.9000
Epoch 33/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1676 -
accuracy: 0.9308 - val_loss: 0.2447 - val_accuracy: 0.9000
Epoch 34/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1701 -
accuracy: 0.9340 - val_loss: 0.2366 - val_accuracy: 0.9125
Epoch 35/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1739 -
accuracy: 0.9308 - val_loss: 0.2331 - val_accuracy: 0.9125
Epoch 36/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1980 -
accuracy: 0.9308 - val_loss: 0.2992 - val_accuracy: 0.9000
Epoch 37/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1767 -
accuracy: 0.9277 - val_loss: 0.2483 - val_accuracy: 0.9125
Epoch 38/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1772 -
accuracy: 0.9182 - val_loss: 0.2599 - val_accuracy: 0.9000
Epoch 39/100
10/10 [==============================] - 0s 9ms/step - loss: 0.1794 -
accuracy: 0.9245 - val_loss: 0.2249 - val_accuracy: 0.9125
Epoch 40/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1661 -
accuracy: 0.9277 - val_loss: 0.2732 - val_accuracy: 0.9125
Epoch 41/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1786 -
accuracy: 0.9245 - val_loss: 0.2639 - val_accuracy: 0.9000
Epoch 42/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1575 -
accuracy: 0.9403 - val_loss: 0.2314 - val_accuracy: 0.9250
Epoch 43/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1796 -
accuracy: 0.9340 - val_loss: 0.2753 - val_accuracy: 0.9125
Epoch 44/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1741 -
accuracy: 0.9308 - val_loss: 0.2906 - val_accuracy: 0.9000
Epoch 45/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1628 -
accuracy: 0.9371 - val_loss: 0.2329 - val_accuracy: 0.9125
Epoch 46/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1711 -
accuracy: 0.9245 - val_loss: 0.2806 - val_accuracy: 0.8750
Epoch 47/100
10/10 [==============================] - 0s 11ms/step - loss: 0.1695 -
accuracy: 0.9403 - val_loss: 0.2185 - val_accuracy: 0.9250
```

```
Epoch 48/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1612 -
accuracy: 0.9277 - val_loss: 0.3169 - val_accuracy: 0.9000
Epoch 49/100
10/10 [==============================] - 0s 6ms/step - loss: 0.2511 -
accuracy: 0.8899 - val_loss: 0.2568 - val_accuracy: 0.9125
Epoch 50/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1968 -
accuracy: 0.9277 - val_loss: 0.3008 - val_accuracy: 0.8750
Epoch 51/100
10/10 [==============================] - 0s 8ms/step - loss: 0.2187 -
accuracy: 0.9182 - val_loss: 0.2447 - val_accuracy: 0.9250
Epoch 52/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1763 -
accuracy: 0.9151 - val_loss: 0.2926 - val_accuracy: 0.9000
Epoch 53/100
10/10 [==============================] - 0s 13ms/step - loss: 0.1916 -
accuracy: 0.9182 - val_loss: 0.2247 - val_accuracy: 0.9250
Epoch 54/100
10/10 [==============================] - 0s 13ms/step - loss: 0.1668 -
accuracy: 0.9308 - val_loss: 0.2506 - val_accuracy: 0.9250
Epoch 55/100
10/10 [==============================] - 0s 12ms/step - loss: 0.1569 -
accuracy: 0.9308 - val_loss: 0.2190 - val_accuracy: 0.9250
Epoch 56/100
10/10 [==============================] - 0s 14ms/step - loss: 0.1788 -
accuracy: 0.9214 - val_loss: 0.2405 - val_accuracy: 0.9125
Epoch 57/100
10/10 [==============================] - 0s 13ms/step - loss: 0.1706 -
accuracy: 0.9214 - val_loss: 0.2262 - val_accuracy: 0.9125
Epoch 58/100
10/10 [==============================] - 0s 13ms/step - loss: 0.1631 -
accuracy: 0.9340 - val_loss: 0.2168 - val_accuracy: 0.9125
Epoch 59/100
10/10 [==============================] - 0s 9ms/step - loss: 0.1537 -
accuracy: 0.9403 - val_loss: 0.2239 - val_accuracy: 0.9125
Epoch 60/100
10/10 [==============================] - 0s 12ms/step - loss: 0.1602 -
accuracy: 0.9340 - val_loss: 0.2174 - val_accuracy: 0.9250
Epoch 61/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1661 -
accuracy: 0.9277 - val_loss: 0.2148 - val_accuracy: 0.9125
Epoch 62/100
10/10 [==============================] - 0s 11ms/step - loss: 0.1551 -
accuracy: 0.9371 - val_loss: 0.2261 - val_accuracy: 0.9125
Epoch 63/100
10/10 [==============================] - 0s 12ms/step - loss: 0.1737 -
accuracy: 0.9277 - val_loss: 0.2525 - val_accuracy: 0.9125
Epoch 64/100
10/10 [==============================] - 0s 11ms/step - loss: 0.1621 -
```

```
accuracy: 0.9497 - val_loss: 0.2904 - val_accuracy: 0.9000
Epoch 65/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1691 -
accuracy: 0.9277 - val_loss: 0.2804 - val_accuracy: 0.9125
Epoch 66/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1613 -
accuracy: 0.9308 - val_loss: 0.2254 - val_accuracy: 0.9125
Epoch 67/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1468 -
accuracy: 0.9403 - val_loss: 0.2342 - val_accuracy: 0.9125
Epoch 68/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1526 -
accuracy: 0.9277 - val_loss: 0.2239 - val_accuracy: 0.9250
Epoch 69/100
10/10 [==============================] - 0s 12ms/step - loss: 0.1662 -
accuracy: 0.9182 - val_loss: 0.3314 - val_accuracy: 0.8875
Epoch 70/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1732 -
accuracy: 0.9214 - val_loss: 0.2448 - val_accuracy: 0.9250
Epoch 71/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1457 -
accuracy: 0.9371 - val_loss: 0.2099 - val_accuracy: 0.9125
Epoch 72/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1625 -
accuracy: 0.9245 - val_loss: 0.2765 - val_accuracy: 0.8875
Epoch 73/100
10/10 [==============================] - 0s 10ms/step - loss: 0.2111 -
accuracy: 0.9057 - val_loss: 0.2489 - val_accuracy: 0.9000
Epoch 74/100
10/10 [==============================] - 0s 14ms/step - loss: 0.1839 -
accuracy: 0.9151 - val_loss: 0.3529 - val_accuracy: 0.8875
Epoch 75/100
10/10 [==============================] - 0s 9ms/step - loss: 0.1941 -
accuracy: 0.9214 - val_loss: 0.2996 - val_accuracy: 0.9000
Epoch 76/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1891 -
accuracy: 0.9151 - val_loss: 0.2440 - val_accuracy: 0.9250
Epoch 77/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1749 -
accuracy: 0.9182 - val_loss: 0.2427 - val_accuracy: 0.9250
Epoch 78/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1575 -
accuracy: 0.9371 - val_loss: 0.2125 - val_accuracy: 0.9250
Epoch 79/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1531 -
accuracy: 0.9277 - val_loss: 0.2401 - val_accuracy: 0.9125
Epoch 80/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1536 -
accuracy: 0.9371 - val_loss: 0.2027 - val_accuracy: 0.9125
Epoch 81/100
```

```
10/10 [==============================] - 0s 9ms/step - loss: 0.1729 -
accuracy: 0.9403 - val_loss: 0.2937 - val_accuracy: 0.9125
Epoch 82/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1659 -
accuracy: 0.9308 - val_loss: 0.2952 - val_accuracy: 0.9125
Epoch 83/100
10/10 [==============================] - 0s 8ms/step - loss: 0.2214 -
accuracy: 0.9119 - val_loss: 0.2537 - val_accuracy: 0.9000
Epoch 84/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1689 -
accuracy: 0.9403 - val_loss: 0.2326 - val_accuracy: 0.9125
Epoch 85/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1501 -
accuracy: 0.9371 - val_loss: 0.2721 - val_accuracy: 0.9125
Epoch 86/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1558 -
accuracy: 0.9403 - val_loss: 0.2197 - val_accuracy: 0.9250
Epoch 87/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1558 -
accuracy: 0.9308 - val_loss: 0.2150 - val_accuracy: 0.9125
Epoch 88/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1628 -
accuracy: 0.9371 - val_loss: 0.2526 - val_accuracy: 0.9000
Epoch 89/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1580 -
accuracy: 0.9277 - val_loss: 0.1919 - val_accuracy: 0.9250
Epoch 90/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1422 -
accuracy: 0.9371 - val_loss: 0.1974 - val_accuracy: 0.9125
Epoch 91/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1370 -
accuracy: 0.9434 - val_loss: 0.3343 - val_accuracy: 0.9000
Epoch 92/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1806 -
accuracy: 0.9308 - val_loss: 0.2495 - val_accuracy: 0.9250
Epoch 93/100
10/10 [==============================] - 0s 7ms/step - loss: 0.2107 -
accuracy: 0.9057 - val_loss: 0.2719 - val_accuracy: 0.9250
Epoch 94/100
10/10 [==============================] - 0s 7ms/step - loss: 0.1748 -
accuracy: 0.9245 - val_loss: 0.2692 - val_accuracy: 0.8875
Epoch 95/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1925 -
accuracy: 0.9340 - val_loss: 0.2613 - val_accuracy: 0.9125
Epoch 96/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1653 -
accuracy: 0.9340 - val_loss: 0.2647 - val_accuracy: 0.9125
Epoch 97/100
10/10 [==============================] - 0s 6ms/step - loss: 0.1504 -
accuracy: 0.9371 - val_loss: 0.2308 - val_accuracy: 0.9250
```

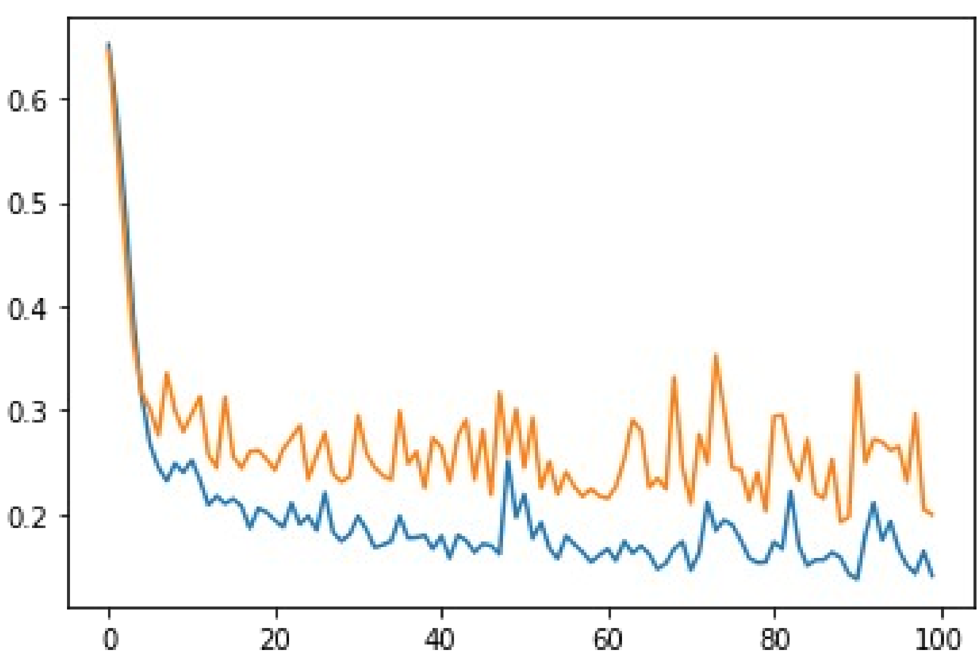
```
Epoch 98/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1424 -
accuracy: 0.9371 - val_loss: 0.2967 - val_accuracy: 0.9000
Epoch 99/100
10/10 [==============================] - 0s 10ms/step - loss: 0.1638 -
accuracy: 0.9277 - val_loss: 0.2045 - val_accuracy: 0.9250
Epoch 100/100
10/10 [==============================] - 0s 8ms/step - loss: 0.1405 -
accuracy: 0.9403 - val_loss: 0.1992 - val_accuracy: 0.9250
```

```
pred_train= model.predict(X_train)
scores = model.evaluate(X_train, y_train, verbose=0)
print('Accuracy on training data: {}% \n Error on training data:
{}'.format(scores[1], 1 - scores[1]))

pred_test= model.predict(X_test)
scores2 = model.evaluate(X_test, y_test, verbose=0)
print('Accuracy on test data: {}% \n Error on test data:
{}'.format(scores2[1], 1 - scores2[1]))
```

```
13/13 [==============================] - 0s 2ms/step
Accuracy on training data: 0.9396985173225403%
 Error on training data: 0.06030148267745972
6/6 [==============================] - 0s 2ms/step
Accuracy on test data: 0.9181286692619324%
 Error on test data: 0.08187133073806763
```

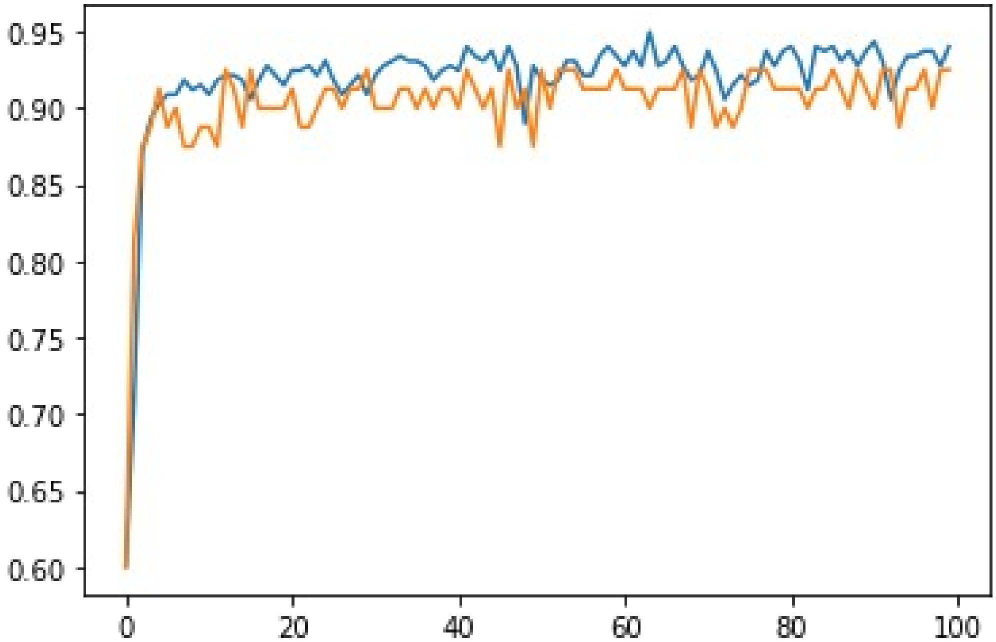
```
plt.plot(md.history['loss'])
plt.plot(md.history['val_loss'])
```

```
[<matplotlib.lines.Line2D at 0x7fdbf526ab50>]
```



```
plt.plot(md.history['accuracy'])
plt.plot(md.history['val_accuracy'])
```

```
[<matplotlib.lines.Line2D at 0x7fdbf5407d60>]
```



Question 3

Bank Dataset

```
df3 = pd.read_csv('sample_data/bank-full.csv', delimiter=';')
print(df3.shape)
df3.head()
```

```
(45211, 17)
```

```
   age           job  marital  education default  balance housing loan  
\
0   58    management  married   tertiary      no     2143     yes   no   

1   44    technician   single  secondary      no       29     yes   no   

2   33  entrepreneur  married  secondary      no        2     yes  yes   

3   47   blue-collar  married    unknown      no     1506     yes   no   

4   33       unknown   single    unknown      no        1      no   no   


   contact  day month  duration  campaign  pdays  previous poutcome
```

```
y
0  unknown    5   may       261          1     -1          0  unknown
no
1  unknown    5   may       151          1     -1          0  unknown
no
2  unknown    5   may        76          1     -1          0  unknown
no
3  unknown    5   may        92          1     -1          0  unknown
no
4  unknown    5   may       198          1     -1          0  unknown
no
```

```
df3.housing.replace(('yes', 'no'), (1, 0), inplace=True)
df3.default.replace(('yes', 'no'), (1, 0), inplace=True)
df3.loan.replace(('yes', 'no'), (1, 0), inplace=True)
df3.y.replace(('yes', 'no'), (1, 0), inplace=True)
df3.contact.replace(('unknown', 'telephone', 'cellular'), (0, 1, 2),
inplace=True)
df3.marital.replace(('married', 'divorced', 'single'), (0, 1, 2),
inplace=True)
df3.education.replace(('unknown', 'primary', 'secondary', 'tertiary'),
(0, 1, 2, 3), inplace=True)
df3.poutcome.replace(('unknown', 'other', 'failure', 'success'), (0,
1, 2, 3, ), inplace=True)
df3.month.replace(('jan', 'feb', 'mar', 'apr', 'may', 'jun', 'jul',
'aug', 'sep', 'oct', 'nov', 'dec'), (1,2,3,4,5,6,7,8,9,10,11,12),
inplace=True)
df3.job.replace(("admin.","unknown","unemployed","management","housema
id","entrepreneur","student", "blue-collar","self-
employed","retired","technician","services"),
(1,2,3,4,5,6,7,8,9,10,11,12), inplace=True)
df3.head()
```

```
   age  job  marital  education  default  balance  housing  loan
contact  \
0   58    4        0          3        0     2143        1     0
0
1   44   11        2          2        0       29        1     0
0
2   33    6        0          2        0        2        1     1
0
3   47    8        0          0        0     1506        1     0
0
4   33    2        2          0        0        1        0     0
0

   day  month  duration  campaign  pdays  previous  poutcome  y
0    5      5       261         1     -1         0         0  0
1    5      5       151         1     -1         0         0  0
2    5      5        76         1     -1         0         0  0
```

```
3    5      5        92          1     -1          0          0  0
4    5      5       198          1     -1          0          0  0
```

```
target_column = ['y']
predictors = list(set(list(df3.columns))-set(target_column))
df3.describe()
```

```
                age           job       marital     education  
default  \
count  45211.000000  45211.000000  45211.000000  45211.000000  
45211.000000   
mean      40.936210      7.018159      0.680963      2.060516  
0.018027   
std       10.618762      3.543218      0.884908      0.778704  
0.133049   
min       18.000000      1.000000      0.000000      0.000000  
0.000000   
25%       33.000000      4.000000      0.000000      2.000000  
0.000000   
50%       39.000000      8.000000      0.000000      2.000000  
0.000000   
75%       48.000000     11.000000      2.000000      3.000000  
0.000000   
max       95.000000     12.000000      2.000000      3.000000  
1.000000   

             balance       housing          loan       contact  
day  \
count   45211.000000  45211.000000  45211.000000  45211.000000  
45211.000000   
mean     1362.272058      0.555838      0.160226      1.359758  
15.806419   
std      3044.765829      0.496878      0.366820      0.897951  
8.322476   
min     -8019.000000      0.000000      0.000000      0.000000  
1.000000   
25%        72.000000      0.000000      0.000000      0.000000  
8.000000   
50%       448.000000      1.000000      0.000000      2.000000  
16.000000   
75%      1428.000000      1.000000      0.000000      2.000000  
21.000000   
max    102127.000000      1.000000      1.000000      2.000000  
31.000000   

              month      duration      campaign         pdays  
previous  \
count  45211.000000  45211.000000  45211.000000  45211.000000  
45211.000000   
mean       6.144655    258.163080      2.763841     40.197828  
```

```
0.580323
std        2.408034    257.527812      3.098021    100.128746
2.303441
min        1.000000      0.000000      1.000000     -1.000000
0.000000
25%        5.000000    103.000000      1.000000     -1.000000
0.000000
50%        6.000000    180.000000      2.000000     -1.000000
0.000000
75%        8.000000    319.000000      3.000000     -1.000000
0.000000
max       12.000000   4918.000000     63.000000    871.000000
275.000000

           poutcome             y
count  45211.000000  45211.000000
mean       0.357767      0.116985
std        0.804435      0.321406
min        0.000000      0.000000
25%        0.000000      0.000000
50%        0.000000      0.000000
75%        0.000000      0.000000
max        3.000000      1.000000
```

```
X = df3[predictors].values
y = df3[target_column].values
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.30, random_state=40)
print(X_train.shape);print(X_test.shape)
```

```
(31647, 16)
(13564, 16)
```

```
model = Sequential()
model.add(Dense(16, activation='sigmoid', input_dim=16))
model.add(Dense(32, activation='sigmoid'))
model.add(Dense(1, activation='sigmoid'))
model.summary()
```

```
Model: "sequential_6"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_20 (Dense)            (None, 16)                272

 dense_21 (Dense)            (None, 32)                544

 dense_22 (Dense)            (None, 1)                 33

=================================================================
Total params: 849
```

```
Trainable params: 849
Non-trainable params: 0
_________________________________________________________________
```

```
# Compile the model
model.compile(optimizer='adam',loss='binary_crossentropy',metrics=['ac
curacy'])

md = model.fit(X_train,y_train,epochs=100,validation_split=0.2)
```

```
Epoch 1/100
792/792 [==============================] - 2s 2ms/step - loss: 0.3553
- accuracy: 0.8840 - val_loss: 0.3336 - val_accuracy: 0.8809
Epoch 2/100
792/792 [==============================] - 2s 2ms/step - loss: 0.3098
- accuracy: 0.8840 - val_loss: 0.3019 - val_accuracy: 0.8809
Epoch 3/100
792/792 [==============================] - 2s 2ms/step - loss: 0.3024
- accuracy: 0.8838 - val_loss: 0.2994 - val_accuracy: 0.8809
Epoch 4/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2978
- accuracy: 0.8841 - val_loss: 0.3013 - val_accuracy: 0.8817
Epoch 5/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2939
- accuracy: 0.8834 - val_loss: 0.2960 - val_accuracy: 0.8809
Epoch 6/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2927
- accuracy: 0.8842 - val_loss: 0.2929 - val_accuracy: 0.8826
Epoch 7/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2902
- accuracy: 0.8828 - val_loss: 0.2948 - val_accuracy: 0.8821
Epoch 8/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2858
- accuracy: 0.8847 - val_loss: 0.2886 - val_accuracy: 0.8826
Epoch 9/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2849
- accuracy: 0.8843 - val_loss: 0.2864 - val_accuracy: 0.8828
Epoch 10/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2845
- accuracy: 0.8846 - val_loss: 0.2847 - val_accuracy: 0.8831
Epoch 11/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2845
- accuracy: 0.8858 - val_loss: 0.2859 - val_accuracy: 0.8853
Epoch 12/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2837
- accuracy: 0.8863 - val_loss: 0.2841 - val_accuracy: 0.8859
Epoch 13/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2834
- accuracy: 0.8882 - val_loss: 0.2837 - val_accuracy: 0.8858
Epoch 14/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2804
```

```
- accuracy: 0.8864 - val_loss: 0.2840 - val_accuracy: 0.8867
Epoch 15/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2793
- accuracy: 0.8881 - val_loss: 0.2804 - val_accuracy: 0.8859
Epoch 16/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2777
- accuracy: 0.8888 - val_loss: 0.2820 - val_accuracy: 0.8847
Epoch 17/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2780
- accuracy: 0.8886 - val_loss: 0.2793 - val_accuracy: 0.8845
Epoch 18/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2839
- accuracy: 0.8875 - val_loss: 0.2794 - val_accuracy: 0.8836
Epoch 19/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2739
- accuracy: 0.8873 - val_loss: 0.2778 - val_accuracy: 0.8820
Epoch 20/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2753
- accuracy: 0.8880 - val_loss: 0.2762 - val_accuracy: 0.8870
Epoch 21/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2738
- accuracy: 0.8884 - val_loss: 0.2751 - val_accuracy: 0.8900
Epoch 22/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2727
- accuracy: 0.8884 - val_loss: 0.2741 - val_accuracy: 0.8883
Epoch 23/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2733
- accuracy: 0.8888 - val_loss: 0.2725 - val_accuracy: 0.8874
Epoch 24/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2757
- accuracy: 0.8868 - val_loss: 0.2758 - val_accuracy: 0.8833
Epoch 25/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2760
- accuracy: 0.8871 - val_loss: 0.2721 - val_accuracy: 0.8850
Epoch 26/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2773
- accuracy: 0.8860 - val_loss: 0.2796 - val_accuracy: 0.8866
Epoch 27/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2763
- accuracy: 0.8876 - val_loss: 0.2774 - val_accuracy: 0.8806
Epoch 28/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2734
- accuracy: 0.8879 - val_loss: 0.2716 - val_accuracy: 0.8889
Epoch 29/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2729
- accuracy: 0.8869 - val_loss: 0.2711 - val_accuracy: 0.8807
Epoch 30/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2708
- accuracy: 0.8866 - val_loss: 0.2761 - val_accuracy: 0.8821
Epoch 31/100
```

```
792/792 [==============================] - 2s 2ms/step - loss: 0.2728
- accuracy: 0.8877 - val_loss: 0.2706 - val_accuracy: 0.8902
Epoch 32/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2719
- accuracy: 0.8890 - val_loss: 0.2723 - val_accuracy: 0.8874
Epoch 33/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2761
- accuracy: 0.8884 - val_loss: 0.2739 - val_accuracy: 0.8886
Epoch 34/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2721
- accuracy: 0.8888 - val_loss: 0.2681 - val_accuracy: 0.8874
Epoch 35/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2697
- accuracy: 0.8888 - val_loss: 0.2672 - val_accuracy: 0.8874
Epoch 36/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2710
- accuracy: 0.8878 - val_loss: 0.2711 - val_accuracy: 0.8902
Epoch 37/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2702
- accuracy: 0.8886 - val_loss: 0.2709 - val_accuracy: 0.8894
Epoch 38/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2695
- accuracy: 0.8891 - val_loss: 0.2722 - val_accuracy: 0.8888
Epoch 39/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2697
- accuracy: 0.8915 - val_loss: 0.2741 - val_accuracy: 0.8837
Epoch 40/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2717
- accuracy: 0.8892 - val_loss: 0.2720 - val_accuracy: 0.8885
Epoch 41/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2710
- accuracy: 0.8890 - val_loss: 0.2672 - val_accuracy: 0.8886
Epoch 42/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2685
- accuracy: 0.8903 - val_loss: 0.2698 - val_accuracy: 0.8880
Epoch 43/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2703
- accuracy: 0.8901 - val_loss: 0.2666 - val_accuracy: 0.8863
Epoch 44/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2686
- accuracy: 0.8892 - val_loss: 0.2656 - val_accuracy: 0.8875
Epoch 45/100
792/792 [==============================] - 3s 4ms/step - loss: 0.2690
- accuracy: 0.8881 - val_loss: 0.2682 - val_accuracy: 0.8891
Epoch 46/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2705
- accuracy: 0.8892 - val_loss: 0.2764 - val_accuracy: 0.8858
Epoch 47/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2735
- accuracy: 0.8880 - val_loss: 0.2735 - val_accuracy: 0.8848
```

```
Epoch 48/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2695
- accuracy: 0.8892 - val_loss: 0.2685 - val_accuracy: 0.8837
Epoch 49/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2681
- accuracy: 0.8884 - val_loss: 0.2704 - val_accuracy: 0.8894
Epoch 50/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2682
- accuracy: 0.8886 - val_loss: 0.2703 - val_accuracy: 0.8885
Epoch 51/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2703
- accuracy: 0.8887 - val_loss: 0.2702 - val_accuracy: 0.8878
Epoch 52/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2685
- accuracy: 0.8876 - val_loss: 0.2699 - val_accuracy: 0.8866
Epoch 53/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2696
- accuracy: 0.8875 - val_loss: 0.2664 - val_accuracy: 0.8882
Epoch 54/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2670
- accuracy: 0.8888 - val_loss: 0.2695 - val_accuracy: 0.8897
Epoch 55/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2686
- accuracy: 0.8893 - val_loss: 0.2728 - val_accuracy: 0.8888
Epoch 56/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2684
- accuracy: 0.8901 - val_loss: 0.2712 - val_accuracy: 0.8847
Epoch 57/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2662
- accuracy: 0.8899 - val_loss: 0.2707 - val_accuracy: 0.8893
Epoch 58/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2677
- accuracy: 0.8898 - val_loss: 0.2632 - val_accuracy: 0.8837
Epoch 59/100
792/792 [==============================] - 2s 3ms/step - loss: 0.2653
- accuracy: 0.8910 - val_loss: 0.2729 - val_accuracy: 0.8888
Epoch 60/100
792/792 [==============================] - 2s 3ms/step - loss: 0.2660
- accuracy: 0.8900 - val_loss: 0.2688 - val_accuracy: 0.8809
Epoch 61/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2670
- accuracy: 0.8900 - val_loss: 0.2688 - val_accuracy: 0.8929
Epoch 62/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2652
- accuracy: 0.8899 - val_loss: 0.2662 - val_accuracy: 0.8918
Epoch 63/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2646
- accuracy: 0.8915 - val_loss: 0.2638 - val_accuracy: 0.8926
Epoch 64/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2650
```

```
- accuracy: 0.8907 - val_loss: 0.2720 - val_accuracy: 0.8856
Epoch 65/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2663
- accuracy: 0.8906 - val_loss: 0.2686 - val_accuracy: 0.8855
Epoch 66/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2654
- accuracy: 0.8916 - val_loss: 0.2661 - val_accuracy: 0.8866
Epoch 67/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2654
- accuracy: 0.8854 - val_loss: 0.2651 - val_accuracy: 0.8874
Epoch 68/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2654
- accuracy: 0.8907 - val_loss: 0.2652 - val_accuracy: 0.8888
Epoch 69/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2642
- accuracy: 0.8903 - val_loss: 0.2811 - val_accuracy: 0.8874
Epoch 70/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2675
- accuracy: 0.8887 - val_loss: 0.2598 - val_accuracy: 0.8893
Epoch 71/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2606
- accuracy: 0.8901 - val_loss: 0.2601 - val_accuracy: 0.8869
Epoch 72/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2647
- accuracy: 0.8889 - val_loss: 0.2604 - val_accuracy: 0.8889
Epoch 73/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2627
- accuracy: 0.8885 - val_loss: 0.2643 - val_accuracy: 0.8878
Epoch 74/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2645
- accuracy: 0.8885 - val_loss: 0.2659 - val_accuracy: 0.8866
Epoch 75/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2627
- accuracy: 0.8880 - val_loss: 0.2636 - val_accuracy: 0.8853
Epoch 76/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2633
- accuracy: 0.8884 - val_loss: 0.2582 - val_accuracy: 0.8902
Epoch 77/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2593
- accuracy: 0.8906 - val_loss: 0.2711 - val_accuracy: 0.8874
Epoch 78/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2607
- accuracy: 0.8920 - val_loss: 0.2572 - val_accuracy: 0.8893
Epoch 79/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2659
- accuracy: 0.8889 - val_loss: 0.2624 - val_accuracy: 0.8897
Epoch 80/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2624
- accuracy: 0.8886 - val_loss: 0.2683 - val_accuracy: 0.8883
Epoch 81/100
```

```
792/792 [==============================] - 2s 2ms/step - loss: 0.2633
- accuracy: 0.8896 - val_loss: 0.2603 - val_accuracy: 0.8864
Epoch 82/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2598
- accuracy: 0.8905 - val_loss: 0.2692 - val_accuracy: 0.8834
Epoch 83/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2614
- accuracy: 0.8888 - val_loss: 0.2599 - val_accuracy: 0.8883
Epoch 84/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2628
- accuracy: 0.8875 - val_loss: 0.2600 - val_accuracy: 0.8855
Epoch 85/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2604
- accuracy: 0.8900 - val_loss: 0.2689 - val_accuracy: 0.8872
Epoch 86/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2607
- accuracy: 0.8883 - val_loss: 0.2566 - val_accuracy: 0.8875
Epoch 87/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2573
- accuracy: 0.8895 - val_loss: 0.2546 - val_accuracy: 0.8915
Epoch 88/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2582
- accuracy: 0.8907 - val_loss: 0.2643 - val_accuracy: 0.8880
Epoch 89/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2580
- accuracy: 0.8915 - val_loss: 0.2583 - val_accuracy: 0.8907
Epoch 90/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2593
- accuracy: 0.8900 - val_loss: 0.2580 - val_accuracy: 0.8863
Epoch 91/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2594
- accuracy: 0.8899 - val_loss: 0.2578 - val_accuracy: 0.8894
Epoch 92/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2605
- accuracy: 0.8902 - val_loss: 0.2585 - val_accuracy: 0.8897
Epoch 93/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2609
- accuracy: 0.8909 - val_loss: 0.2581 - val_accuracy: 0.8924
Epoch 94/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2598
- accuracy: 0.8900 - val_loss: 0.2576 - val_accuracy: 0.8904
Epoch 95/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2590
- accuracy: 0.8920 - val_loss: 0.2593 - val_accuracy: 0.8878
Epoch 96/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2576
- accuracy: 0.8895 - val_loss: 0.2563 - val_accuracy: 0.8840
Epoch 97/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2564
- accuracy: 0.8892 - val_loss: 0.2558 - val_accuracy: 0.8888
```

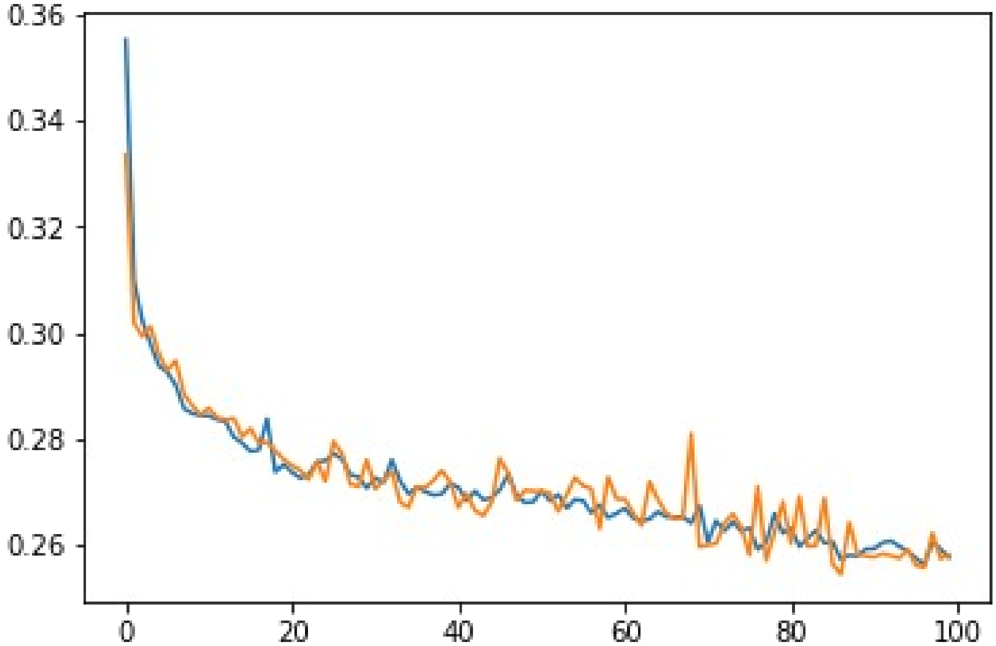
```
Epoch 98/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2607
- accuracy: 0.8905 - val_loss: 0.2623 - val_accuracy: 0.8924
Epoch 99/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2593
- accuracy: 0.8918 - val_loss: 0.2575 - val_accuracy: 0.8889
Epoch 100/100
792/792 [==============================] - 2s 2ms/step - loss: 0.2577
- accuracy: 0.8896 - val_loss: 0.2583 - val_accuracy: 0.8855
```

```
pred_train= model.predict(X_train)
scores = model.evaluate(X_train, y_train, verbose=0)
print('Accuracy on training data: {}% \n Error on training data:
{}'.format(scores[1], 1 - scores[1]))

pred_test= model.predict(X_test)
scores2 = model.evaluate(X_test, y_test, verbose=0)
print('Accuracy on test data: {}% \n Error on test data:
{}'.format(scores2[1], 1 - scores2[1]))
```

```
989/989 [==============================] - 3s 3ms/step
Accuracy on training data: 0.8889310359954834%
 Error on training data: 0.1110689640045166
424/424 [==============================] - 1s 3ms/step
Accuracy on test data: 0.8850634098052979%
 Error on test data: 0.11493659019470215
```

```
plt.plot(md.history['loss'])
plt.plot(md.history['val_loss'])
```

```
[<matplotlib.lines.Line2D at 0x7fdbee8edc70>]
```




```
plt.plot(md.history['accuracy'])
plt.plot(md.history['val_accuracy'])
```

```
[<matplotlib.lines.Line2D at 0x7fdbef849730>]
```