```
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Group B: Machine Learning

Assignment B3

Given a bank customer, build a neural network-based classifier that can determine whether they will leave or not in the next 6 months.

Dataset Description: The case study is from an open-source dataset from Kaggle. The dataset contains 10,000 sample points with 14 distinct features such as CustomerId, CreditScore, Geography, Gender, Age, Tenure, Balance, etc.

Link to the Kaggle project: https://www.kaggle.com/barelydedicated/bank-customer-churnmodeling (https://www.kaggle.com/barelydedicated/bank-customer-churn-modeling)

Perform following steps:

1. Read the dataset.
2. Distinguish the feature and target set and divide the data set into training and test sets.
3. Normalize the train and test data.
4. Initialize and build the model. Identify the points of improvement and implement the same.
5. Print the accuracy score and confusion matrix.

In [ ]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
```

In [ ]:

```
df = pd.read_csv('Churn_Modelling.csv')
```

In [ ]:

```
df.head()
```

Out[316]:

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Balance
0	1	15634602	Hargrave	619	France	Female	42	2	0.00
1	2	15647311	Hill	608	Spain	Female	41	1	83807.86
2	3	15619304	Onio	502	France	Female	42	8	159660.80
3	4	15701354	Boni	699	France	Female	39	1	0.00
4	5	15737888	Mitchell	850	Spain	Female	43	2	125510.82

```
df.shape
```

Out[317]:

```
(10000, 14)
```

In [ ]:

```
```

In [ ]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'> RangeIndex:
10000 entries, 0 to 9999
Data columns (total 14 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
  0      RowNumber       10000 non-null  int64
  1      CustomerId      10000 non-null  int64
  2      Surname         10000 non-null  object
  3      CreditScore     10000 non-null  int64
  4      Geography       10000 non-null  object
  5      Gender          10000 non-null  object
  6      Age             10000 non-null  int64
  7      Tenure          10000 non-null  int64
  8      Balance         10000 non-null  float64
  9      NumOfProducts   10000 non-null  int64
  10     HasCrCard       10000 non-null  int64
  11     IsActiveMember  10000 non-null  int64
  12     EstimatedSalary 10000 non-null  float64
  13     Exited          10000 non-null  int64   dtypes: float64(2), int64(9),
 object(3) memory usage: 1.1+ MB
```

In [ ]:

```
df['RowNumber'].value_counts()
```

Out[319]:

```
1        1 6671
1
6664     1
6665     1
6666     1
        ..
3334     1
3335     1
3336     1
3337     1
10000    1
Name: RowNumber, Length: 10000, dtype: int64
```

In [ ]:

```
df['RowNumber'].nunique()
```

Out[320]:

```
10000
```

In [ ]:

```
df['CustomerId'].nunique()
```

Out[321]:

```
10000
```

In [ ]:

```
df.drop(['RowNumber','CustomerId','Surname'],axis=1,inplace=True) df.shape
```

Out[323]:

```
(10000, 11)
```

In [
]:

```
```

In [ ]:

```
df.duplicated().sum()
```

Out[324]:

```
0
```

In [ ]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'> RangeIndex:
10000 entries, 0 to 9999
Data columns (total 11 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
  0     CreditScore      10000 non-null  int64
  1     Geography        10000 non-null  object
  2     Gender           10000 non-null  object
  3     Age              10000 non-null  int64
  4     Tenure           10000 non-null  int64
  5     Balance          10000 non-null  float64
  6     NumOfProducts    10000 non-null  int64
  7     HasCrCard        10000 non-null  int64
  8     IsActiveMember   10000 non-null  int64
  9     EstimatedSalary  10000 non-null  float64
  10    Exited           10000 non-null  int64   dtypes: float64(2), int64(7),
 object(2) memory usage: 859.5+ KB
```

In [ ]:

```
df['Gender'].value_counts()
```

Out[326]:

```
Male      5457 Female
4543
Name: Gender, dtype: int64
```

In [ ]:

```
grp = df.groupby('Gender')['Exited'].value_counts()
grp
```

Out[327]:

```
Gender  Exited
Female  0         3404
        1         1139
Male    0         4559
        1          898
Name: Exited, dtype: int64
```

In [ ]:

```
df['Geography'].value_counts()
```

Out[328]:

```
France     5014 Germany
2509
Spain      2477
Name: Geography, dtype: int64 df.groupby('Geography')['Exited'].value_counts()
```

Out[329]:

```
Geography  Exited
France     0         4204
           1          810
Germany    0         1695
```

In [ ]:

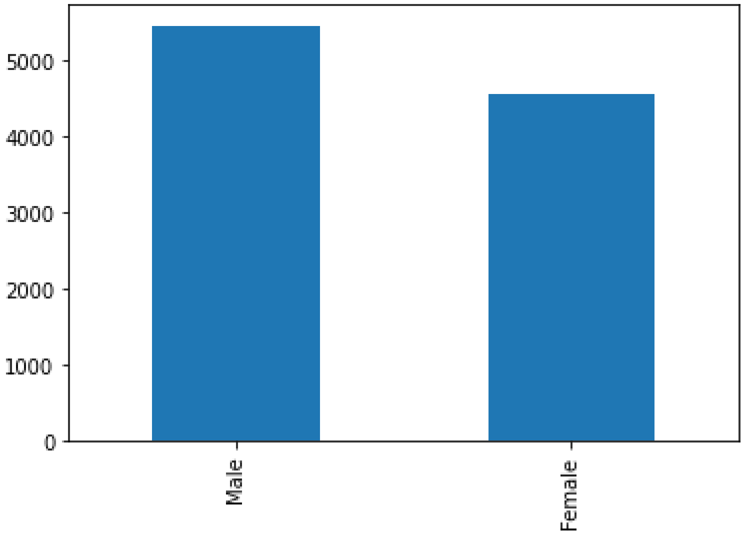
```
            1         814
Spain       0        2064
            1         413
Name: Exited, dtype: int64
```

In [ ]:

```
df['Gender'].value_counts().plot(kind='bar')
```

Out[330]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fd674b1d250>
```

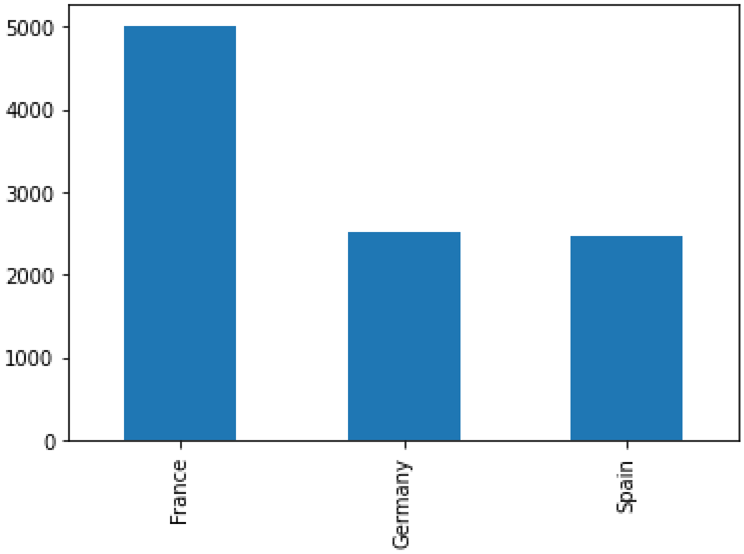


In [ ]:

```
df['Geography'].value_counts().plot(kind='bar')
```

Out[331]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fd674a33210>
```



```
import seaborn as sns
```

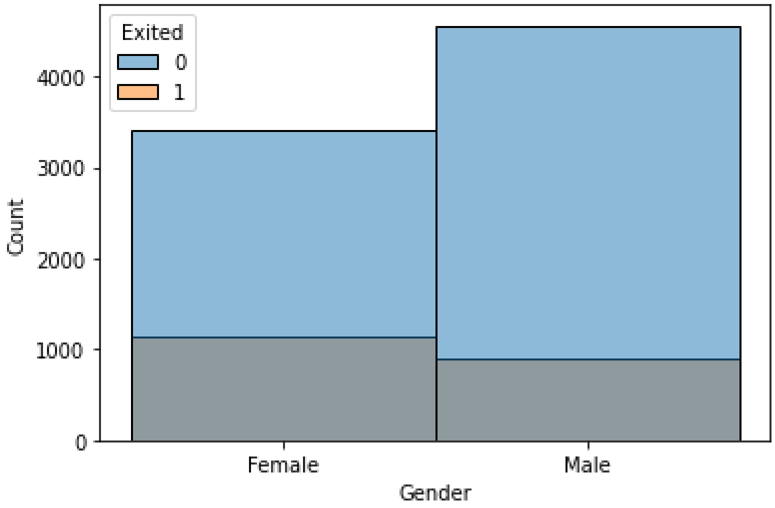
In [ ]:

```
sns.histplot(df,x='Gender',hue='Exited')
```

Out[333]:

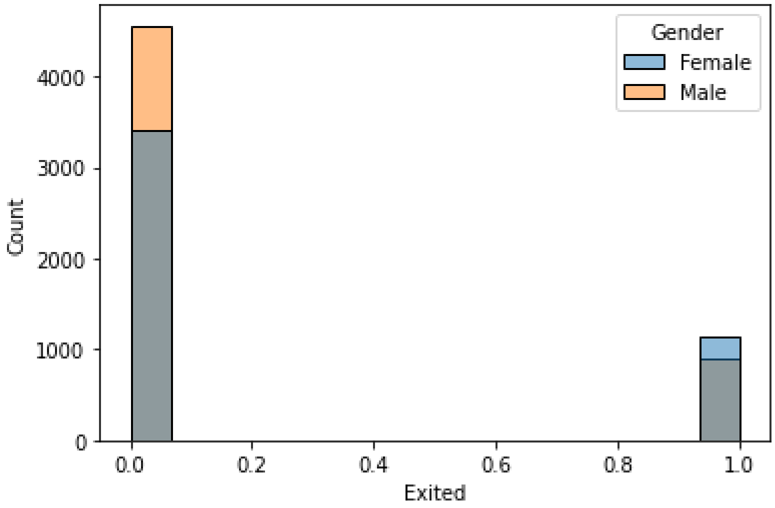
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fd6749f7350>
```

In [ ]:



In [ ]:
```
sns.histplot(df,x='Exited',hue='Gender')
```

Out[334]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fd6748fd7d0>
```



In [ ]:
```
df.Exited.value_counts()
```

Out[335]:
```
0    7963
1    2037
Name: Exited, dtype: int64
```

In [ ]:
```
df.to_csv('analytical_base_table.csv', index=None)
```

In [ ]:
```
df = pd.read_csv('analytical_base_table.csv')
```

In [ ]:

```
x = df.drop(['Exited'],axis=1)
x.shape
```

Out[338]:

```
(10000, 10)
```

Out[339]:

In [ ]:

```
x.head()
```

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActive
0	619	France	Female	42	2	0.00	1	1	
1	608	Spain	Female	41	1	83807.86	1	0	
2	502	France	Female	42	8	159660.80	3	1	
3	699	France	Female	39	1	0.00	2	0	
4	850	Spain	Female	43	2	125510.82	1	1	

In [ ]:

```
y = df['Exited']
y
```

Out[340]:

```
0       1
1       0
2       1
3       0
4       0
       ..
9995    0
9996    0
9997    1
9998    1
9999    0
Name: Exited, Length: 10000, dtype: int64
```

In [ ]:

```
from sklearn.model_selection import train_test_split
```

In [ ]:

```
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.25,random_state=
```

In [ ]:

```
x.shape
```

Out[343]:

```
(10000, 10)
```

In [ ]:

```
x_train.shape
```

Out[344]:

```
(7500, 10)
```

```
In [ ]: x_test.shape
        y_test.value_counts().plot(kind='bar')
```

```
In [ ]: y_train.shape
```

```
Out[345]: (7500,)
Out[346]: (2500, 10)
```

```
In [ ]: y_test.shape
```

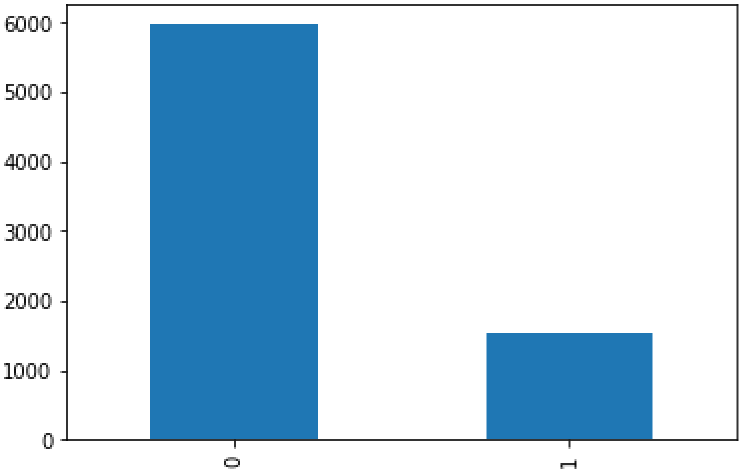
```
Out[347]: (2500,)
```

```
In [ ]: y_train.value_counts()
```

```
Out[348]: 0    5972 1
          1528
          Name: Exited, dtype: int64
```

```
In [ ]: y_train.value_counts().plot(kind='bar')
```

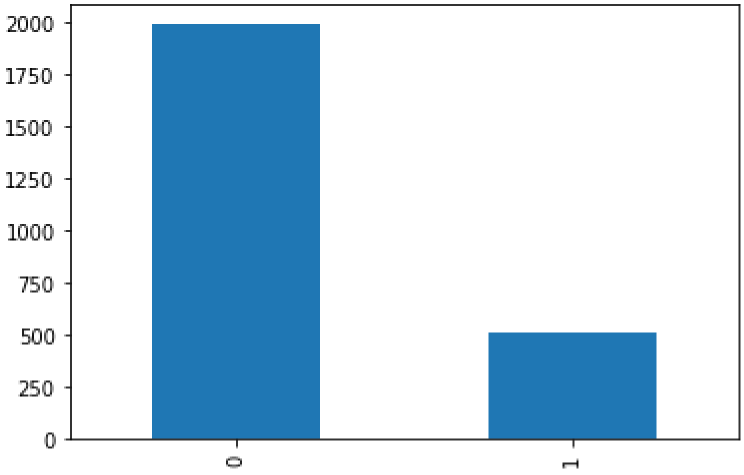
```
Out[349]: <matplotlib.axes._subplots.AxesSubplot at 0x7fd6767cf890>
```



```
In [ ]: y_test.value_counts()
```

```
Out[350]: 0    1991
          1     509
          Name: Exited, dtype: int64
Out[351]: <matplotlib.axes._subplots.AxesSubplot at 0x7fd674b07d90>
```

In [ ]:



In [ ]:

```
x_train.head()
```

Out[352]:

```
      CreditScore  Geography  Gender  Age  Tenure    Balance  NumOfProducts  HasCrCard  IsAc
1792          686      Spain    Male   41       7  102749.72              1          0
8733          749      Spain    Male   42       9  222267.63              1          0
4679          777      Spain  Female   35       3       0.00              2          1
 744          650     France    Male   60       8       0.00              2          1
7985          696    Germany  Female   27       2   96129.32              2          1
```

In [ ]:

```
```

NumOfProducts	HasCrCard	IsAc
1		
1		

```
x_train.reset_index(drop=True,inplace=True)
x_train
```

Out[353]:

	CreditScore	Geography	Gender	Age	Tenure	Balance			
0	686	Spain	Male	41	7	102749.72	0		
1	749	Spain	Male	42	9	222267.63	0		
2	777	Spain	Female	35	3	0.00	2	1	
3	650	France	Male	60	8	0.00	2	1	
4	696	Germany	Female	27	2	96129.32	2	1	
...	...	...	...	...	...	...	...	...	
7495	656	France	Female	46	5	113402.14	2	1	
7496	526	Spain	Male	49	2	0.00	1	1	
7497	780	Germany	Male	51	4	126725.25	1	1	
7498	850	Spain	Male	48	2	0.00	1	1	
7499	705	Germany	Female	46	4	115518.07	1	0	

7500 rows × 10 columns

In [ ]:

```
x_test.reset_index(drop=True,inplace=True)
x_test
```

Out[354]:

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsAc
0	706	France	Female	29	5	112564.62	1	1	
1	554	Germany	Female	31	6	135470.90	1	1	
2	704	Germany	Female	24	7	113034.22	1	1	
3	757	France	Female	71	0	88084.13	2	1	
4	651	France	Male	36	7	0.00	2	1	
...	...	...	...	...	...	...	...	...	

In [ ]:

```
from sklearn.preprocessing import OneHotEncoder
```

In [ ]:

2495	577	Spain	Male	43	8	79757.21	1	1	
2496	608	Germany	Male	26	1	106648.98	1	0	
2497	697	France	Female	25	1	0.00	2	0	
2498	634	France	Male	26	8	0.00	1	1	
2499	437	France	Female	39	0	102721.49	1	0	

2500 rows × 10 columns

```
ohe = OneHotEncoder(drop='first',sparse=False,handle_unknown='ignore')
```

In [ ]:
```
ohe.fit(x_train[['Gender','Geography']])
```

Out[357]:
```
OneHotEncoder(drop='first', handle_unknown='ignore', sparse=False)
```

In [ ]:
```
ohe.get_feature_names(['Gender','Geography'])
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/deprecation.py:87: FutureW
arning: Function get_feature_names is deprecated; get_feature_names is deprecat
ed in 1.0 and will be removed in 1.2. Please use get_feature_names_out instead.
warnings.warn(msg, category=FutureWarning)
```

Out[358]:
```
array(['Gender_Male', 'Geography_Germany', 'Geography_Spain'],
      dtype=object)
```

In [ ]:
```
x_train_encoded = pd.DataFrame(ohe.transform(x_train[['Gender','Geography']]),col
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/deprecation.py:87: FutureW
arning: Function get_feature_names is deprecated; get_feature_names is deprecat
ed in 1.0 and will be removed in 1.2. Please use get_feature_names_out instead.
warnings.warn(msg, category=FutureWarning)
```

In [ ]:
```
x_train_encoded
```

Out[360]:

	Gender_Male	Geography_Germany	Geography_Spain
0	1.0	0.0	1.0
1	1.0	0.0	1.0
2	0.0	0.0	1.0
3	1.0	0.0	0.0
4	0.0	1.0	0.0
...	...	...	...
7495	0.0	0.0	0.0
7496	1.0	0.0	1.0
7497	1.0	1.0	0.0
7498	1.0	0.0	1.0

In [ ]:

```
                                               NumOfProducts  HasCrCard  IsAc

                                                           1

                                                           1
7499        0.0      1.0      0.0


7500        rows × 3 columns
```

```
x_train_new = pd.concat([x_train,x_train_encoded],axis=1)
x_train_new
```

Out[361]:

```
       CreditScore  Geography  Gender  Age  Tenure   Balance

   0        686      Spain    Male     41    7      102749.72      0
   1        749      Spain    Male     42    9      222267.63      0
   2        777      Spain    Female   35    3      0.00      2      1
   3        650      France   Male     60    8      0.00      2      1
   4        696      Germany          Female 27    2      96129.32       2       1
 ...         ...        ...       ...     ...     ...        ...           ...       ...
7495        656      France   Female   46    5      113402.14      2      1
7496        526      Spain    Male     49    2      0.00      1      1
7497        780      Germany          Male   51    4      126725.25      1       1
7498        850      Spain    Male     48    2      0.00      1      1
7499        705      Germany          Female 46    4      115518.07      1       0

7500        rows × 13 columns
```

In [ ]:

```
x_train_new.drop(['Gender','Geography'],axis=1,inplace=True)
x_train_new
```

Out[362]:

```
       CreditScore  Age  Tenure   Balance  NumOfProducts  HasCrCard  IsActiveMember  Estimated
   0        686     41       7  102749.72              1          0               1        194
   1        749        42      9        222267.63      1      0      0      10
   2        777        35      3        0.00      2      1      1      17
   3        650 60 8 0.00 2 1 1 102 4 696 27 2 96129.32 2 1 1 5
 ...         ...    ...     ...       ...           ...        ...          ...
```

In [ ]:

7495	656	46	5	113402.14	2	1	1	138
7496	526	49	2	0.00	1	1	0	114
7497	780	51	4	126725.25	1	1	0	195
7498	850	48	2	0.00	1	1	0	169
7499	705	46	4	115518.07	1	0	0	76

7500 rows × 11 columns

```
x_test_encoded = pd.DataFrame(ohe.transform(x_test[['Gender','Geography']]),colum
x_test_encoded
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/deprecation.py:87: FutureW
arning: Function get_feature_names is deprecated; get_feature_names is deprecat
ed in 1.0 and will be removed in 1.2. Please use get_feature_names_out instead.
warnings.warn(msg, category=FutureWarning)
```

Out[363]:

	Gender_Male	Geography_Germany	Geography_Spain
0	0.0	0.0	0.0
1	0.0	1.0	0.0
2	0.0	1.0	0.0
3	0.0	0.0	0.0
4	1.0	0.0	0.0
...	...	...	...
2495	1.0	0.0	1.0
2496	1.0	1.0	0.0
2497	0.0	0.0	0.0
2498	1.0	0.0	0.0
2499	0.0	0.0	0.0

2500 rows × 3 columns

```
x_test_new = pd.concat([x_test,x_test_encoded],axis=1)
x_test_new
```

Out[364]:

	CreditScore	Geography	Gender	Age	Tenure	Balance		
0	706	France	Female	29	5	112564.62	1	
1	554	Germany	Female	31	6	135470.90	1	
2	704	Germany	Female	24	7	113034.22	1	1

In [ ]:

```
                                                  NumOfProducts  HasCrCard  IsAc
                                                              1

                                                              1
   3      757     France   Female  71    0    88084.13        2       1
   4      651     France   Male    36    7    0.00      2     1
 ...      ...     ...      ...     ...   ...       ...                ...       ...
2495      577     Spain    Male    43    8    79757.21        1       1
2496      608     Germany          Male  26   1         106648.98     1       0
2497      697     France   Female  25    1    0.00      2     0
2498      634     France   Male    26    8    0.00      1     1
2499      437     France   Female  39    0    102721.49       1       0

2500 rows × 13 columns
```

In [ ]:

```python
x_test_new.drop(['Gender','Geography'],axis=1,inplace=True)
x_test_new
```

Out[365]:

```
      CreditScore  Age  Tenure   Balance  NumOfProducts  HasCrCard  IsActiveMember  Estimated
   0          706   29       5  112564.62             1          1               0         42
   1          554       31     6      135470.90     1     1     0     107
   2          704       24     7      113034.22     1     1     0     162
   3          757       71     0      88084.13      2     1     1     154 4    651    36
                7     0.00     2      1        0          13
 ...          ...  ...     ...       ...            ...        ...             ...
2495          577       43     8      79757.21      1     1     0     135
2496          608       26     1      106648.98     1     0     1     7
2497          697       25     1      0.00     2    0     0     87
2498          634       26     8      0.00     1    1     0     21
2499          437       39     0      102721.49     1     0     0     22

2500      rows × 11 columns
```

In [ ]:

```python
from sklearn.linear_model import LogisticRegression
```

In [ ]:

```
lr =LogisticRegression()
```

In [ ]:
```
lr.fit(x_train_new,y_train)
```

Out[368]:
```
LogisticRegression()
```

In [ ]:
```
y_pred=lr.predict(x_test_new)
y_pred
```

Out[369]:
```
array([0, 0, 0, ..., 0, 0, 0])
```

In [ ]:
```
from sklearn.metrics import confusion_matrix,classification_report,precision_scor
```

In [ ]:
```
confusion_matrix(y_test,y_pred)
```

Out[371]:
```
array([[1957,   34],
       [ 483,   26]])
```

In [ ]:
```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.80      0.98      0.88      1991
 1       0.43      0.05      0.09       509

    accuracy                           0.79      2500
macro avg       0.62      0.52      0.49      2500
weighted avg       0.73      0.79      0.72      2500
```

In [ ]:
```
pre = precision_score(y_test,y_pred)
```

In [ ]:
```
re = recall_score(y_test,y_pred)
```

In [ ]:
```
acc = accuracy_score(y_test,y_pred)
```

In [ ]:
```
fbeta = fbeta_score(y_test,y_pred,beta=2)
```

In [ ]:
```
result = pd.DataFrame(columns=['Accuracy','Precision','Reall','Fbeta Score'])
result
```

Out[377]:

Accuracy	Precision	Reall	Fbeta Score

In [
]:

```
result.loc['LR'] = [acc,pre,re,fbeta]
result
```

Out[378]:

	Accuracy	Precision	Reall	Fbeta Score
LR	0.7932	0.433333	0.051081	0.062023

In [ ]:

```
from sklearn.preprocessing import MinMaxScaler
```

In [ ]:

```
scaler = MinMaxScaler()
scaler.fit(x_train_new)
x_train_new_scaled=scaler.transform(x_train_new)
x_test_new_scaled=scaler.transform(x_test_new)
```

In [ ]:

```
lr.fit(x_train_new_scaled,y_train)
y_pred=lr.predict(x_test_new_scaled)
y_pred
```

Out[381]:

```
array([0, 0, 0, ..., 0, 0, 0])
```

In [ ]:

```
confusion_matrix(y_test,y_pred)
```

Out[382]:

```
array([[1918,   73],
 [ 415,   94]])
```

In [ ]:

```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.82      0.96      0.89      1991
 1       0.56      0.18      0.28       509

    accuracy                           0.80      2500
macro avg       0.69      0.57      0.58      2500
weighted avg       0.77      0.80      0.76      2500
```

In [ ]:

```
acc = accuracy_score(y_test,y_pred)
```

In [ ]:

```
re = recall_score(y_test,y_pred)
```

In [ ]:

```
pre = precision_score(y_test,y_pred)
```

In [ ]:

```
fbeta = fbeta_score(y_test,y_pred,beta=2)
```

In [ ]:

```
result.loc['LR_Scaling'] = [acc,pre,re,fbeta]
result
```

Out[388]:

	Accuracy	Precision	Reall	Fbeta Score
LR	0.7932	0.433333	0.051081	0.062023
LR_Scaling	0.8048	0.562874	0.184676	0.213345

In [ ]:

```
# Keras
# from tensorflow.keras.wrappers.scikit_learn import KerasClassifier
# from tensorflow.keras.layers import Dense, Input, Dropout
# from tensorflow.keras.models import Sequential
```

In [ ]:

```
pip install keras_tuner
```

```
Looking in indexes: https://pypi.org/simple, (https://pypi.org/simple,) http
s://us-python.pkg.dev/colab-wheels/public/simple/ (https://us-
python.pkg.dev/ colab-wheels/public/simple/)
Requirement already satisfied: keras_tuner in /usr/local/lib/python3.7/dist-p
ackages (1.1.3)
Requirement already satisfied: numpy in /usr/local/lib/python3.7/dist-package
s (from keras_tuner) (1.21.6)
Requirement already satisfied: requests in /usr/local/lib/python3.7/dist-pack
ages (from keras_tuner) (2.23.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.7/dist-pac
kages (from keras_tuner) (21.3)
Requirement already satisfied: tensorboard in /usr/local/lib/python3.7/dist-p
ackages (from keras_tuner) (2.8.0)
Requirement already satisfied: kt-legacy in /usr/local/lib/python3.7/dist-pac
kages (from keras_tuner) (1.0.4)
Requirement already satisfied: ipython in /usr/local/lib/python3.7/dist-packa
ges (from keras_tuner) (7.9.0)
Requirement already satisfied: pexpect in /usr/local/lib/python3.7/dist-packa
ges (from ipython->keras_tuner) (4.8.0)
Requirement already satisfied: pygments in /usr/local/lib/python3.7/dist-pack
ages (from ipython->keras_tuner) (2.6.1)
Requirement already satisfied: setuptools>=18.5 in /usr/local/lib/python3.7/d
ist-packages (from ipython->keras_tuner) (57.4.0)
Requirement already satisfied: pickleshare in /usr/local/lib/python3.7/dist-p
ackages (from ipython->keras_tuner) (0.7.5)
Requirement already satisfied: backcall in /usr/local/lib/python3.7/dist-pack
ages (from ipython->keras_tuner) (0.2.0)
Requirement already satisfied: jedi>=0.10 in /usr/local/lib/python3.7/dist-pa
ckages (from ipython->keras_tuner) (0.18.1)
Requirement already satisfied: prompt-toolkit<2.1.0,>=2.0.0 in /usr/local/li
b/python3.7/dist-packages (from ipython->keras_tuner) (2.0.10)
Requirement already satisfied: decorator in /usr/local/lib/python3.7/dist-pac
kages (from ipython->keras_tuner) (4.4.2)
Requirement already satisfied: traitlets>=4.2 in /usr/local/lib/python3.7/dis
t-packages (from ipython->keras_tuner) (5.1.1)
Requirement already satisfied: parso<0.9.0,>=0.8.0 in /usr/local/lib/python3.
7/dist-packages (from jedi>=0.10->ipython->keras_tuner) (0.8.3)
Requirement already satisfied: wcwidth in /usr/local/lib/python3.7/dist-packa
ges (from prompt-toolkit<2.1.0,>=2.0.0->ipython->keras_tuner) (0.2.5)
Requirement already satisfied: six>=1.9.0 in /usr/local/lib/python3.7/dist-
pa ckages (from prompt-toolkit<2.1.0,>=2.0.0->ipython->keras_tuner) (1.15.0)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in
/usr/local/lib/pyt hon3.7/dist-packages (from packaging->keras_tuner)
(3.0.9)
Requirement already satisfied: ptyprocess>=0.5 in /usr/local/lib/python3.7/di
st-packages (from pexpect->ipython->keras_tuner) (0.7.0)
Requirement already satisfied: idna<3,>=2.5 in
/usr/local/lib/python3.7/distpackages (from requests->keras_tuner) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.
7/dist-packages (from requests->keras_tuner) (2022.6.15)
```

In [ ]:

```
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in /us
r/local/lib/python3.7/dist-packages (from requests->keras_tuner) (1.24.3)
Requirement already satisfied: chardet<4,>=3.0.2 in
/usr/local/lib/python3.7/ dist-packages (from requests->keras_tuner) (3.0.4)
Requirement already satisfied: absl-py>=0.4 in /usr/local/lib/python3.7/dist-
```

```
packages (from tensorboard->keras_tuner) (1.2.0)
Requirement already satisfied: werkzeug>=0.11.15 in /usr/local/lib/python3.7/
dist-packages (from tensorboard->keras_tuner) (1.0.1)
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.7/di st-
packages (from tensorboard->keras_tuner) (3.4.1)
Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in /usr/
local/lib/python3.7/dist-packages (from tensorboard->keras_tuner) (0.6.1)
Requirement already satisfied: grpcio>=1.24.3 in /usr/local/lib/python3.7/dis t-
packages (from tensorboard->keras_tuner) (1.48.1)
Requirement already satisfied: wheel>=0.26 in /usr/local/lib/python3.7/dist-p
ackages (from tensorboard->keras_tuner) (0.37.1)
Requirement already satisfied: protobuf>=3.6.0 in /usr/local/lib/python3.7/di st-
packages (from tensorboard->keras_tuner) (3.17.3)
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in /usr/loca
l/lib/python3.7/dist-packages (from tensorboard->keras_tuner) (0.4.6) Requirement
already satisfied: tensorboard-plugin-wit>=1.6.0 in /usr/local/li
b/python3.7/dist-packages (from tensorboard->keras_tuner) (1.8.1)
Requirement already satisfied: google-auth<3,>=1.6.3 in /usr/local/lib/python
3.7/dist-packages (from tensorboard->keras_tuner) (1.35.0)
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.7/dist -
packages (from google-auth<3,>=1.6.3->tensorboard->keras_tuner) (4.9) Requirement
already satisfied: cachetools<5.0,>=2.0.0 in /usr/local/lib/pytho n3.7/dist-
packages (from google-auth<3,>=1.6.3->tensorboard->keras_tuner) (4. 2.4)
Requirement already satisfied: pyasn1-modules>=0.2.1 in /usr/local/lib/python
3.7/dist-packages (from google-auth<3,>=1.6.3->tensorboard->keras_tuner) (0.
2.8)
Requirement already satisfied: requests-oauthlib>=0.7.0 in /usr/local/lib/pyt
hon3.7/dist-packages (from google-auth-oauthlib<0.5,>=0.4.1->tensorboard->ker
as_tuner) (1.3.1)
Requirement already satisfied: importlib-metadata>=4.4 in /usr/local/lib/pyth
on3.7/dist-packages (from markdown>=2.6.8->tensorboard->keras_tuner) (4.12.0)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/lib/pyt
hon3.7/dist-packages (from importlib-metadata>=4.4->markdown>=2.6.8->tensorbo
ard->keras_tuner) (4.1.1)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-pac
kages (from importlib-metadata>=4.4->markdown>=2.6.8->tensorboard->keras_tune
r) (3.8.1)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in /usr/local/lib/python
3.7/dist-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorb
oard->keras_tuner) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.7/di st-
packages (from requests-oauthlib>=0.7.0->google-auth-
oauthlib<0.5,>=0.4.1>tensorboard->keras_tuner) (3.2.0)
```

In [ ]:

```
import tensorflow as tf from
keras_tuner.tuners import RandomSearch
```

In [ ]:

```
df = pd.read_csv('analytical_base_table.csv')
```

In [ ]:

```
df.head()
```

Out[393]:

```
     CreditScore  Geography  Gender  Age  Tenure    Balance  NumOfProducts  HasCrCard  IsActive
0           619      France   Female   42       2       0.00              1          1
1           608   Spain    Female  41     1     83807.86      1      0
2           502   France   Female  42     8     159660.80     3      1
3           699   France   Female  39     1     0.00     2      0
4           850   Spain    Female  43     2     125510.82     1      1
```

In [ ]:

```
x=df.drop(['Exited'],axis=1)
x.shape
```

Out[394]:

```
(10000, 10)
```

In [ ]:

```
y=df['Exited']
y.shape
```

Out[395]:

```
(10000,)
```

In [ ]:

```
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.2,random_state=4
```

In [ ]:

```
x_train.shape,x_test.shape,y_train.shape,y_test.shape
```

Out[397]:

```
((8000, 10), (2000, 10), (8000,), (2000,))
```

In [ ]:

```
x_train.head()
```

Out[398]:

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsAc
2151	753	France	Male	57	7	0.00	1	1	
8392	739	Germany	Male	32	3	102128.27	1	1	
5006	755	Germany	Female	37	0	113865.23	2	1	
4117	561	France	Male	37	5	0.00	2	1	
7182	692	Germany	Male	49	6	110540.43	2	0	

In [ ]:

```
x_train.reset_index(drop=True,inplace=True)
```

In [ ]:

```
x_train.head()
```

Out[400]:

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActive
0	753	France	Male	57	7	0.00	1	1	
1	739	Germany	Male	32	3	102128.27	1	1	
2	755	Germany	Female	37	0	113865.23	2	1	
3	561	France	Male	37	5	0.00	2	1	
4	692	Germany	Male	49	6	110540.43	2	0	

In [ ]:

```
ohe = OneHotEncoder(drop='first',sparse=False,handle_unknown='ignore')
```

In [ ]:

```
ohe.fit(x_train[['Gender','Geography']])
```

Out[402]:

```
OneHotEncoder(drop='first', handle_unknown='ignore', sparse=False)
```

In [ ]:

```
x_train_encoded = ohe.transform(x_train[['Gender','Geography']])
```

In [ ]:

```
x_train_encoded
```

Out[404]:

```
array([[1., 0., 0.],
       [1., 1., 0.],
       [0., 1., 0.],
 ...,
       [0., 0., 0.],
       [1., 0., 1.],
 [1., 0., 1.]])
```

```
 x_train_new =
 pd.DataFrame(x_train_en
 coded,columns=ohe.get_f
 eature_names(['Gender
 x_train_new
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/deprecation.py:87: FutureW
arning: Function get_feature_names is deprecated; get_feature_names is deprecat
ed in 1.0 and will be removed in 1.2. Please use get_feature_names_out instead.
warnings.warn(msg, category=FutureWarning)
```

Out[405]:

	Gender_Male	Geography_Germany	Geography_Spain
0	1.0	0.0	0.0
1	1.0	1.0	0.0

In [ ]:

2	0.0	1.0	0.0
3	1.0	0.0	0.0
4	1.0	1.0	0.0
...	...	...	...
7995	0.0	0.0	1.0
7996	1.0	0.0	1.0
7997	0.0	0.0	0.0
7998	1.0	0.0	1.0
7999	1.0	0.0	1.0

8000 rows × 3 columns

In [ ]:
```
x_train1 = pd.concat([x_train,x_train_new],axis=1)
x_train1.head()
```

Out[406]:

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActive
0	753	France	Male	57	7	0.00	1	1	
1	739	Germany	Male	32	3	102128.27	1	1	
2	755	Germany	Female	37	0	113865.23	2	1	
3	561	France	Male	37	5	0.00	2	1	
4	692	Germany	Male	49	6	110540.43	2	0	

In [ ]:
```
x_train1.drop(['Geography','Gender'],axis=1,inplace=True)
x_train1.shape
```

Out[407]:
```
(8000, 11)
```

```
x_test.head()
```

Out[408]:

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsAc
5702	585	France	Male	36	7	0.00	2	1	
3667	525	Germany	Male	33	4	131023.76	2	0	
1617	557	Spain	Female	40	4	0.00	2	0	
5673	639	Spain	Male	34	5	139393.19	2	0	
4272	640	Spain	Female	34	3	77826.80	1	1	

In [ ]:

In [ ]:

```
x_test.reset_index(drop=True,inplace=True)
x_test.head()
```

Out[409]:

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActive
0	585	France	Male	36	7	0.00	2	1	
1	525	Germany	Male	33	4	131023.76	2	0	
2	557	Spain	Female	40	4	0.00	2	0	
3	639	Spain	Male	34	5	139393.19	2	0	
4	640	Spain	Female	34	3	77826.80	1	1	

```
ohe.fit(x_test[['Gender','Geography']])
x_test_encoded = ohe.transform(x_test[['Gender','Geography']])
x_test_new = pd.DataFrame(x_test_encoded,columns=ohe.get_feature_names(['Gender',
x_test_new
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/deprecation.py:87: FutureW
arning: Function get_feature_names is deprecated; get_feature_names is deprecat
ed in 1.0 and will be removed in 1.2. Please use get_feature_names_out instead.
warnings.warn(msg, category=FutureWarning)
```

Out[410]:

	Gender_Male	Geography_Germany	Geography_Spain
0	1.0	0.0	0.0
1	1.0	1.0	0.0
2	0.0	0.0	1.0
3	1.0	0.0	1.0
4	0.0	0.0	1.0
...	...	...	...
1995	1.0	0.0	0.0
1996	1.0	1.0	0.0
1997	0.0	1.0	0.0
1998	1.0	0.0	0.0
1999	1.0	0.0	0.0

In [ ]:

2000 rows × 3 columns

In [ ]:
```
x_test1 = pd.concat([x_test,x_test_new],axis=1)
x_test1.head()
```

Out[411]:

	CreditScore	Geography	Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActive
0	585	France	Male	36	7	0.00	2	1	
1	525	Germany	Male	33	4	131023.76	2	0	
2	557	Spain	Female	40	4	0.00	2	0	
3	639	Spain	Male	34	5	139393.19	2	0	
4	640	Spain	Female	34	3	77826.80	1	1	

```
x_test1.drop(['Geography','Gender'],axis=1,inplace=True)
x_test1.head()
```

Out[412]:

	CreditScore	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActiveMember	EstimatedSa
0	585	36	7	0.00	2	1	0	94283
1	525	33	4	131023.76	2	0	0	55072
2	557	40	4	0.00	2	0	1	105433
3	639	34	5	139393.19	2	0	0	33950
4	640	34	3	77826.80	1	1	1	168544

In [ ]:
```
import seaborn as sns
```

In [ ]:
```
x_train1.columns
```

Out[414]:
```
Index(['CreditScore', 'Age', 'Tenure', 'Balance', 'NumOfProducts', 'HasCrCard',
       'IsActiveMember', 'EstimatedSalary', 'Gender_Male', 'Geography_Germany',
       'Geography_Spain'],
      dtype='object')
```

In [ ]:
```
for i in x_train1.columns:
  print(i)
```

```
CreditScore
Age
Tenure
Balance
NumOfProducts
```

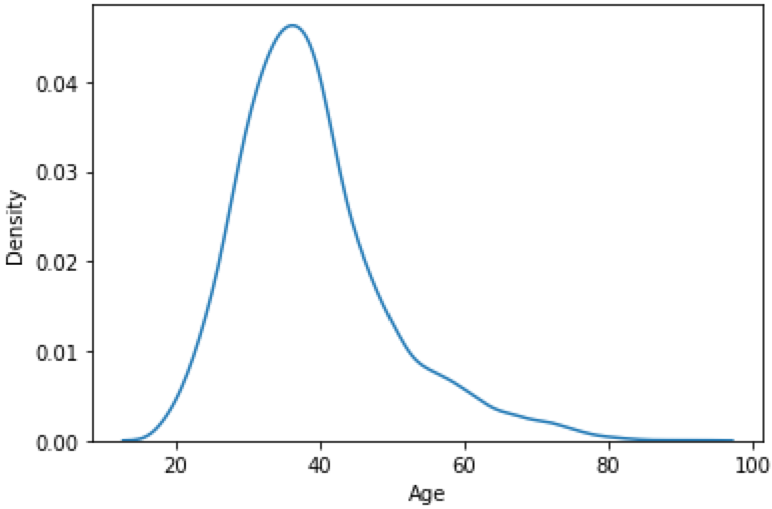
In [ ]:

```
HasCrCard
IsActiveMember
EstimatedSalary
Gender_Male
Geography_Germany
Geography_Spain
```

```
sns.kdeplot(x_train1['Age'])
```

Out[416]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fd674dd40d0>
```



In [ ]:

```
import tensorflow.keras as tk
```

In [ ]:

In [ ]:
```
from sklearn.preprocessing import MinMaxScaler
```

In [ ]:
```
sc = MinMaxScaler()
sc.fit(x_train1)
x_train1_sc = sc.transform(x_train1)
x_test1_sc = sc.transform(x_test1)
```

In [ ]:
```
x_train1_sc.shape
```

Out[419]:
```
(8000, 11)
```

In [ ]:
```
type(x_train1_sc)
```

Out[420]:
```
numpy.ndarray
```

```
# instantiate the model
model = tk.Sequential()
```

In [ ]:
```
# Adding the input layer
model.add(tk.layers.Input(shape=(11,)))
# Adding the first hidden layer
model.add(tk.layers.Dense(units=6,activation='relu',kernel_initializer='he_unifor
# Adding the second hidden layer
model.add(tk.layers.Dense(units=6,activation='relu',kernel_initializer='he_unifor
# Adding the output layer
model.add(tk.layers.Dense(units=1,activation='sigmoid',kernel_initializer='glorot
```

In [ ]:
```
# Compiling the model
model.compile(optimizer='Adam',loss='binary_crossentropy',metrics=['Precision','a
```

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

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
          dense_12 (Dense)            (None, 6)                 72
          dense_13 (Dense)            (None, 6)                 42
           dense_14 (Dense)            (None, 1)                 7
=================================================================
Total params: 121
Trainable params: 121
Non-trainable params: 0
_________________________________________________________________
```

In [ ]:
```
x_train1_sc.shape,x_test1_sc.shape,y_train.shape,y_test.shape
```

```
In [ ]:
Out[426]: ((8000, 11), (2000, 11), (8000,), (2000,))
```

```
In [ ]: import time
```

```
# Training the model
start = time.time()
history_object = model.fit(x=x_train1_sc,
y=y_train,
epochs=100,
batch_size=32,
                           validation_data=(x_test1_sc,y_test))
end=time.time() print(end-start)
```

```
Epoch 1/100
250/250 [==============================] - 2s 4ms/step - loss: 0.5900 - preci
sion: 0.1512 - accuracy: 0.7588 - val_loss: 0.5179 - val_precision: 0.0000e+0
0 - val_accuracy: 0.7965
Epoch 2/100
250/250 [==============================] - 0s 2ms/step - loss: 0.5055 - preci
sion: 0.0000e+00 - accuracy: 0.7962 - val_loss: 0.4992 - val_precision: 0.000
0e+00 - val_accuracy: 0.7965
Epoch 3/100
250/250 [==============================] - 1s 2ms/step - loss: 0.4938 - preci
sion: 0.0000e+00 - accuracy: 0.7962 - val_loss: 0.4910 - val_precision: 0.000
0e+00 - val_accuracy: 0.7965
Epoch 4/100
250/250 [==============================] - 1s 2ms/step - loss: 0.4864 - preci
sion: 0.0000e+00 - accuracy: 0.7962 - val_loss: 0.4846 - val_precision: 0.000
0e+00 - val_accuracy: 0.7965
Epoch 5/100
250/250 [==============================] - 1s 2ms/step - loss: 0.4803 - preci
sion: 0.0000e+00 - accuracy: 0.7962 - val_loss: 0.4786 - val_precision: 0.000
0 +00     l          0 7965
```

```
In [ ]: history_object.history.keys()
```

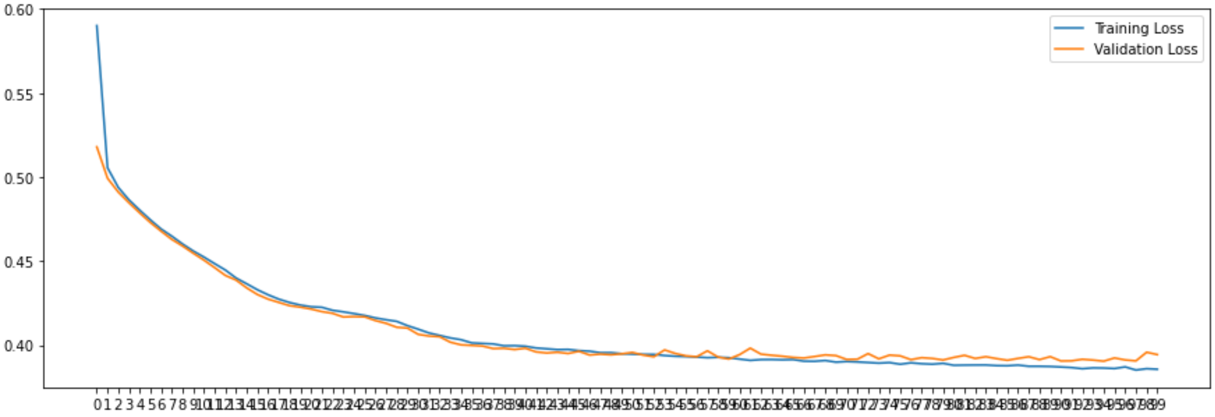
```
Out[429]: dict_keys(['loss', 'precision', 'accuracy', 'val_loss', 'val_precision', 'val_a
ccuracy'])
```

```
In [ ]: def lineplotter(history_object, keyword):
epochs_ = history_object.epoch
history_data = history_object.history
tr_key = keyword
  val_key = f'val_{keyword}'

  tr_data = history_data.get(tr_key)
val_data = history_data.get(val_key)

  plt.figure(figsize=(15,5))   sns.lineplot(x =
epochs_, y = tr_data)   sns.lineplot(x =
epochs_, y = val_data)   plt.xticks(ticks =
epochs_, labels = epochs_)
```

In [ ]:

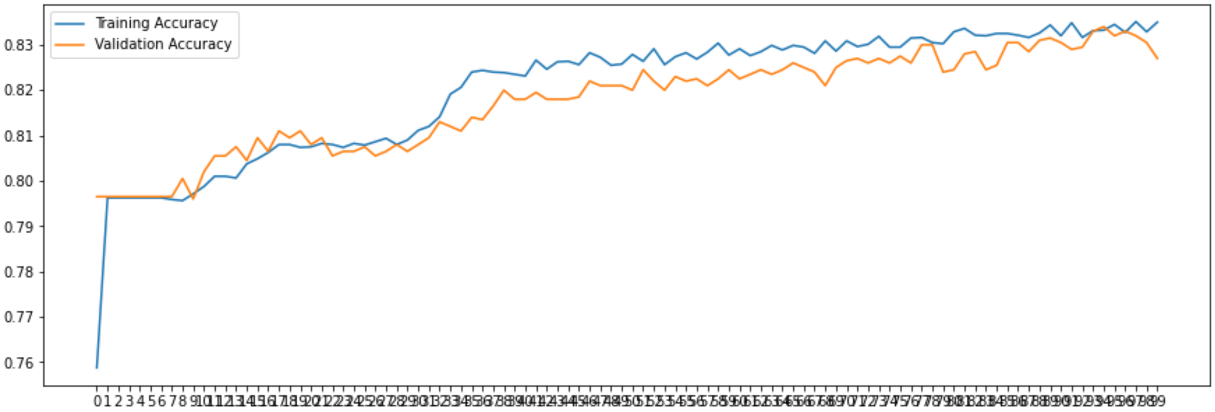
```
  plt.legend([f'Training {keyword.title()}',f'Validation {keyword.title()}'])
plt.show()
```

```
lineplotter(history_object, 'loss')
```



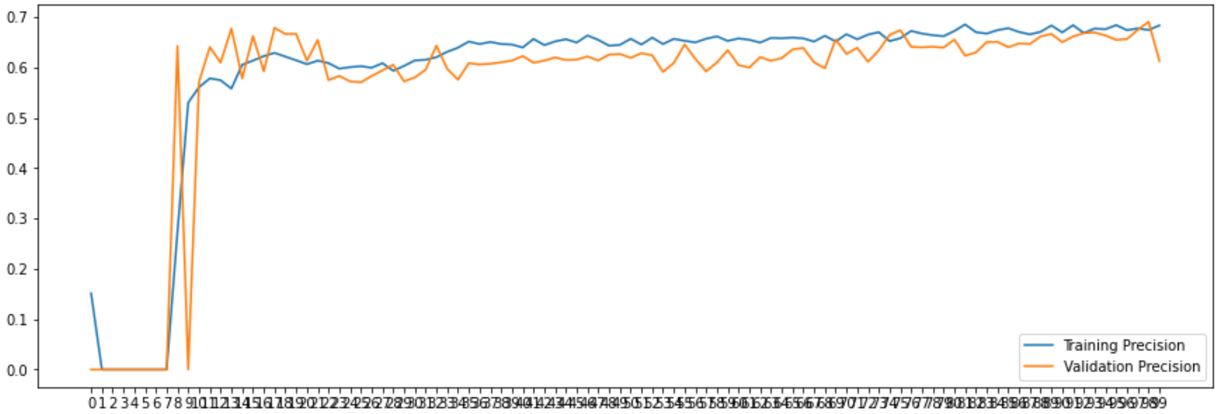
In [ ]:

```
lineplotter(history_object, 'accuracy')
```



In [ ]:

In [ ]:
```
lineplotter(history_object, 'precision')
```



In [ ]: