TASK-2

Develop the ML model(s) to predict the credit risk(low or high) for a given applicant.

Business Constraint: Note that it is worse to state an applicant as a low credit risk when they are actually a high risk(Type2) - False Negative , than it is to state an applicant to be a high credit risk when they aren't(Type1) - False Positive.

In [1]:
```
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
data = pd.read_csv('data2')
```

In [3]:
```
data.head()
```

Out[3]:

	Unnamed: 0	applicant_id	Primary_applicant_age_in_years	Gender	Marital_status	Numbe
0	0	436	67	1	3	
1	1	115	22	0	1	
2	2	380	49	1	3	
3	3	117	45	1	3	
4	4	713	53	1	3	

In [4]:
```
data.drop(['Unnamed: 0','loan_application_id','applicant_id','Principal_loa
```

In [5]:
```
data.head(2)
```

Out[5]:

	Primary_applicant_age_in_years	Marital_status	Number_of_dependents	Housing	Years_
0	67	3	1	1	
1	22	1	1	1	

In [6]:
```
X = data.loc[:, data.columns != 'high_risk_applicant' ] # independent vari

y = data.loc[:, data.columns == 'high_risk_applicant'] #target variable
```

In [7]:
```
X = pd.get_dummies(X, drop_first=True)
```

In [8]:
```
X.head()
```

Out[8]:

	Primary_applicant_age_in_years	Marital_status	Number_of_dependents	Housing	Years_
0	67	3	1	1	
1	22	1	1	1	
2	49	3	2	1	
3	45	3	2	0	
4	53	3	2	0	

In [9]:
```
y.head()
```

Out[9]:

	high_risk_applicant
0	0
1	1
2	0
3	0
4	1

In [10]:
```
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix
from sklearn.linear_model import LogisticRegression
```

In [11]:
```
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.3,random_s
```

In [12]:
```
X_train.head()
```

Out[12]:

	Primary_applicant_age_in_years	Marital_status	Number_of_dependents	Housing	Yea
834	25	1	1	1	
227	53	3	1	0	
471	23	1	1	1	
929	43	3	2	1	
457	35	3	1	0	

In [13]:
```
X_test.head()
```

Out[13]:

	Primary_applicant_age_in_years	Marital_status	Number_of_dependents	Housing	Yea
518	43	3	1	1	
871	46	3	2	1	
797	22	1	1	2	
274	34	0	1	1	
325	39	3	1	1	

In [14]:
```
X_train.shape,X_test.shape
```

Out[14]:
```
((700, 13), (300, 13))
```

In [15]:
```
logreg = LogisticRegression()
logreg.fit(X_train, y_train)
```

Out[15]:
```
▾ LogisticRegression
LogisticRegression()
```

In [16]:
```
y_pred = logreg.predict(X_test)
print('Accuracy of logistic regression classifier on test set: {:.2f}'.forr
```

```
Accuracy of logistic regression classifier on test set: 0.71
```

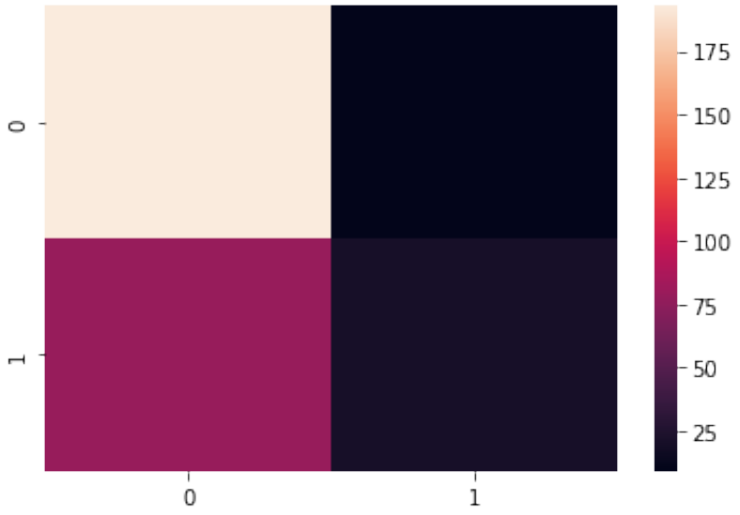
In [17]:
```
from sklearn.metrics import confusion_matrix
confusion_matrix = confusion_matrix(y_test, y_pred)
```

In [18]:
```
confusion_matrix
```

Out[18]:
```
array([[193,   9],
       [ 78,  20]])
```

In [19]:
```
sns.heatmap(confusion_matrix)
```

Out[19]: <AxesSubplot:>



In [20]:
```
TN = 193
FP = 78
FN = 9
TP = 20
```

In [21]:
```
TPR = 11/(11+4) #TPR = TP/P
TPR
```

Out[21]: 0.7333333333333333

In [22]:
```
TNR = 198/(198+87) #TNR = TN/N
TNR
```

Out[22]: 0.6947368421052632

In [23]:
```
FPR = 87/(198+87) #FPR = FP/N
FPR
```

Out[23]: 0.30526315789473685

In [24]:
```
FNR = 4/(11+4) #FNR = FN/p
FNR
```

Out[24]: 0.26666666666666666

In [25]:
```
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred))
```

```
                precision    recall  f1-score   support

           0       0.71      0.96      0.82       202
           1       0.69      0.20      0.31        98

    accuracy                           0.71       300
   macro avg       0.70      0.58      0.57       300
weighted avg       0.70      0.71      0.65       300
```

In [26]:
```
data = pd.read_csv('data2')
```

In [27]:
```
data.head()
```

Out[27]:

	Unnamed: 0	applicant_id	Primary_applicant_age_in_years	Gender	Marital_status	Numbe
0	0	436	67	1	3	
1	1	115	22	0	1	
2	2	380	49	1	3	
3	3	117	45	1	3	
4	4	713	53	1	3	

In [28]:
```
data.drop(['Unnamed: 0','loan_application_id','applicant_id','Principal_loa
```

In [29]:
```
data.head()
```

Out[29]:

	Primary_applicant_age_in_years	Gender	Number_of_dependents	Housing	Years_at_cur
0	67	1	1	1	
1	22	0	1	1	
2	49	1	2	1	
3	45	1	2	0	
4	53	1	2	0	

In [30]:
```
X = data.loc[:, data.columns != 'high_risk_applicant']  # independent vari

y = data.loc[:, data.columns == 'high_risk_applicant']  # Target variable
```

In [31]:
```
X = pd.get_dummies(X,drop_first=True)
```

In [32]:
```
y.head()
```

Out[32]:

	high_risk_applicant
0	0
1	1
2	0
3	0
4	1

In [33]:
```
X.head()
```

Out[33]:

	Primary_applicant_age_in_years	Gender	Number_of_dependents	Housing	Years_at_cur
0	67	1	1	1	
1	22	0	1	1	
2	49	1	2	1	
3	45	1	2	0	
4	53	1	2	0	

In [34]:
```
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,rando
```

In [35]:
```
X_train.shape,X_test.shape
```

Out[35]:
```
((700, 13), (300, 13))
```

In [36]:
```
X_train.head()
```

Out[36]:

	Primary_applicant_age_in_years	Gender	Number_of_dependents	Housing	Years_at_c
570	23	0	1	2	
137	66	1	1	1	
953	26	0	1	1	
882	36	1	1	1	
606	74	1	1	1	

In [37]:
```
from sklearn.metrics import confusion_matrix, recall_score, precision_score
```

In [38]:
```
# Logistic Regression
from sklearn.linear_model import LogisticRegression
model = LogisticRegression(random_state=7)

model.fit(X_train, y_train)
```

Out[38]:
```
LogisticRegression(random_state=7)
```

In [39]:
```
model.coef_.round(2)
```

Out[39]:
```
array([[-0.02, -0.5 ,  0.05,  0.17, -0.03, -0.02,  0.41,  0.03,  0.12,
         0.88, -0.58, -0.15,  0.03]])
```

In [40]:
```
model.intercept_.round(2)
```

Out[40]:
```
array([-1.41])
```

In [41]:
```
y_pred_class=model.predict(X_test)
y_pred_prob=model.predict_proba(X_test)
```

In [42]:
```
y_pred_class[:20]
```

Out[42]:
```
array([0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0])
```

In [43]:
```
y_pred_class[:5][:]
```

Out[43]:
```
array([0, 0, 0, 0, 0])
```

In [44]:
```
y_pred_prob[:5,:]
```

Out[44]:
```
array([[0.76572881, 0.23427119],
       [0.82419106, 0.17580894],
       [0.699331  , 0.300669  ],
       [0.81894042, 0.18105958],
       [0.57882288, 0.42117712]])
```

In [45]:
```
y_pred_prob[:5,0]
```

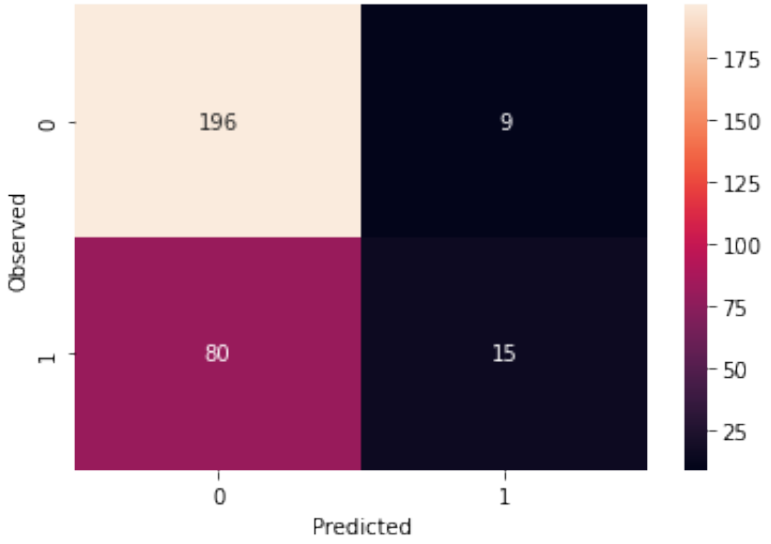
Out[45]:
```
array([0.76572881, 0.82419106, 0.699331  , 0.81894042, 0.57882288])
```

In [46]:
```
#y_pred_prob[:20,:]
(y_pred_prob[:5,0]>0.5)*1
```

Out[46]:
```
array([1, 1, 1, 1, 1])
```

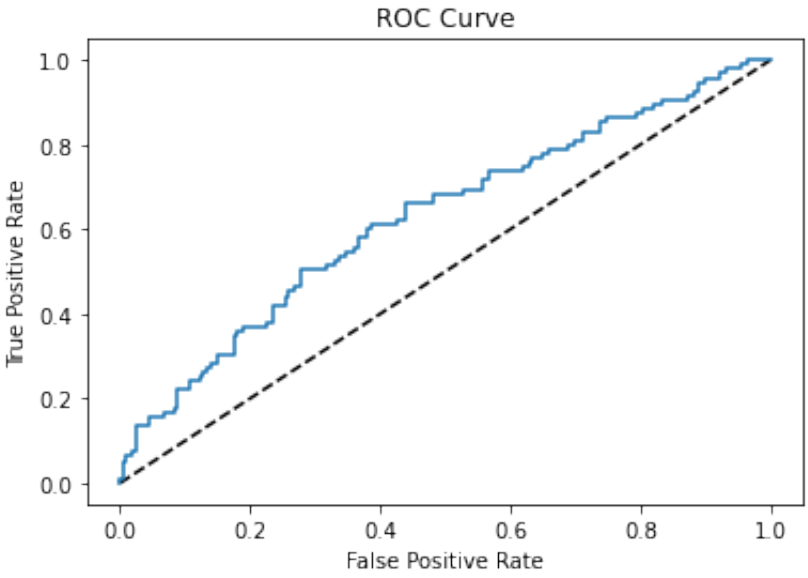
In [47]:
```
## function to get confusion matrix in a proper format
def draw_cm( actual, predicted ):
    cm = confusion_matrix( actual, predicted)
    sns.heatmap(cm, annot=True,  fmt='.0f', xticklabels = [0,1] , yticklabe
    plt.ylabel('Observed')
    plt.xlabel('Predicted')
    plt.show()
```

In [48]:
```
draw_cm(y_test,y_pred_class);
```



In [49]:
```
fpr, tpr, thresholds = roc_curve(y_test, y_pred_prob[:,1])
```

In [50]:
```
# Plot ROC curve
plt.plot([0, 1], [0, 1], 'k--')
plt.plot(fpr, tpr)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.show()
```



In [51]:
```
data_ = pd.read_csv('data2')
```

In [52]:
```
data_.drop(['Unnamed: 0','loan_application_id','applicant_id','Marital_sta
```

In [53]:
```
data_.head()
```

Out[53]:

	Primary_applicant_age_in_years	Gender	Employment_status	Months_loan_taken_for	N
0	67	1	1	6	
1	22	0	1	48	
2	49	1	3	12	
3	45	1	1	42	
4	53	1	1	24	

In [54]:
```
X = data_.loc[:, data_.columns != 'high_risk_applicant']  # independent va

y = data_.loc[:, data_.columns == 'high_risk_applicant']  # Target variabl
```

In [55]:
```
X = pd.get_dummies(X,drop_first=True)
```

In [56]:
```
y.head()
```

Out[56]:

	high_risk_applicant
0	0
1	1
2	0
3	0
4	1

In [57]:
```
X.head()
```

Out[57]:

	Primary_applicant_age_in_years	Gender	Employment_status	Months_loan_taken_for	Nu
0	67	1	1	6	
1	22	0	1	48	
2	49	1	3	12	
3	45	1	1	42	
4	53	1	1	24	

In [58]:
```
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,rando
```

In [59]:
```
X_train.shape,X_test.shape
```

Out[59]:
```
((700, 6), (300, 6))
```

In [60]:
```
X_train.head()
```

Out[60]:

	Primary_applicant_age_in_years	Gender	Employment_status	Months_loan_taken_for
570	23	0	3	24
137	66	1	3	12
953	26	0	0	36
882	36	1	1	30
606	74	1	0	24

In [61]:
```
from sklearn.metrics import confusion_matrix, recall_score, precision_score
```

In [62]:
```
# Logistic Regression
from sklearn.linear_model import LogisticRegression
model = LogisticRegression(random_state=7)

model.fit(X_train, y_train)
```

Out[62]:
```
▾ LogisticRegression
LogisticRegression(random_state=7)
```

In [63]:
```
model.coef_.round(2)
```

Out[63]:
```
array([[-0.02, -0.53, -0.02,  0.04, -0.03,  0.08]])
```

In [64]:
```
model.intercept_.round(2)
```

Out[64]:
```
array([-0.78])
```

In [65]:
```
y_pred_class=model.predict(X_test)
y_pred_prob=model.predict_proba(X_test)
```

In [66]:
```
y_pred_class[:20]
```

Out[66]:
```
array([0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0])
```

In [67]:
```
y_pred_class[:5][:]
```

Out[67]:
```
array([0, 0, 0, 0, 0])
```

In [68]:
```
y_pred_prob[:5,:]
```

Out[68]:
```
array([[0.74116869, 0.25883131],
       [0.81851872, 0.18148128],
       [0.64998628, 0.35001372],
       [0.74147581, 0.25852419],
       [0.64224862, 0.35775138]])
```

In [69]:
```
y_pred_prob[:5,0]
```

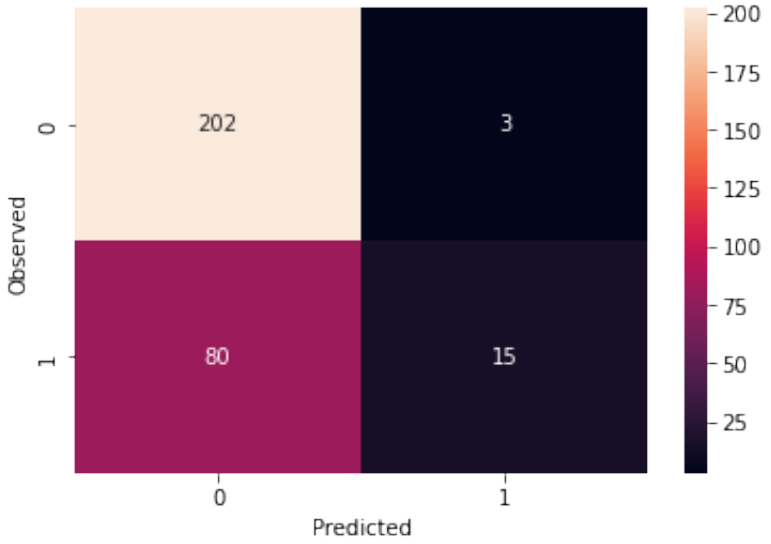
Out[69]:
```
array([0.74116869, 0.81851872, 0.64998628, 0.74147581, 0.64224862])
```

In [70]:
```
#y_pred_prob[:20,:]
(y_pred_prob[:5,0]>0.5)*1
```

Out[70]:
```
array([1, 1, 1, 1, 1])
```

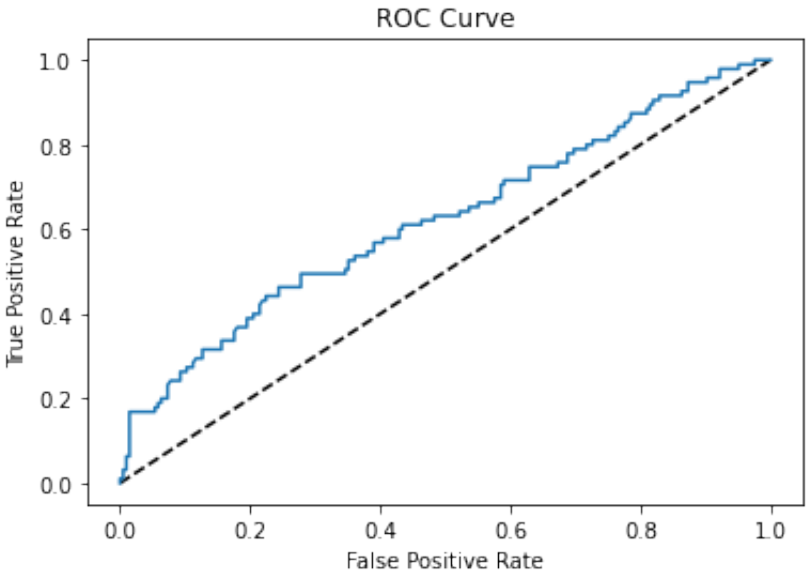
In [71]:
```
## function to get confusion matrix in a proper format
def draw_cm( actual, predicted ):
    cm = confusion_matrix( actual, predicted)
    sns.heatmap(cm, annot=True,  fmt='.0f', xticklabels = [0,1] , yticklabe
    plt.ylabel('Observed')
    plt.xlabel('Predicted')
    plt.show()
```

In [72]:
```
draw_cm(y_test,y_pred_class);
```



In [73]:
```
fpr, tpr, thresholds = roc_curve(y_test, y_pred_prob[:,1])
```

In [74]:
```
# Plot ROC curve
plt.plot([0, 1], [0, 1], 'k--')
plt.plot(fpr, tpr)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.show()
```



In [75]:
```
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_class))
```

```
              precision    recall  f1-score   support

           0       0.72      0.99      0.83       205
           1       0.83      0.16      0.27        95

    accuracy                           0.72       300
   macro avg       0.77      0.57      0.55       300
weighted avg       0.75      0.72      0.65       300
```

In [76]:
```
data_.head()
```

Out[76]:

	Primary_applicant_age_in_years	Gender	Employment_status	Months_loan_taken_for	N
0	67	1	1	6	
1	22	0	1	48	
2	49	1	3	12	
3	45	1	1	42	
4	53	1	1	24	

In [77]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
```

In [78]:
```
scaler.fit(data_.drop('high_risk_applicant',axis=1))
```

Out[78]:
```
▾ StandardScaler
StandardScaler()
```

In [79]:
```
scaled_features = scaler.transform(data_.drop('high_risk_applicant',axis=1
```

In [80]:
```
df_feat = pd.DataFrame(scaled_features,columns=data_.columns[:-1])
```

In [81]:
```
df_feat.head()
```

Out[81]:

	Primary_applicant_age_in_years	Gender	Employment_status	Months_loan_taken_for
0	2.766456	0.670280	-0.289639	-1.236478
1	-1.191404	-1.491914	-0.289639	2.248194
2	1.183312	0.670280	1.824516	-0.738668
3	0.831502	0.670280	-0.289639	1.750384
4	1.535122	0.670280	-0.289639	0.256953

In [82]:
```
X_train, X_test, y_train, y_test = train_test_split(scaled_features,data_[
                                                    test_size=0.30,random_s
```

In [83]:
```
from sklearn.neighbors import KNeighborsClassifier
```

In [84]:
```
knn = KNeighborsClassifier(n_neighbors=1)
```

In [85]:
```
knn.fit(X_train,y_train)
```

Out[85]:
```
▾          KNeighborsClassifier
KNeighborsClassifier(n_neighbors=1)
```

In [86]:
```
pred = knn.predict(X_test)
```

In [87]:
```
from sklearn.metrics import classification_report,confusion_matrix
```

In [88]:
```
print(confusion_matrix(y_test,pred))
```

```
[[148  56]
 [ 56  40]]
```

In [89]:

```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

           0       0.73      0.73      0.73       204
           1       0.42      0.42      0.42        96

    accuracy                           0.63       300
   macro avg       0.57      0.57      0.57       300
weighted avg       0.63      0.63      0.63       300
```

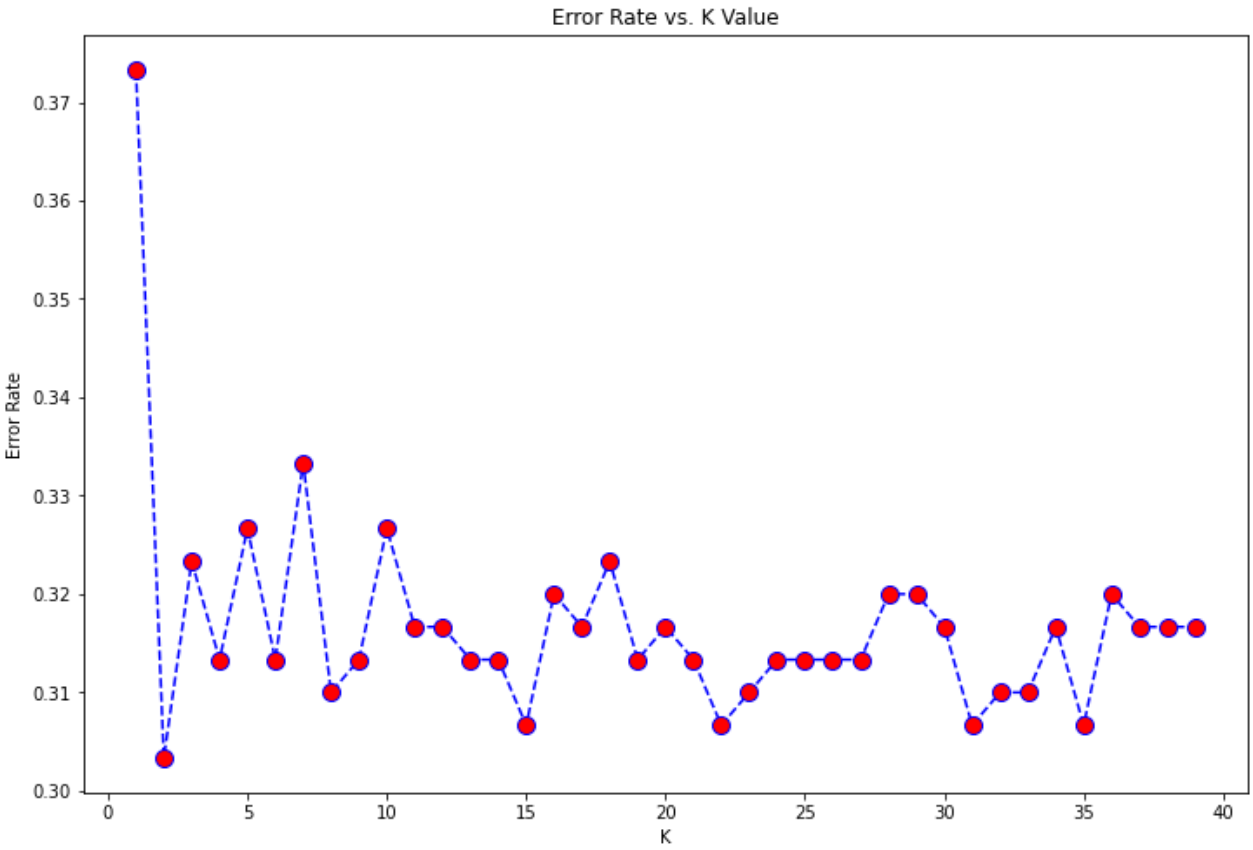
In [90]:

```
import numpy as np
error_rate = []
test_scores = []
train_scores = []

# Will take some time
for i in range(1,40):

    knn = KNeighborsClassifier(n_neighbors=i)
    knn.fit(X_train,y_train)
    pred_i = knn.predict(X_test)

    error_rate.append(np.mean(pred_i != y_test))
    train_scores.append(knn.score(X_train,y_train))
    test_scores.append(knn.score(X_test,y_test))
```

In [91]:

```
plt.figure(figsize=(12,8))
plt.plot(range(1,40),error_rate,color='blue', linestyle='dashed', marker='
         markerfacecolor='red', markersize=10)
plt.title('Error Rate vs. K Value')
plt.xlabel('K')
plt.ylabel('Error Rate')
```

Out[91]:
```
Text(0, 0.5, 'Error Rate')
```



In [92]:
```
## score that comes from testing on the same datapoints that were used for
max_train_score = max(train_scores)
train_scores_ind = [i for i, v in enumerate(train_scores) if v == max_trai
print('Max train score {} % and k = {}'.format(max_train_score*100,list(ma
```

```
Max train score 96.57142857142857 % and k = [1]
```

In [93]:
```
## score that comes from testing on the datapoints that were split in the
max_test_score = max(test_scores)
test_scores_ind = [i for i, v in enumerate(test_scores) if v == max_test_s
print('Max test score {} % and k = {}'.format(max_test_score*100,list(map(
```

```
Max test score 69.66666666666667 % and k = [2]
```

In [94]:
```
# NOW WITH K=20
knn = KNeighborsClassifier(n_neighbors=20)

knn.fit(X_train,y_train)
pred = knn.predict(X_test)

print('WITH K=20')
print('\n')
print(confusion_matrix(y_test,pred))
print('\n')
print(classification_report(y_test,pred))
```

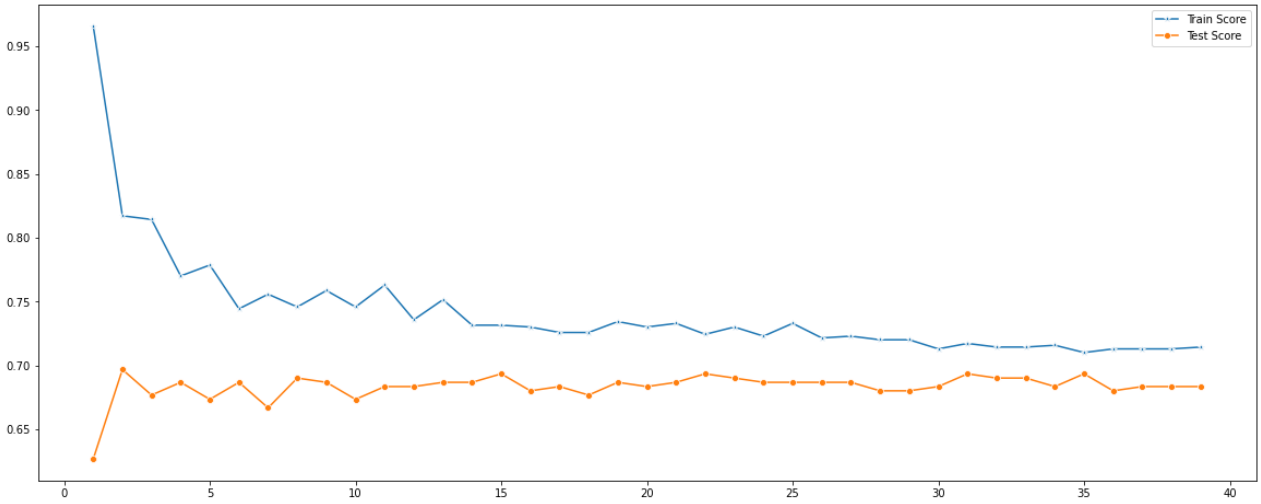
```
WITH K=20


[[193  11]
 [ 84  12]]

              precision    recall  f1-score   support

           0       0.70      0.95      0.80       204
           1       0.52      0.12      0.20        96

    accuracy                           0.68       300
   macro avg       0.61      0.54      0.50       300
weighted avg       0.64      0.68      0.61       300
```

In [95]:

```
plt.figure(figsize=(20,8))
sns.lineplot(range(1,40),train_scores,marker='*',label='Train Score')
sns.lineplot(range(1,40),test_scores,marker='o',label='Test Score')
```

Out[95]:

```
<AxesSubplot:>
```



In [96]:

```
#Setup a knn classifier with k neighbors
knn = KNeighborsClassifier(20)

knn.fit(X_train,y_train)
knn.score(X_test,y_test)
```

Out[96]:

```
0.6833333333333333
```

In [97]:

```
#import confusion_matrix
from sklearn.metrics import confusion_matrix
```

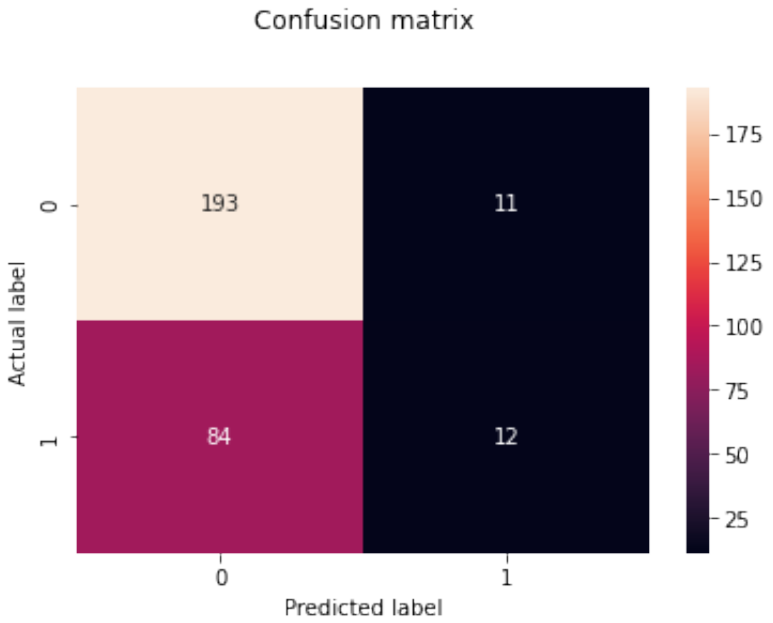
In [98]:
```
#let us get the predictions using the classifier we had fit above
y_pred = knn.predict(X_test)
confusion_matrix(y_test,y_pred)
pd.crosstab(y_test, y_pred, rownames=['True'], colnames=['Predicted'], marg
```

Out[98]:

Predicted	0	1	All
True			
0	193	11	204
1	84	12	96
All	277	23	300

In [99]:
```
from sklearn import metrics

cnf_matrix = metrics.confusion_matrix(y_test, y_pred)
p = sns.heatmap(pd.DataFrame(cnf_matrix), annot=True,fmt='g')
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[99]:
```
Text(0.5, 15.0, 'Predicted label')
```



In [100…
```
12/(12+11)
```

Out[100…
```
0.5217391304347826
```

In [101…
```
#import classification_report
from sklearn.metrics import classification_report
print(classification_report(y_test,y_pred))
```

	precision	recall	f1-score	support
0	0.70	0.95	0.80	204
1	0.52	0.12	0.20	96
accuracy			0.68	300
macro avg	0.61	0.54	0.50	300
weighted avg	0.64	0.68	0.61	300

In [102…

```
#Import scikit-learn metrics module for accuracy calculation
from sklearn import metrics

# Printing the Overall Accuracy of the model
print("Accuracy of the model : {0:0.3f}".format(metrics.accuracy_score(y_te
```

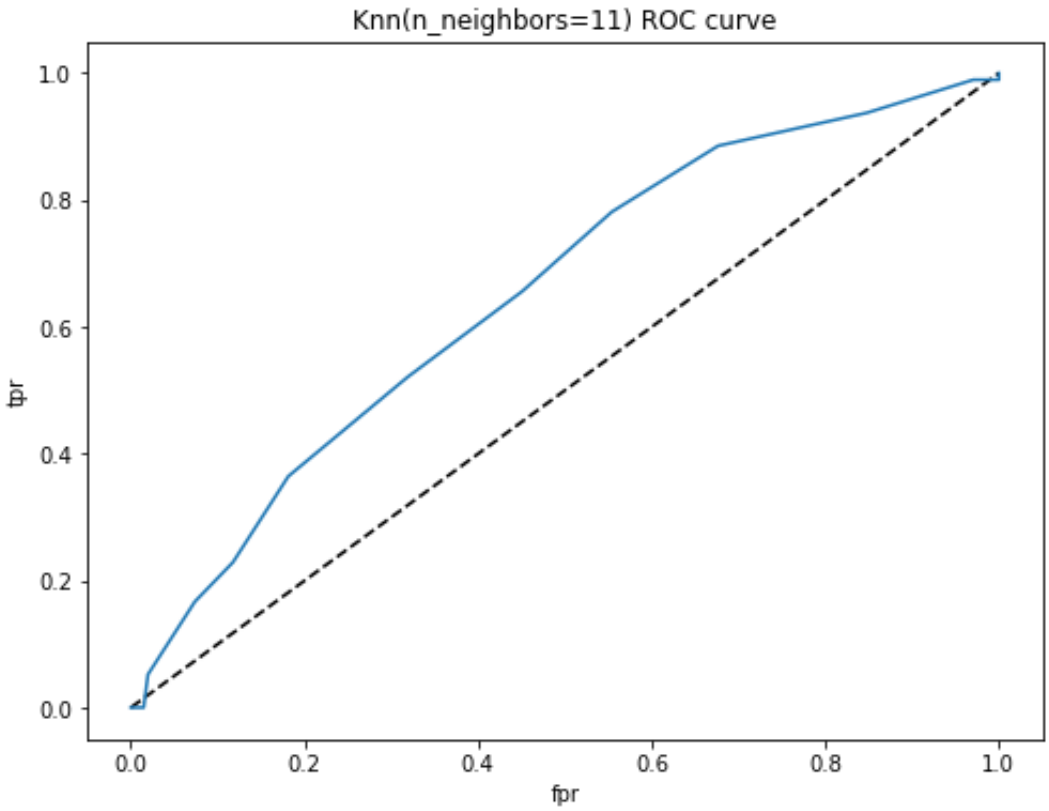
```
Accuracy of the model : 0.683
```

In [103…

```
y_pred_proba = knn.predict_proba(X_test)[:,1]
fpr, tpr, thresholds = roc_curve(y_test, y_pred_proba)
```

In [104…

```
plt.figure(figsize=(8,6))
plt.plot([0,1],[0,1],'k--')
plt.plot(fpr,tpr, label='Knn')
plt.xlabel('fpr')
plt.ylabel('tpr')
plt.title('Knn(n_neighbors=11) ROC curve')
plt.show()
```



In [105…

```
#Area under ROC curve
from sklearn.metrics import roc_auc_score
roc_auc_score(y_test,y_pred_proba)
```

Out[105… 0.6520118464052287

Provide the answers for the below points:

1. Explain your intuition behind the features used for modeling.

- Dropped Id Columns, Tried Both Keeping ''Principal_loan_amount'' & Removing also, Removing It Increases Accuracy,Keeping It Just Increases The Calculation Part It's Of No Use For Our Prediction Part.

1. Are you creating new derived features? If yes explain the intuition behind them.

- No.

1. Are there missing values? If yes how you plan to handle it.

- Yes, Dropped The Columns Containing Missing Values.

1. How categorical features are handled for modeling.

- Applied Label Encoder.

1. Describe the features correlation using correlation matrix. Tell us about few correlated feature & share your understanding on why they are correlated.

- Marital_status & Gender (Strong Positive Correlation 0.75), Principal_loan_amount & Months_loan_taken_for (Strong Positive Correlation 0.62).

1. Do you plan to drop the correlated feature? If yes then how.

- Tried Both Keeping And Removing, Gender, Marital, Principal_loan_amount, Months_loan_taken_for, Removing It Increases Accuracy,Keeping It Just Increases The Calculation Part It's Of No Use For Our Prediction Part.

1. Which ML algorithm you plan to use for modeling.

- Logistic Regression, KNN.