Project 2: Binary Classification on 'Customer_Churn'using Keras

```
import pandas as pd
df= pd.read_csv("customer_churn.csv")

df.head()

   customerID  gender  SeniorCitizen Partner Dependents  tenure
PhoneService  \
0  7590-VHVEG  Female              0     Yes         No       1
No
1  5575-GNVDE    Male              0      No         No      34
Yes
2  3668-QPYBK    Male              0      No         No       2
Yes
3  7795-CFOCW    Male              0      No         No      45
No
4  9237-HQITU  Female              0      No         No       2
Yes

      MultipleLines InternetService OnlineSecurity  ...
DeviceProtection  \
0  No phone service             DSL             No  ...
No
1                No             DSL            Yes  ...
Yes
2                No             DSL            Yes  ...
No
3  No phone service             DSL            Yes  ...
Yes
4                No     Fiber optic             No  ...
No

  TechSupport StreamingTV StreamingMovies        Contract
PaperlessBilling  \
0          No          No              No  Month-to-month
Yes
1          No          No              No        One year
No
2          No          No              No  Month-to-month
Yes
3         Yes          No              No        One year
No
4          No          No              No  Month-to-month
Yes

               PaymentMethod MonthlyCharges  TotalCharges Churn
0           Electronic check          29.85         29.85    No
```

```
1                 Mailed check          56.95         1889.5    No
2                 Mailed check          53.85         108.15   Yes
3  Bank transfer (automatic)          42.30        1840.75    No
4             Electronic check          70.70         151.65   Yes

[5 rows x 21 columns]
```

```
# A) Data Manipulation:
# a. Find the total number of male customers
# b. Find the total number of customers whose Internet Service is
‘DSL’
# c. Extract all the Female senior citizens whose Payment Method is
Mailed check & store the
# result in ‘new_customer’
# d. Extract all those customers whose tenure is less than 10 months
or their Total charges is less
# than 500$ & store the result in ‘new_customer’

total_male_customers = df[df['gender'] == 'Male'].shape[0]
print("Total number of male customers:", total_male_customers)
```

```
Total number of male customers: 3555
```

```
# b. Find the total number of customers whose Internet Service is
‘DSL’
total_dsl_customers = df[df['InternetService'] == 'DSL'].shape[0]
print("Total number of customers with DSL internet service:",
total_dsl_customers)
```

```
Total number of customers with DSL internet service: 2421
```

```
# c. Extract all the Female senior citizens whose Payment Method is
Mailed check & store the result in ‘new_customer’
new_customer = df[(df['gender'] == 'Female') & (df['SeniorCitizen'] ==
1) & (df['PaymentMethod'] == 'Mailed check')]
print("Female senior citizens with Payment Method as Mailed check:")
print(new_customer)
```

```
Female senior citizens with Payment Method as Mailed check:
      customerID  gender  SeniorCitizen Partner Dependents  tenure  \
139   0390-DCFDQ  Female              1     Yes         No       1
176   2656-FMOKZ  Female              1      No         No      15
267   3197-ARFOY  Female              1      No         No      19
451   5760-WRAHC  Female              1      No         No      22
470   4933-IKULF  Female              1      No         No      17
694   2682-KEVRP  Female              1      No         No      22
747   3966-HRMZA  Female              1      No         No       3
947   9904-EHEVJ  Female              1     Yes        Yes      32
1029  4184-TJFAN  Female              1     Yes        Yes       3
1112  2176-LVPNX  Female              1      No         No      71
1513  0661-XEYAN  Female              1      No         No       1
```

```
1811  2070-XYMFH  Female              1      No          No      23
1831  3402-XRIUO  Female              1     Yes          No      22
1864  7105-MXJLL  Female              1     Yes          No      26
1891  4193-ORFCL  Female              1      No          No       1
2037  8309-IEYJD  Female              1      No          No       1
2344  9796-MVYXX  Female              1      No          No      14
2441  9050-IKDZA  Female              1      No          No       2
2674  1855-CFULU  Female              1      No          No       4
3005  0516-QREYC  Female              1      No          No      24
3185  9907-SWKKF  Female              1      No          No       1
3341  1125-SNVCK  Female              1      No          No      49
3373  2516-VQRRV  Female              1      No          No       2
3374  7580-UGXNC  Female              1      No          No       2
3454  6773-LQTVT  Female              1     Yes         Yes      29
3893  5816-SCGFC  Female              1      No          No       7
4258  9360-AHGNL  Female              1     Yes          No      43
4382  2277-VWCNI  Female              1      No          No       4
4541  9058-CBREO  Female              1      No          No       1
4542  9029-FEGVJ  Female              1     Yes          No      32
4673  6402-ZFPPI  Female              1      No          No      25
5183  8988-ECPJR  Female              1     Yes         Yes      34
5251  8485-GJCDN  Female              1      No          No       5
5319  9866-OCCKE  Female              1     Yes          No      72
5341  2982-IHMFT  Female              1      No          No       1
5437  7000-WCEVQ  Female              1      No          No      20
5476  6060-DRTNL  Female              1      No          No       5
5569  0013-EXCHZ  Female              1     Yes          No       3
5680  6982-UQZLY  Female              1     Yes          No       1
5743  2384-OVPSA  Female              1      No          No      38
5757  5539-HIVAK  Female              1     Yes          No      28
5792  3500-RMZLT  Female              1      No          No      15
6031  0282-NVSJS  Female              1     Yes         Yes      12
6042  4750-UKWJK  Female              1     Yes          No      37
6147  6383-ZTSIW  Female              1     Yes          No      39
6178  3719-TDVQB  Female              1     Yes          No      54
6219  1496-GGSUK  Female              1      No          No       1
6231  3296-SILRA  Female              1     Yes          No       1
6534  5195-KPUNQ  Female              1      No          No      53
6581  2453-SAFNS  Female              1      No          No      54

     PhoneService     MultipleLines InternetService
OnlineSecurity  ...  \
139           Yes                No     Fiber optic
No  ...
176           Yes               Yes     Fiber optic
No  ...
267           Yes                No     Fiber optic
Yes  ...
451           Yes                No             DSL
```

```
Yes  ...
470           Yes                 No               No  No internet
service  ...
694           Yes                 No               No  No internet
service  ...
747           Yes                 No     Fiber optic
No  ...
947           Yes                Yes     Fiber optic
No  ...
1029          Yes                 No     Fiber optic
Yes  ...
1112          Yes                Yes             DSL
Yes  ...
1513           No  No phone service             DSL
No  ...
1811          Yes                Yes     Fiber optic
No  ...
1831          Yes                Yes             DSL
Yes  ...
1864          Yes                 No             DSL
No  ...
1891          Yes                 No             DSL
No  ...
2037          Yes                 No     Fiber optic
No  ...
2344           No  No phone service             DSL
Yes  ...
2441          Yes                 No     Fiber optic
No  ...
2674          Yes                 No               No  No internet
service  ...
3005          Yes                 No               No  No internet
service  ...
3185           No  No phone service             DSL
No  ...
3341          Yes                 No             DSL
No  ...
3373          Yes                Yes     Fiber optic
No  ...
3374          Yes                 No             DSL
Yes  ...
3454           No  No phone service             DSL
No  ...
3893          Yes                 No             DSL
No  ...
4258          Yes                Yes     Fiber optic
Yes  ...
4382          Yes                Yes             DSL
No  ...
```

```
4541          Yes                Yes          DSL
No  ...
4542          Yes                Yes     Fiber optic
No  ...
4673          Yes                Yes     Fiber optic
Yes  ...
5183          Yes                Yes     Fiber optic
No  ...
5251          Yes                 No     Fiber optic
No  ...
5319          Yes                Yes     Fiber optic
Yes  ...
5341          Yes                Yes     Fiber optic
No  ...
5437          Yes                Yes          DSL
No  ...
5476          Yes                 No     Fiber optic
No  ...
5569          Yes                 No     Fiber optic
No  ...
5680          Yes                 No               No  No internet
service  ...
5743          Yes                 No               No  No internet
service  ...
5757          Yes                Yes               No  No internet
service  ...
5792          Yes                 No     Fiber optic
Yes  ...
6031           No  No phone service          DSL
No  ...
6042          Yes                 No               No  No internet
service  ...
6147          Yes                 No     Fiber optic
Yes  ...
6178          Yes                 No               No  No internet
service  ...
6219           No  No phone service          DSL
No  ...
6231          Yes                 No     Fiber optic
No  ...
6534          Yes                 No     Fiber optic
Yes  ...
6581          Yes                Yes          DSL
No  ...

         DeviceProtection          TechSupport          StreamingTV  \
139                    No                   No                   No
176                    No                   No                   No
267                    No                  Yes                  Yes
```

451	Yes	Yes	No
470	No internet service	No internet service	No internet service
694	No internet service	No internet service	No internet service
747	Yes	No	No
947	Yes	No	Yes
1029	No	Yes	Yes
1112	Yes	Yes	Yes
1513	No	No	No
1811	Yes	No	No
1831	No	Yes	No
1864	Yes	No	No
1891	No	No	No
2037	No	No	No
2344	Yes	Yes	No
2441	No	No	Yes
2674	No internet service	No internet service	No internet service
3005	No internet service	No internet service	No internet service
3185	No	No	No
3341	No	No	No
3373	No	No	No
3374	No	No	No
3454	Yes	No	No
3893	No	No	No
4258	Yes	Yes	Yes
4382	No	No	No
4541	No	No	No
4542	Yes	No	No
4673	No	No	Yes
5183	No	No	No
5251	No	No	No
5319	Yes	Yes	Yes
5341	No	No	No
5437	No	No	No
5476	Yes	No	Yes
5569	No	Yes	Yes
5680	No internet service	No internet service	No internet service
5743	No internet service	No internet service	No internet service
5757	No internet service	No internet service	No internet service
5792	Yes	Yes	No
6031	No	Yes	No
6042	No internet service	No internet service	No internet service
6147	No	No	Yes
6178	No internet service	No internet service	No internet service
6219	No	No	No
6231	No	No	No
6534	No	Yes	No
6581	No	Yes	Yes

```
          StreamingMovies        Contract PaperlessBilling
```

```
PaymentMethod  \
139                      No  Month-to-month              Yes  Mailed
check
176                      No  Month-to-month              Yes  Mailed
check
267                     Yes  Month-to-month              Yes  Mailed
check
451                     Yes  Month-to-month              Yes  Mailed
check
470   No internet service        One year               No  Mailed
check
694   No internet service        One year              Yes  Mailed
check
747                      No  Month-to-month               No  Mailed
check
947                      No  Month-to-month              Yes  Mailed
check
1029                     No  Month-to-month              Yes  Mailed
check
1112                    Yes        Two year               No  Mailed
check
1513                     No  Month-to-month              Yes  Mailed
check
1811                     No  Month-to-month              Yes  Mailed
check
1831                     No  Month-to-month              Yes  Mailed
check
1864                    Yes        One year               No  Mailed
check
1891                     No  Month-to-month               No  Mailed
check
2037                     No  Month-to-month              Yes  Mailed
check
2344                     No        Two year               No  Mailed
check
2441                     No  Month-to-month               No  Mailed
check
2674  No internet service  Month-to-month               No  Mailed
check
3005  No internet service  Month-to-month              Yes  Mailed
check
3185                     No  Month-to-month               No  Mailed
check
3341                     No  Month-to-month               No  Mailed
check
3373                     No  Month-to-month              Yes  Mailed
check
3374                     No  Month-to-month               No  Mailed
check
```

```
3454                     No  Month-to-month              Yes  Mailed
check
3893                     No  Month-to-month              Yes  Mailed
check
4258                    Yes        One year              Yes  Mailed
check
4382                     No  Month-to-month               No  Mailed
check
4541                     No  Month-to-month               No  Mailed
check
4542                     No  Month-to-month               No  Mailed
check
4673                    Yes  Month-to-month              Yes  Mailed
check
5183                     No  Month-to-month              Yes  Mailed
check
5251                     No  Month-to-month              Yes  Mailed
check
5319                    Yes        Two year              Yes  Mailed
check
5341                     No  Month-to-month              Yes  Mailed
check
5437                    Yes  Month-to-month              Yes  Mailed
check
5476                     No  Month-to-month              Yes  Mailed
check
5569                     No  Month-to-month              Yes  Mailed
check
5680  No internet service  Month-to-month              Yes  Mailed
check
5743  No internet service        Two year               No  Mailed
check
5757  No internet service  Month-to-month               No  Mailed
check
5792                    Yes  Month-to-month              Yes  Mailed
check
6031                     No  Month-to-month              Yes  Mailed
check
6042  No internet service        One year               No  Mailed
check
6147                    Yes        One year               No  Mailed
check
6178  No internet service        Two year              Yes  Mailed
check
6219                     No  Month-to-month              Yes  Mailed
check
6231                     No  Month-to-month              Yes  Mailed
check
6534                    Yes        One year              Yes  Mailed
```

```
check
6581                   No         One year               No  Mailed
check

     MonthlyCharges  TotalCharges Churn
139           70.45         70.45   Yes
176           74.45        1145.7   Yes
267          105.00       2007.25    No
451           69.75        1545.4    No
470           20.65         330.6    No
694           20.05           417    No
747           75.05         202.9    No
947           91.35       2896.55    No
1029          88.30        273.75   Yes
1112          89.85       6293.45    No
1513          25.80          25.8   Yes
1811          79.35        1835.3    No
1831          63.55        1381.8    No
1864          60.70        1597.4    No
1891          45.10          45.1   Yes
2037          70.60          70.6    No
2344          39.70        692.35    No
2441          81.50        162.55    No
2674          20.05         91.45    No
3005          20.30        459.95    No
3185          25.05         25.05   Yes
3341          43.80       2106.05    No
3373          75.45         158.4   Yes
3374          54.85         104.2   Yes
3454          35.65       1025.15    No
3893          51.30        419.35    No
4258         109.55       4830.25   Yes
4382          48.75        179.85    No
4541          50.55         50.55   Yes
4542          79.30          2570    No
4673         102.80        2660.2   Yes
5183          79.60        2718.3   Yes
5251          69.05         318.5   Yes
5319         109.75       8075.35    No
5341          74.45         74.45   Yes
5437          61.60       1174.35   Yes
5476          84.85        415.55   Yes
5569          83.90         267.4   Yes
5680          20.85         20.85   Yes
5743          20.20         735.9    No
5757          25.70         734.6    No
5792          96.30       1426.75   Yes
6031          29.30         355.9    No
6042          19.60         727.8    No
```

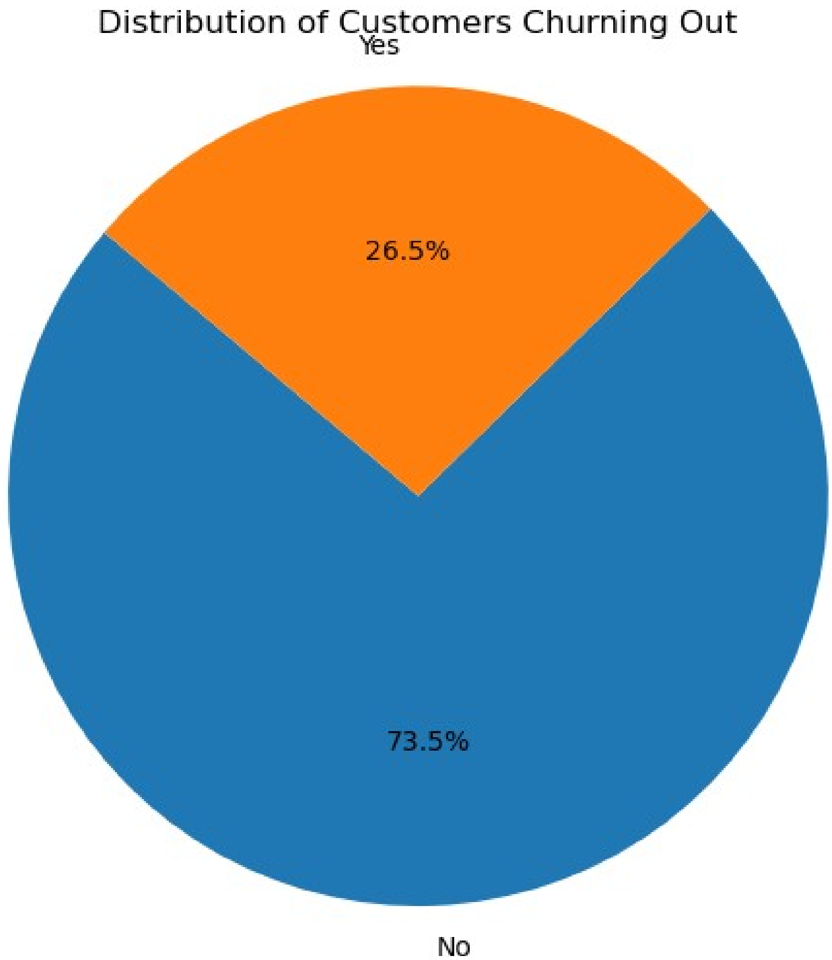
```
6147          99.10       3877.95    No
6178          18.95        1031.1    No
6219          25.70          25.7   Yes
6231          76.40          76.4   Yes
6534          96.75       5206.55    No
6581          72.10       3886.05    No

[50 rows x 21 columns]
```

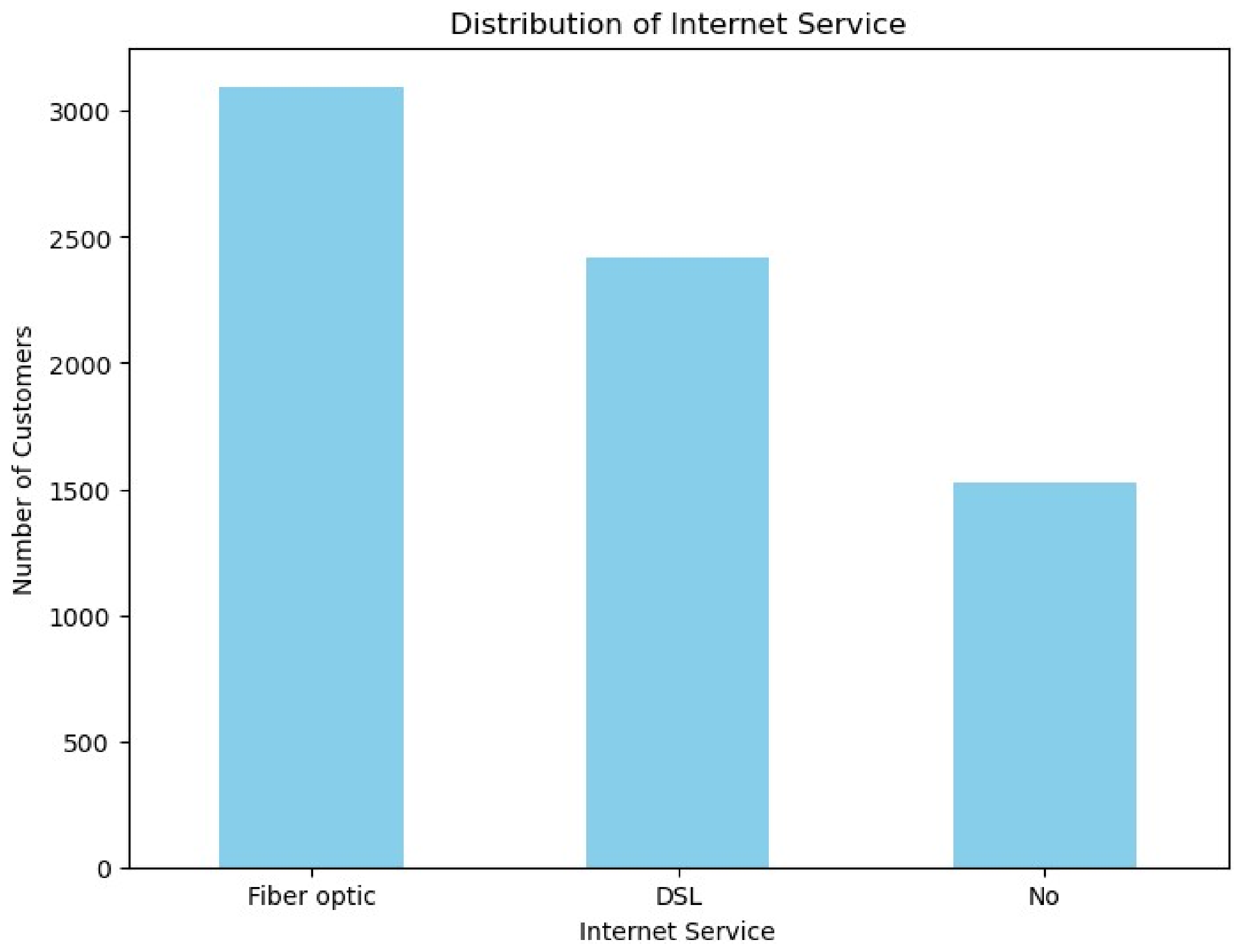
```
df['TotalCharges'] = pd.to_numeric(df['TotalCharges'],
errors='coerce')

new_customer = df[(df['tenure'] < 10) | (df['TotalCharges'] < 500)]
print("Customers with tenure less than 10 months or Total charges less
than $500:")
print(new_customer)
```

```
Customers with tenure less than 10 months or Total charges less than
$500:
      customerID  gender  SeniorCitizen Partner Dependents  tenure  \
0     7590-VHVEG  Female              0     Yes         No       1
2     3668-QPYBK    Male              0      No         No       2
4     9237-HQITU  Female              0      No         No       2
5     9305-CDSKC  Female              0      No         No       8
7     6713-OKOMC  Female              0      No         No      10
...          ...     ...            ...     ...        ...     ...
7029  2235-DWLJU  Female              1      No         No       6
7030  0871-OPBXW  Female              0      No         No       2
7032  6894-LFHLY    Male              1      No         No       1
7040  4801-JZAZL  Female              0     Yes        Yes      11
7041  8361-LTMKD    Male              1     Yes         No       4

     PhoneService     MultipleLines InternetService
OnlineSecurity  ...  \
0              No  No phone service             DSL
No  ...
2             Yes                No             DSL
Yes  ...
4             Yes                No     Fiber optic
No  ...
5             Yes               Yes     Fiber optic
No  ...
7              No  No phone service             DSL
Yes  ...
...           ...               ...             ...                  .
..  ...
7029           No  No phone service             DSL
No  ...
7030          Yes                No              No  No internet
service  ...
```

```
7032          Yes               Yes     Fiber optic
No  ...
7040           No  No phone service             DSL
Yes  ...
7041          Yes               Yes     Fiber optic
No  ...

         DeviceProtection          TechSupport          StreamingTV  \
0                      No                   No                   No
2                      No                   No                   No
4                      No                   No                   No
5                     Yes                   No                  Yes
7                      No                   No                   No
...                   ...                  ...                  ...
7029                   No                   No                  Yes
7030  No internet service  No internet service  No internet service
7032                   No                   No                   No
7040                   No                   No                   No
7041                   No                   No                   No

          StreamingMovies        Contract PaperlessBilling
PaymentMethod  \
0                      No  Month-to-month              Yes  Electronic
check
2                      No  Month-to-month              Yes      Mailed
check
4                      No  Month-to-month              Yes  Electronic
check
5                     Yes  Month-to-month              Yes  Electronic
check
7                      No  Month-to-month               No      Mailed
check
...                   ...             ...              ...
...
7029                  Yes  Month-to-month              Yes  Electronic
check
7030  No internet service  Month-to-month              Yes      Mailed
check
7032                   No  Month-to-month              Yes  Electronic
check
7040                   No  Month-to-month              Yes  Electronic
check
7041                   No  Month-to-month              Yes      Mailed
check

     MonthlyCharges  TotalCharges  Churn
0             29.85         29.85     No
2             53.85        108.15    Yes
4             70.70        151.65    Yes
5             99.65        820.50    Yes
```

```
7               29.75        301.90     No
...               ...           ...    ...
7029            44.40        263.05     No
7030            20.05         39.25     No
7032            75.75         75.75    Yes
7040            29.60        346.45     No
7041            74.40        306.60    Yes

[2233 rows x 21 columns]

# B) Data Visualization:
a. Build a pie-chart to show the distribution of customers would be
churning out
b. Build a bar-plot to show the distribution of ‘Internet Service’

import matplotlib.pyplot as plt
churn_distribution = df['Churn'].value_counts()
plt.figure(figsize=(6, 6))
plt.pie(churn_distribution, labels=churn_distribution.index,
autopct='%1.1f%%', startangle=140)
plt.title('Distribution of Customers Churning Out')
plt.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a
circle
plt.show()

# b. Build a bar-plot to show the distribution of ‘Internet Service’
internet_service_distribution = df['InternetService'].value_counts()
plt.figure(figsize=(8, 6))
internet_service_distribution.plot(kind='bar', color='skyblue')
plt.title('Distribution of Internet Service')
plt.xlabel('Internet Service')
plt.ylabel('Number of Customers')
plt.xticks(rotation=0)  # Rotate x-labels to avoid overlap
plt.show()
```


Distribution of Customers Churning Out
Yes
26.5%
73.5%
No




```
C) Model Building:
a. Build a sequential model using Keras, to find out if the
customerwouldchurn or not, using
‘tenure’ as the feature and ‘Churn’ as the dependent/target column:
i. The visible/input layer should have 12 nodes with ‘Relu’ as
activation function.
ii. This model would have 1 hidden layer with 8 nodes and ‘Relu’ as
activation function
iii. Use ‘Adam’ as the optimization algorithm
iv. Fit the model on the train set, with number of epochs to be 150
v. Predict the values on the test set and build a confusion matrix
vi. Plot the ‘Accuracy vs Epochs’ graph

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from keras.models import Sequential
from keras.layers import Dense
from sklearn.metrics import confusion_matrix

X = df[['tenure']]
y = df['Churn'].map({'No': 0, 'Yes': 1})  # Map 'No' to 0 and 'Yes' to
```

```
1 for binary classification

# Train-test split
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

# Feature scaling
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Build the sequential model
model = Sequential()
model.add(Dense(12, input_dim=1, activation='relu'))  # Input layer
with 12 nodes and 'relu' activation function
model.add(Dense(8, activation='relu'))  # Hidden layer with 8 nodes
and 'relu' activation function
model.add(Dense(1, activation='sigmoid'))  # Output layer with sigmoid
activation function for binary classification

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

# Fit the model on the train set
history = model.fit(X_train_scaled, y_train, epochs=150,
batch_size=10, verbose=1)
y_pred = model.predict_classes(X_test_scaled)

# Build a confusion matrix
conf_matrix = confusion_matrix(y_test, y_pred)
print("Confusion Matrix:")
print(conf_matrix)

# Plot the 'Accuracy vs Epochs' graph
plt.plot(history.history['accuracy'])
plt.title('Accuracy vs Epochs')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.show()
```

```
Epoch 1/150
564/564 [==============================] - 0s 313us/step - loss:
0.5556 - accuracy: 0.7345
Epoch 2/150
564/564 [==============================] - 0s 301us/step - loss:
0.5204 - accuracy: 0.7345
Epoch 3/150
564/564 [==============================] - 0s 298us/step - loss:
0.5163 - accuracy: 0.7345
```

```
Epoch 4/150
564/564 [==============================] - 0s 297us/step - loss:
0.5146 - accuracy: 0.7345
Epoch 5/150
564/564 [==============================] - 0s 297us/step - loss:
0.5140 - accuracy: 0.7345
Epoch 6/150
564/564 [==============================] - 0s 296us/step - loss:
0.5132 - accuracy: 0.7345
Epoch 7/150
564/564 [==============================] - 0s 297us/step - loss:
0.5130 - accuracy: 0.7345
Epoch 8/150
564/564 [==============================] - 0s 296us/step - loss:
0.5127 - accuracy: 0.7352
Epoch 9/150
564/564 [==============================] - 0s 297us/step - loss:
0.5123 - accuracy: 0.7467
Epoch 10/150
564/564 [==============================] - 0s 296us/step - loss:
0.5121 - accuracy: 0.7457
Epoch 11/150
564/564 [==============================] - 0s 296us/step - loss:
0.5122 - accuracy: 0.7492
Epoch 12/150
564/564 [==============================] - 0s 295us/step - loss:
0.5113 - accuracy: 0.7512
Epoch 13/150
564/564 [==============================] - 0s 296us/step - loss:
0.5111 - accuracy: 0.7533
Epoch 14/150
564/564 [==============================] - 0s 297us/step - loss:
0.5108 - accuracy: 0.7512
Epoch 15/150
564/564 [==============================] - 0s 297us/step - loss:
0.5111 - accuracy: 0.7503
Epoch 16/150
564/564 [==============================] - 0s 296us/step - loss:
0.5108 - accuracy: 0.7528
Epoch 17/150
564/564 [==============================] - 0s 297us/step - loss:
0.5111 - accuracy: 0.7538
Epoch 18/150
564/564 [==============================] - 0s 296us/step - loss:
0.5108 - accuracy: 0.7522
Epoch 19/150
564/564 [==============================] - 0s 297us/step - loss:
0.5106 - accuracy: 0.7513
Epoch 20/150
```

```
564/564 [==============================] - 0s 297us/step - loss:
0.5104 - accuracy: 0.7501
Epoch 21/150
564/564 [==============================] - 0s 296us/step - loss:
0.5106 - accuracy: 0.7512
Epoch 22/150
564/564 [==============================] - 0s 297us/step - loss:
0.5105 - accuracy: 0.7528
Epoch 23/150
564/564 [==============================] - 0s 304us/step - loss:
0.5106 - accuracy: 0.7517
Epoch 24/150
564/564 [==============================] - 0s 304us/step - loss:
0.5104 - accuracy: 0.7531
Epoch 25/150
564/564 [==============================] - 0s 299us/step - loss:
0.5101 - accuracy: 0.7551
Epoch 26/150
564/564 [==============================] - 0s 295us/step - loss:
0.5101 - accuracy: 0.7506
Epoch 27/150
564/564 [==============================] - 0s 296us/step - loss:
0.5102 - accuracy: 0.7531
Epoch 28/150
564/564 [==============================] - 0s 295us/step - loss:
0.5102 - accuracy: 0.7512
Epoch 29/150
564/564 [==============================] - 0s 296us/step - loss:
0.5101 - accuracy: 0.7496
Epoch 30/150
564/564 [==============================] - 0s 301us/step - loss:
0.5099 - accuracy: 0.7535
Epoch 31/150
564/564 [==============================] - 0s 294us/step - loss:
0.5102 - accuracy: 0.7513
Epoch 32/150
564/564 [==============================] - 0s 299us/step - loss:
0.5099 - accuracy: 0.7524
Epoch 33/150
564/564 [==============================] - 0s 302us/step - loss:
0.5097 - accuracy: 0.7512
Epoch 34/150
564/564 [==============================] - 0s 303us/step - loss:
0.5100 - accuracy: 0.7519
Epoch 35/150
564/564 [==============================] - 0s 297us/step - loss:
0.5095 - accuracy: 0.7519
Epoch 36/150
564/564 [==============================] - 0s 296us/step - loss:
```

```
0.5106 - accuracy: 0.7506
Epoch 37/150
564/564 [==============================] - 0s 295us/step - loss:
0.5093 - accuracy: 0.7519
Epoch 38/150
564/564 [==============================] - 0s 296us/step - loss:
0.5100 - accuracy: 0.7522
Epoch 39/150
564/564 [==============================] - 0s 295us/step - loss:
0.5094 - accuracy: 0.7540
Epoch 40/150
564/564 [==============================] - 0s 303us/step - loss:
0.5097 - accuracy: 0.7531
Epoch 41/150
564/564 [==============================] - 0s 296us/step - loss:
0.5100 - accuracy: 0.7526
Epoch 42/150
564/564 [==============================] - 0s 296us/step - loss:
0.5093 - accuracy: 0.7524
Epoch 43/150
564/564 [==============================] - 0s 296us/step - loss:
0.5096 - accuracy: 0.7506
Epoch 44/150
564/564 [==============================] - 0s 295us/step - loss:
0.5094 - accuracy: 0.7540
Epoch 45/150
564/564 [==============================] - 0s 298us/step - loss:
0.5092 - accuracy: 0.7515
Epoch 46/150
564/564 [==============================] - 0s 297us/step - loss:
0.5098 - accuracy: 0.7522
Epoch 47/150
564/564 [==============================] - 0s 296us/step - loss:
0.5095 - accuracy: 0.7506
Epoch 48/150
564/564 [==============================] - 0s 296us/step - loss:
0.5097 - accuracy: 0.7526
Epoch 49/150
564/564 [==============================] - 0s 296us/step - loss:
0.5095 - accuracy: 0.7524
Epoch 50/150
564/564 [==============================] - 0s 296us/step - loss:
0.5093 - accuracy: 0.7520
Epoch 51/150
564/564 [==============================] - 0s 295us/step - loss:
0.5095 - accuracy: 0.7526
Epoch 52/150
564/564 [==============================] - 0s 310us/step - loss:
0.5091 - accuracy: 0.7538
```

```
Epoch 53/150
564/564 [==============================] - 0s 297us/step - loss:
0.5093 - accuracy: 0.7545
Epoch 54/150
564/564 [==============================] - 0s 296us/step - loss:
0.5093 - accuracy: 0.7499
Epoch 55/150
564/564 [==============================] - 0s 296us/step - loss:
0.5089 - accuracy: 0.7517
Epoch 56/150
564/564 [==============================] - 0s 296us/step - loss:
0.5094 - accuracy: 0.7520
Epoch 57/150
564/564 [==============================] - 0s 295us/step - loss:
0.5091 - accuracy: 0.7533
Epoch 58/150
564/564 [==============================] - 0s 296us/step - loss:
0.5089 - accuracy: 0.7519
Epoch 59/150
564/564 [==============================] - 0s 296us/step - loss:
0.5092 - accuracy: 0.7542
Epoch 60/150
564/564 [==============================] - 0s 296us/step - loss:
0.5091 - accuracy: 0.7513
Epoch 61/150
564/564 [==============================] - 0s 296us/step - loss:
0.5092 - accuracy: 0.7506
Epoch 62/150
564/564 [==============================] - 0s 295us/step - loss:
0.5092 - accuracy: 0.7512
Epoch 63/150
564/564 [==============================] - 0s 295us/step - loss:
0.5090 - accuracy: 0.7515
Epoch 64/150
564/564 [==============================] - 0s 307us/step - loss:
0.5090 - accuracy: 0.7547
Epoch 65/150
564/564 [==============================] - 0s 297us/step - loss:
0.5088 - accuracy: 0.7528
Epoch 66/150
564/564 [==============================] - 0s 297us/step - loss:
0.5092 - accuracy: 0.7526
Epoch 67/150
564/564 [==============================] - 0s 296us/step - loss:
0.5089 - accuracy: 0.7551
Epoch 68/150
564/564 [==============================] - 0s 296us/step - loss:
0.5089 - accuracy: 0.7529
Epoch 69/150
```

```
564/564 [==============================] - 0s 296us/step - loss:
0.5091 - accuracy: 0.7526
Epoch 70/150
564/564 [==============================] - 0s 296us/step - loss:
0.5094 - accuracy: 0.7490
Epoch 71/150
564/564 [==============================] - 0s 302us/step - loss:
0.5090 - accuracy: 0.7519
Epoch 72/150
564/564 [==============================] - 0s 297us/step - loss:
0.5090 - accuracy: 0.7517
Epoch 73/150
564/564 [==============================] - 0s 297us/step - loss:
0.5091 - accuracy: 0.7512
Epoch 74/150
564/564 [==============================] - 0s 303us/step - loss:
0.5090 - accuracy: 0.7533
Epoch 75/150
564/564 [==============================] - 0s 299us/step - loss:
0.5089 - accuracy: 0.7547
Epoch 76/150
564/564 [==============================] - 0s 297us/step - loss:
0.5087 - accuracy: 0.7533
Epoch 77/150
564/564 [==============================] - 0s 297us/step - loss:
0.5091 - accuracy: 0.7528
Epoch 78/150
564/564 [==============================] - 0s 297us/step - loss:
0.5089 - accuracy: 0.7503
Epoch 79/150
564/564 [==============================] - 0s 296us/step - loss:
0.5090 - accuracy: 0.7536
Epoch 80/150
564/564 [==============================] - 0s 296us/step - loss:
0.5089 - accuracy: 0.7535
Epoch 81/150
564/564 [==============================] - 0s 296us/step - loss:
0.5090 - accuracy: 0.7526
Epoch 82/150
564/564 [==============================] - 0s 296us/step - loss:
0.5089 - accuracy: 0.7526
Epoch 83/150
564/564 [==============================] - 0s 296us/step - loss:
0.5088 - accuracy: 0.7545
Epoch 84/150
564/564 [==============================] - 0s 296us/step - loss:
0.5094 - accuracy: 0.7524
Epoch 85/150
564/564 [==============================] - 0s 297us/step - loss:
```

```
0.5085 - accuracy: 0.7522
Epoch 86/150
564/564 [==============================] - 0s 295us/step - loss:
0.5087 - accuracy: 0.7536
Epoch 87/150
564/564 [==============================] - 0s 296us/step - loss:
0.5085 - accuracy: 0.7552
Epoch 88/150
564/564 [==============================] - 0s 296us/step - loss:
0.5086 - accuracy: 0.7535
Epoch 89/150
564/564 [==============================] - 0s 298us/step - loss:
0.5089 - accuracy: 0.7499
Epoch 90/150
564/564 [==============================] - 0s 297us/step - loss:
0.5089 - accuracy: 0.7528
Epoch 91/150
564/564 [==============================] - 0s 297us/step - loss:
0.5091 - accuracy: 0.7517
Epoch 92/150
564/564 [==============================] - 0s 297us/step - loss:
0.5086 - accuracy: 0.7517
Epoch 93/150
564/564 [==============================] - 0s 296us/step - loss:
0.5088 - accuracy: 0.7528
Epoch 94/150
564/564 [==============================] - 0s 297us/step - loss:
0.5088 - accuracy: 0.7545
Epoch 95/150
564/564 [==============================] - 0s 297us/step - loss:
0.5089 - accuracy: 0.7515
Epoch 96/150
564/564 [==============================] - 0s 297us/step - loss:
0.5089 - accuracy: 0.7535
Epoch 97/150
564/564 [==============================] - 0s 297us/step - loss:
0.5093 - accuracy: 0.7531
Epoch 98/150
564/564 [==============================] - 0s 298us/step - loss:
0.5089 - accuracy: 0.7524
Epoch 99/150
564/564 [==============================] - 0s 300us/step - loss:
0.5089 - accuracy: 0.7504
Epoch 100/150
564/564 [==============================] - 0s 297us/step - loss:
0.5089 - accuracy: 0.7528
Epoch 101/150
564/564 [==============================] - 0s 299us/step - loss:
0.5088 - accuracy: 0.7533
```

```
Epoch 102/150
564/564 [==============================] - 0s 298us/step - loss:
0.5087 - accuracy: 0.7529
Epoch 103/150
564/564 [==============================] - 0s 297us/step - loss:
0.5090 - accuracy: 0.7519
Epoch 104/150
564/564 [==============================] - 0s 299us/step - loss:
0.5091 - accuracy: 0.7526
Epoch 105/150
564/564 [==============================] - 0s 299us/step - loss:
0.5087 - accuracy: 0.7552
Epoch 106/150
564/564 [==============================] - 0s 298us/step - loss:
0.5088 - accuracy: 0.7519
Epoch 107/150
564/564 [==============================] - 0s 298us/step - loss:
0.5086 - accuracy: 0.7517
Epoch 108/150
564/564 [==============================] - 0s 297us/step - loss:
0.5088 - accuracy: 0.7545
Epoch 109/150
564/564 [==============================] - 0s 298us/step - loss:
0.5088 - accuracy: 0.7524
Epoch 110/150
564/564 [==============================] - 0s 300us/step - loss:
0.5088 - accuracy: 0.7494
Epoch 111/150
564/564 [==============================] - 0s 299us/step - loss:
0.5086 - accuracy: 0.7528
Epoch 112/150
564/564 [==============================] - 0s 298us/step - loss:
0.5089 - accuracy: 0.7529
Epoch 113/150
564/564 [==============================] - 0s 299us/step - loss:
0.5090 - accuracy: 0.7522
Epoch 114/150
564/564 [==============================] - 0s 298us/step - loss:
0.5090 - accuracy: 0.7531
Epoch 115/150
564/564 [==============================] - 0s 299us/step - loss:
0.5091 - accuracy: 0.7520
Epoch 116/150
564/564 [==============================] - 0s 299us/step - loss:
0.5091 - accuracy: 0.7504
Epoch 117/150
564/564 [==============================] - 0s 299us/step - loss:
0.5087 - accuracy: 0.7503
Epoch 118/150
```

```
564/564 [==============================] - 0s 299us/step - loss:
0.5086 - accuracy: 0.7519
Epoch 119/150
564/564 [==============================] - 0s 300us/step - loss:
0.5091 - accuracy: 0.7529
Epoch 120/150
564/564 [==============================] - 0s 308us/step - loss:
0.5088 - accuracy: 0.7538
Epoch 121/150
564/564 [==============================] - 0s 299us/step - loss:
0.5088 - accuracy: 0.7536
Epoch 122/150
564/564 [==============================] - 0s 300us/step - loss:
0.5088 - accuracy: 0.7503
Epoch 123/150
564/564 [==============================] - 0s 300us/step - loss:
0.5088 - accuracy: 0.7528
Epoch 124/150
564/564 [==============================] - 0s 300us/step - loss:
0.5088 - accuracy: 0.7547
Epoch 125/150
564/564 [==============================] - 0s 293us/step - loss:
0.5085 - accuracy: 0.7529
Epoch 126/150
564/564 [==============================] - 0s 304us/step - loss:
0.5086 - accuracy: 0.7522
Epoch 127/150
564/564 [==============================] - 0s 304us/step - loss:
0.5091 - accuracy: 0.7504
Epoch 128/150
564/564 [==============================] - 0s 305us/step - loss:
0.5086 - accuracy: 0.7515
Epoch 129/150
564/564 [==============================] - 0s 300us/step - loss:
0.5085 - accuracy: 0.7543
Epoch 130/150
564/564 [==============================] - 0s 300us/step - loss:
0.5086 - accuracy: 0.7504
Epoch 131/150
564/564 [==============================] - 0s 300us/step - loss:
0.5090 - accuracy: 0.7533
Epoch 132/150
564/564 [==============================] - 0s 300us/step - loss:
0.5086 - accuracy: 0.7552
Epoch 133/150
564/564 [==============================] - 0s 311us/step - loss:
0.5088 - accuracy: 0.7529
Epoch 134/150
564/564 [==============================] - 0s 301us/step - loss:
```

```
0.5089 - accuracy: 0.7531
Epoch 135/150
564/564 [==============================] - 0s 300us/step - loss:
0.5085 - accuracy: 0.7547
Epoch 136/150
564/564 [==============================] - 0s 300us/step - loss:
0.5088 - accuracy: 0.7529
Epoch 137/150
564/564 [==============================] - 0s 299us/step - loss:
0.5093 - accuracy: 0.7512
Epoch 138/150
564/564 [==============================] - 0s 300us/step - loss:
0.5087 - accuracy: 0.7517
Epoch 139/150
564/564 [==============================] - 0s 300us/step - loss:
0.5090 - accuracy: 0.7538
Epoch 140/150
564/564 [==============================] - 0s 300us/step - loss:
0.5090 - accuracy: 0.7540
Epoch 141/150
564/564 [==============================] - 0s 300us/step - loss:
0.5084 - accuracy: 0.7547
Epoch 142/150
564/564 [==============================] - 0s 299us/step - loss:
0.5088 - accuracy: 0.7517
Epoch 143/150
564/564 [==============================] - 0s 299us/step - loss:
0.5086 - accuracy: 0.7520
Epoch 144/150
564/564 [==============================] - 0s 311us/step - loss:
0.5084 - accuracy: 0.7549
Epoch 145/150
564/564 [==============================] - 0s 300us/step - loss:
0.5088 - accuracy: 0.7547
Epoch 146/150
564/564 [==============================] - 0s 299us/step - loss:
0.5089 - accuracy: 0.7515
Epoch 147/150
564/564 [==============================] - 0s 302us/step - loss:
0.5092 - accuracy: 0.7513
Epoch 148/150
564/564 [==============================] - 0s 300us/step - loss:
0.5087 - accuracy: 0.7519
Epoch 149/150
564/564 [==============================] - 0s 300us/step - loss:
0.5086 - accuracy: 0.7533
Epoch 150/150
564/564 [==============================] - 0s 300us/step - loss:
0.5088 - accuracy: 0.7538
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
Cell In[16], line 23
     21 # Fit the model on the train set
     22 history = model.fit(X_train_scaled, y_train, epochs=150, batch_size=10, verbose=1)
---> 23 y_pred = model.predict_classes(X_test_scaled)
     25 # Build a confusion matrix
     26 conf_matrix = confusion_matrix(y_test, y_pred)

AttributeError: 'Sequential' object has no attribute 'predict_classes'
```

```
plt.plot(history.history['accuracy'])
plt.title('Accuracy vs Epochs')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.show()
```