In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np

import warnings
warnings.filterwarnings('ignore')

from matplotlib.pyplot import MultipleLocator
from sklearn.preprocessing import LabelEncoder,StandardScaler
from sklearn.model_selection import train_test_split,cross_val_score, GridSea
from sklearn.neighbors import KNeighborsClassifier, KNeighborsRegressor,Neare
from sklearn.metrics import classification_report,f1_score,precision_recall_c
from sklearn.neural_network import MLPClassifier
from sklearn import tree
from imblearn.datasets import make_imbalance
from imblearn.under_sampling import NearMiss
from collections import Counter
```

Data Cleaning

In [2]:
```
df = pd.read_csv('Data2015_2016.csv')
```

In [3]:
```
df = df.dropna()
```

In [4]:
```
df.isnull().sum()
```

Out[4]:
```
SEQN                      0
Age                       0
Body_Mass_Index           0
Gender                    0
Physical_Activity         0
Total_Caffeine            0
Food_Security             0
Count_Meds                0
Heart_Medication          0
Eye_Medication            0
Diabetes                  0
Race_and_Ethnicity        0
Total_Sodium_Intake       0
Diastolic_Blood_Pressure  0
Systolic_Blood_Pressure   0
dtype: int64
```

In [5]:
```
data2015_2016 = df.loc[~((df['Diastolic_Blood_Pressure'] == 0) | (df['Systoli
data2015_2016
```

Out[5]:

	SEQN	Age	Body_Mass_Index	Gender	Physical_Activity	Total_Caffeine	Food_Security
0	83732	62	27.8	1	0	360	2
1	83733	53	30.8	1	0	192	2
2	83734	78	28.8	1	8	306	2
3	83735	56	42.4	2	2	248	2
4	83736	42	20.3	2	5	0	2
...	...	...	...	...	...	...	...
9537	93696	26	33.8	1	0	0	2
9538	93697	80	31.0	2	2	13	2
9541	93700	35	26.0	1	0	0	2
9542	93701	8	18.1	1	0	5	2
9543	93702	24	21.4	2	0	192	2

7087 rows × 15 columns

In [6]:
```
data2015_2016.to_csv("Data2015_2016_clean.csv", index = False)
```

Label the Target Category

In [7]:
```
data2015_2016['Sy_Label'] = pd.cut(x=data2015_2016['Systolic_Blood_Pressure']
                     bins=[0,140,250],
                     labels=['0', '1'])
```

In [8]:
```
data2015_2016['Da_Label'] = pd.cut(x=data2015_2016['Diastolic_Blood_Pressure'
                     bins=[0,140,250],
                     labels=['0', '1'])
```

Combine Systolic and Diastolic Pressure

In [9]:
```
class_list = []
for sys, dia in zip(data2015_2016["Sy_Label"],data2015_2016["Da_Label"]):
    if int(sys) + int(dia) >0:
        class_list.append(1)
    else:
        class_list.append(0)
```

In [10]:
```
data2015_2016["target"] = class_list
```

Split X and Y

In [11]:
```
X = data2015_2016.drop(["Diastolic_Blood_Pressure","Systolic_Blood_Pressure",
y = data2015_2016["target"].values
le = LabelEncoder()
y = le.fit_transform(y)
```

In [12]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, ra
```

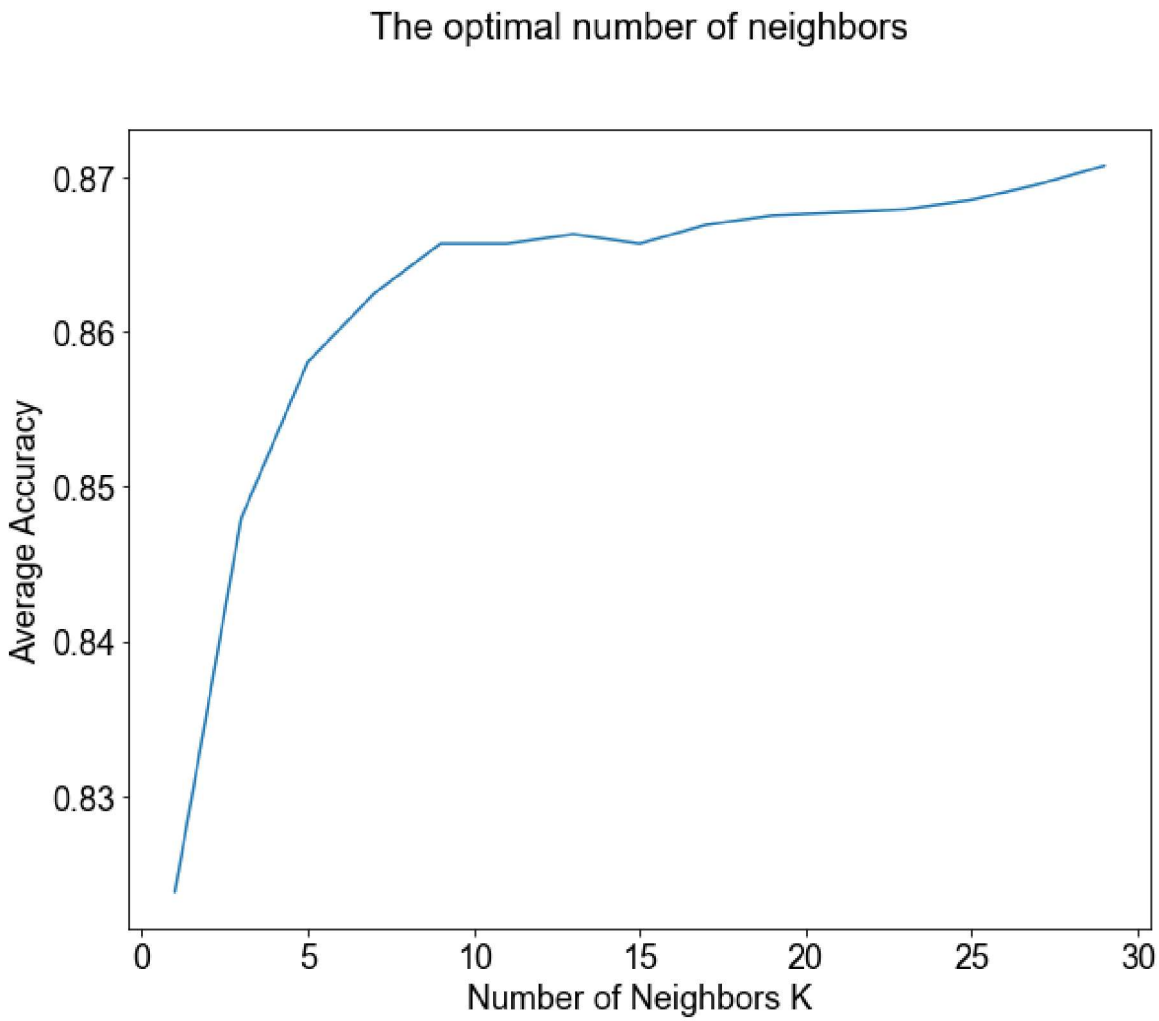
Find the Optimal K with Cross Validation

In [13]:
```
k_list = list(range(1,30,2))

cv_scores = []

for k in k_list:
    knn = KNeighborsClassifier(n_neighbors=k)
    scores = cross_val_score(knn, X_train, y_train, cv=8, scoring='accuracy')
    cv_scores.append(scores.mean())
```

In [14]:

```
plt.figure()
plt.figure(figsize=(10,8))
plt.title('The optimal number of neighbors', fontsize=20, y = 1.1)
plt.xlabel('Number of Neighbors K', fontsize=18)
plt.ylabel('Average Accuracy', fontsize=18)
plt.tick_params(axis='both', which='major', labelsize = 18)
sns.set_style("whitegrid")

plt.plot(k_list, cv_scores)
plt.show()
```

```
<Figure size 432x288 with 0 Axes>
```



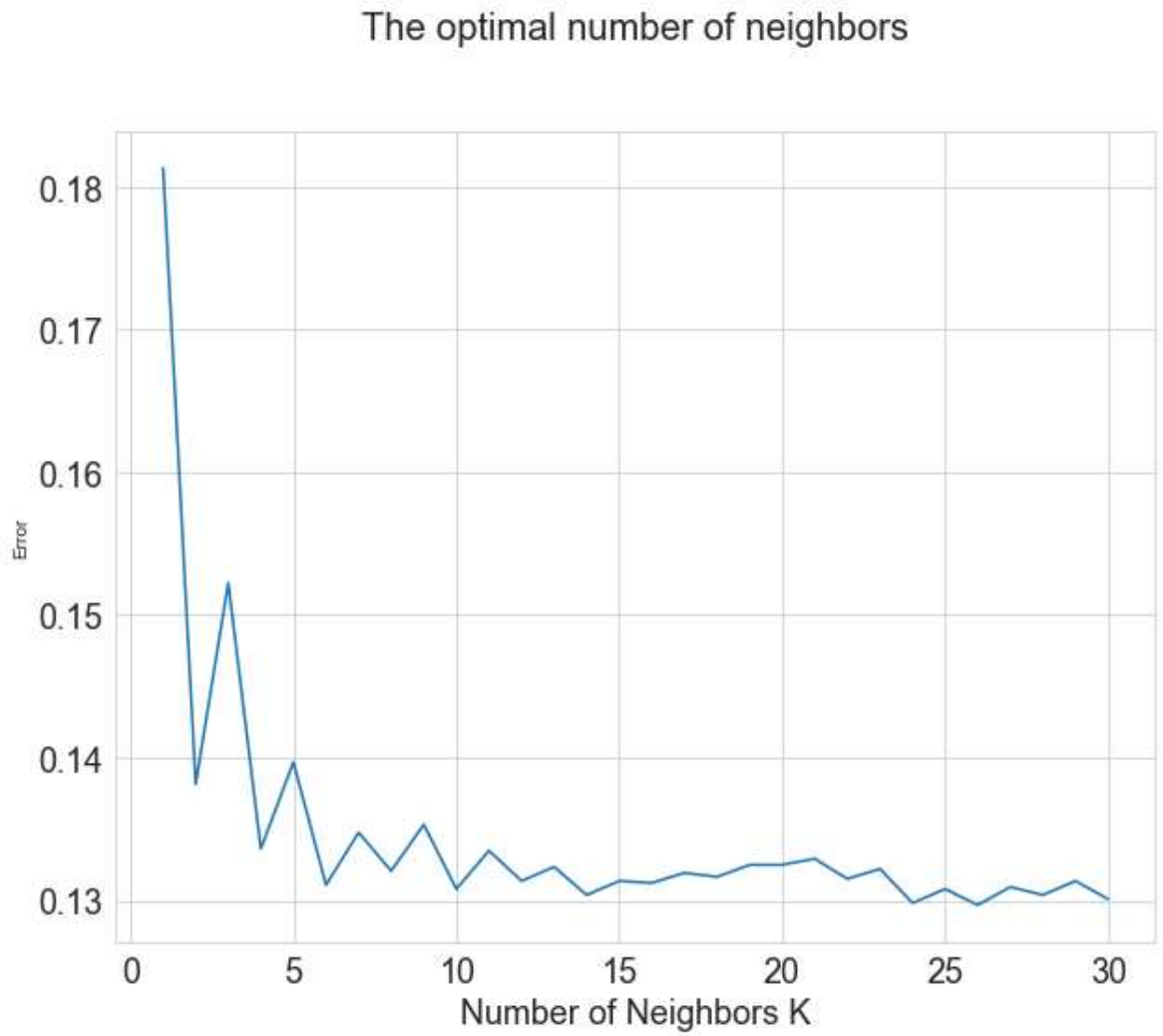
In [15]:

```
# Double Check with whole data

k_range = range(1,31)
k_error = []

for k in k_range:
    KNN = KNeighborsClassifier(n_neighbors = k)
    scores = cross_val_score(KNN, X, y, cv=8, scoring='accuracy')
    a = scores.mean()
    random_state = 42
    print(a)
    k_error.append(1-a)
```

```
0.8186823277346291
0.8618610590350844
0.8477503156444887
0.8663754128884978
0.8603086620499675
0.8689150756909108
0.8652465853005318
0.867927172207981
0.8646812947163025
0.8691980398158421
0.8665168152427594
0.8686332274808382
0.8676454834143169
0.8696211309637678
0.8686338651464718
0.868773992169466
0.8680692122278761
0.8683502633559067
0.8675039216436469
0.8675034433944218
0.8670800334136792
0.8684910280445346
0.8677857698537195
0.870184827383913
0.869196764484575
0.8703255920725408
0.8690556809631302
0.8696206527145427
0.8686327492316129
0.8699031385902489
```

In [16]:

```
plt.figure(figsize=(10,8))
plt.plot(k_range,k_error)
plt.xlabel('Number of Neighbors K', size = 18)
plt.ylabel('Error', size = 10)
plt.title('The optimal number of neighbors',fontsize=20, y = 1.1) #fontweight
plt.tick_params(axis='both', which='major', labelsize = 18)
sns.set_style("whitegrid")
plt.show()
```



In this regard,the optimal k will be 5

Define the Confusion Matrxi and Roc Curve Function

In [17]:
```
def plot_cnf_matirx(cnf_matrix,description):
    class_names = [0,1]
    fig,ax = plt.subplots(figsize = (10,8))
    tick_marks = np.arange(len(class_names))
    plt.xticks(tick_marks,class_names)
    plt.yticks(tick_marks,class_names)
    sns.heatmap(pd.DataFrame(cnf_matrix), annot = True, cmap = 'OrRd',
                fmt = 'g',annot_kws={"fontsize":18})
    ax.xaxis.set_label_position('top')

    plt.tight_layout()
    plt.title(description, y = 1.1,fontsize=20)
    plt.ylabel('True',fontsize=20)
    plt.xlabel('Prediction',fontsize=20)
    plt.show()
```

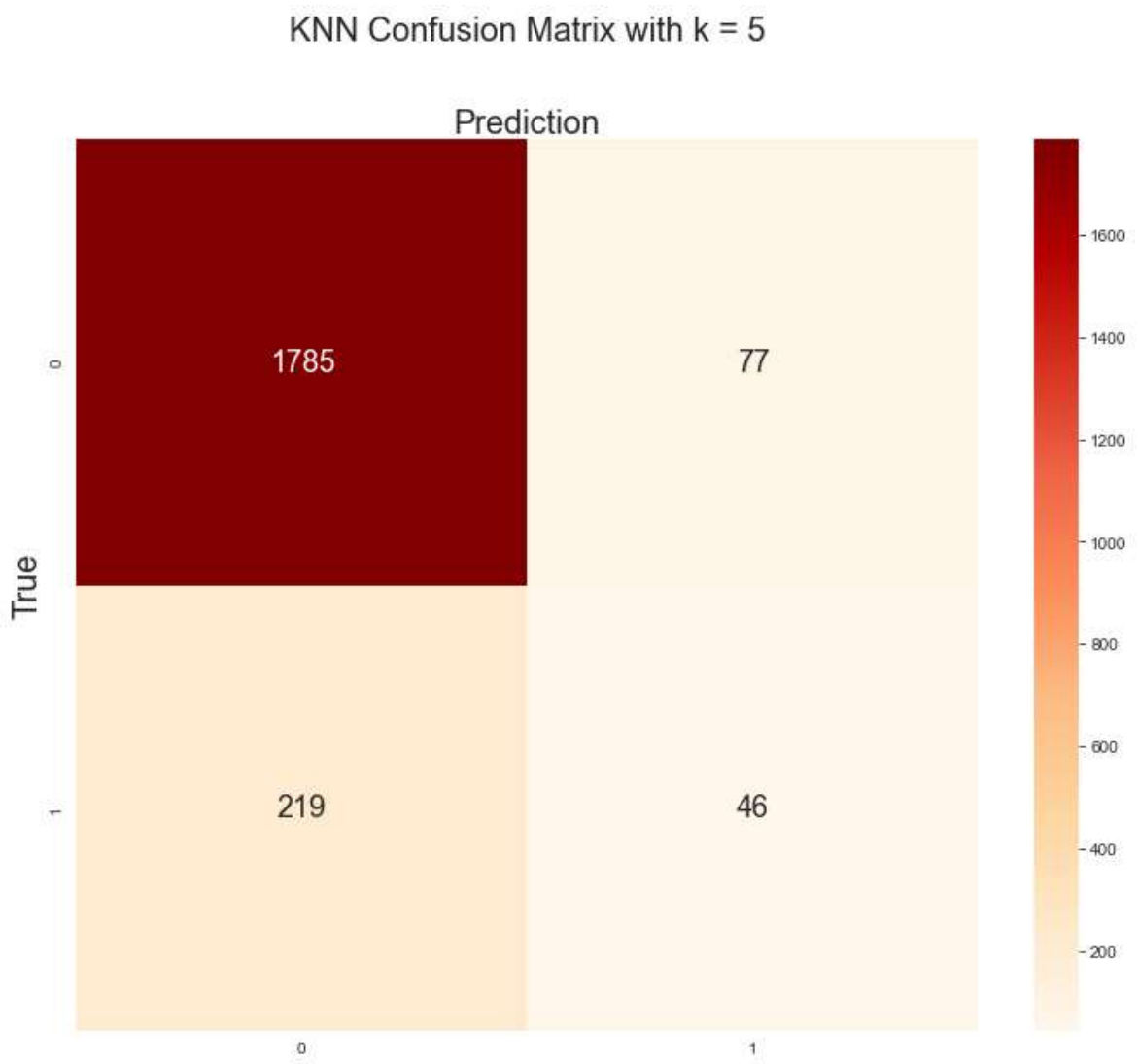
In [18]:
```
def plot_roc_curve(fprs,tprs):
    plt.figure(figsize=(10,8),dpi=80)
    plt.plot(fprs,tprs)
    plt.plot([0,1],linestyle='--')
    plt.xticks(fontsize=18)
    plt.yticks(fontsize=18)
    plt.ylabel('TPR',fontsize=20)
    plt.xlabel('FPR',fontsize=20)
    plt.title('ROC Curve',y = 1.1,fontsize=20)
    plt.show()
```

KNN model with the optimal K = 5

In [19]:
```
classifier = KNeighborsClassifier(n_neighbors=5)
classifier.fit(X_train, y_train)
y_pred = classifier.predict(X_test)
```

In [20]:

```
Conf_matrix = confusion_matrix(y_test, y_pred)
plot_cnf_matirx(Conf_matrix,'KNN Confusion Matrix with k = 5')
```



In [21]:
```
accuracy = accuracy_score(y_test, y_pred)*100
print('Accuracy of our model is equal to ' + str(round(accuracy, 2)) + '%')
```

```
Accuracy of our model is equal to 86.08%
```

In [22]:
```
TN=Conf_matrix[0,0]
TP=Conf_matrix[1,1]
FN=Conf_matrix[1,0]
FP=Conf_matrix[0,1]
```

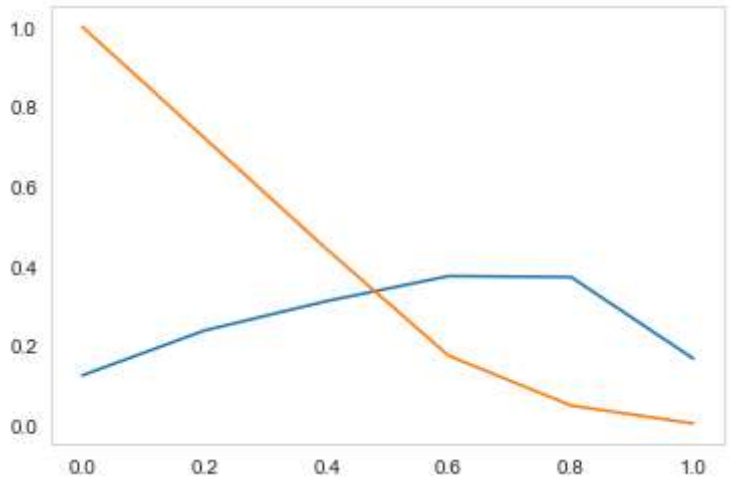
In [23]:
```
print('Sensitivity or True Positive Rate = TP/(TP+FN) = ', round(TP/float(TP+
print('Specificity or True Negative Rate = TN/(TN+FP) = ', round(TN/float(TN+
```

```
Sensitivity or True Positive Rate = TP/(TP+FN) =  0.1736
Specificity or True Negative Rate = TN/(TN+FP) =  0.9586
```

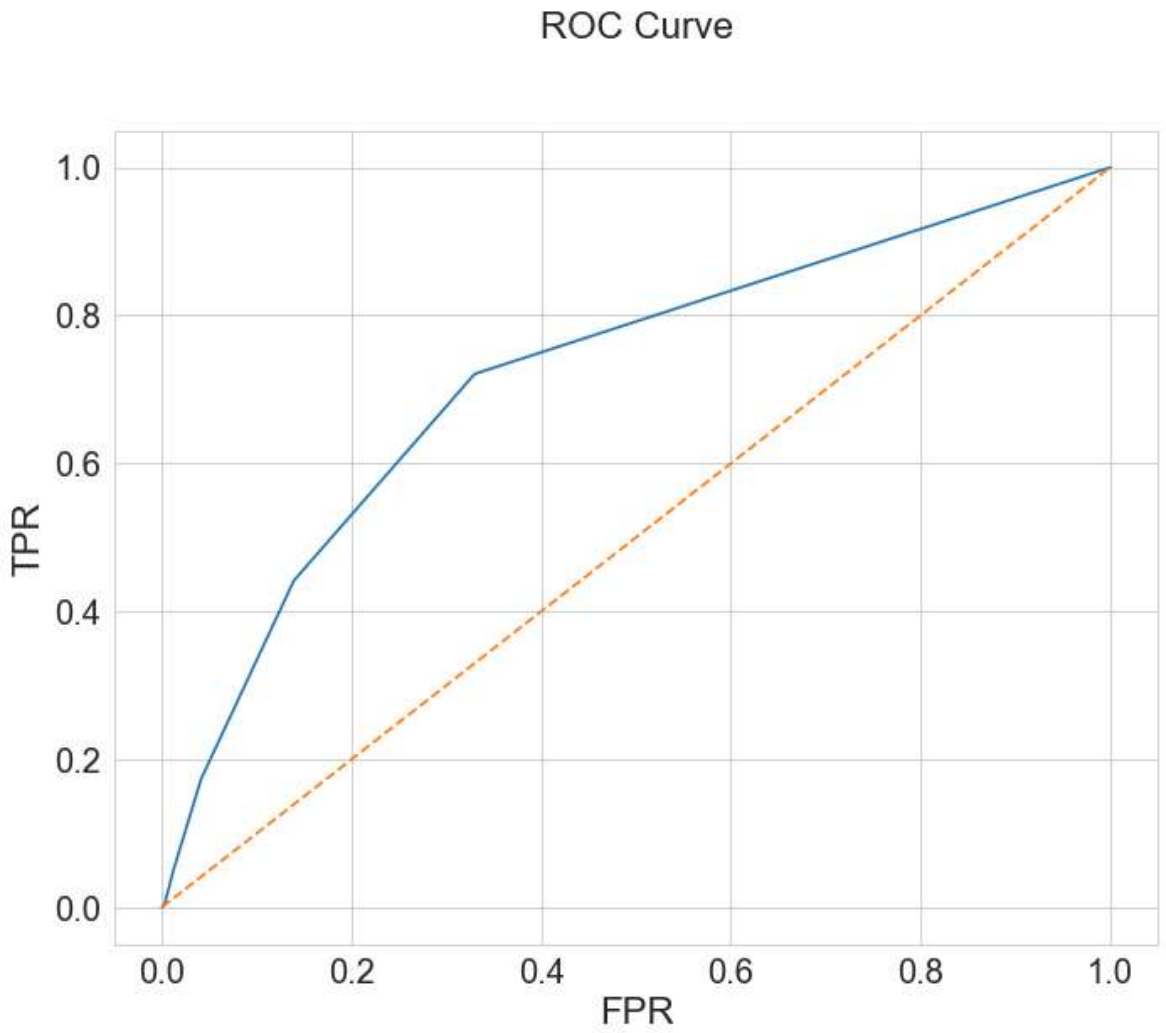
In [24]:
```
print('Precision: %.3f' % precision_score(y_test, y_pred))
print('F1 Score: %.3f' % f1_score(y_test, y_pred))
```

```
Precision: 0.374
F1 Score: 0.237
```

In [25]:
```
y_pred = classifier.predict_proba(X_test)[:,1]
precisions,recalls,thresholds = precision_recall_curve(y_test,y_pred)
plt.plot(thresholds,precisions[:-1])
plt.plot(thresholds,recalls[:-1])
plt.grid()
plt.show()
```



In [26]:
```
fprs,tprs,thresholds = roc_curve(y_test,y_pred)
plot_roc_curve(fprs,tprs, )
```



In [27]:
```
roc_auc_score(y_test,y_pred)
```

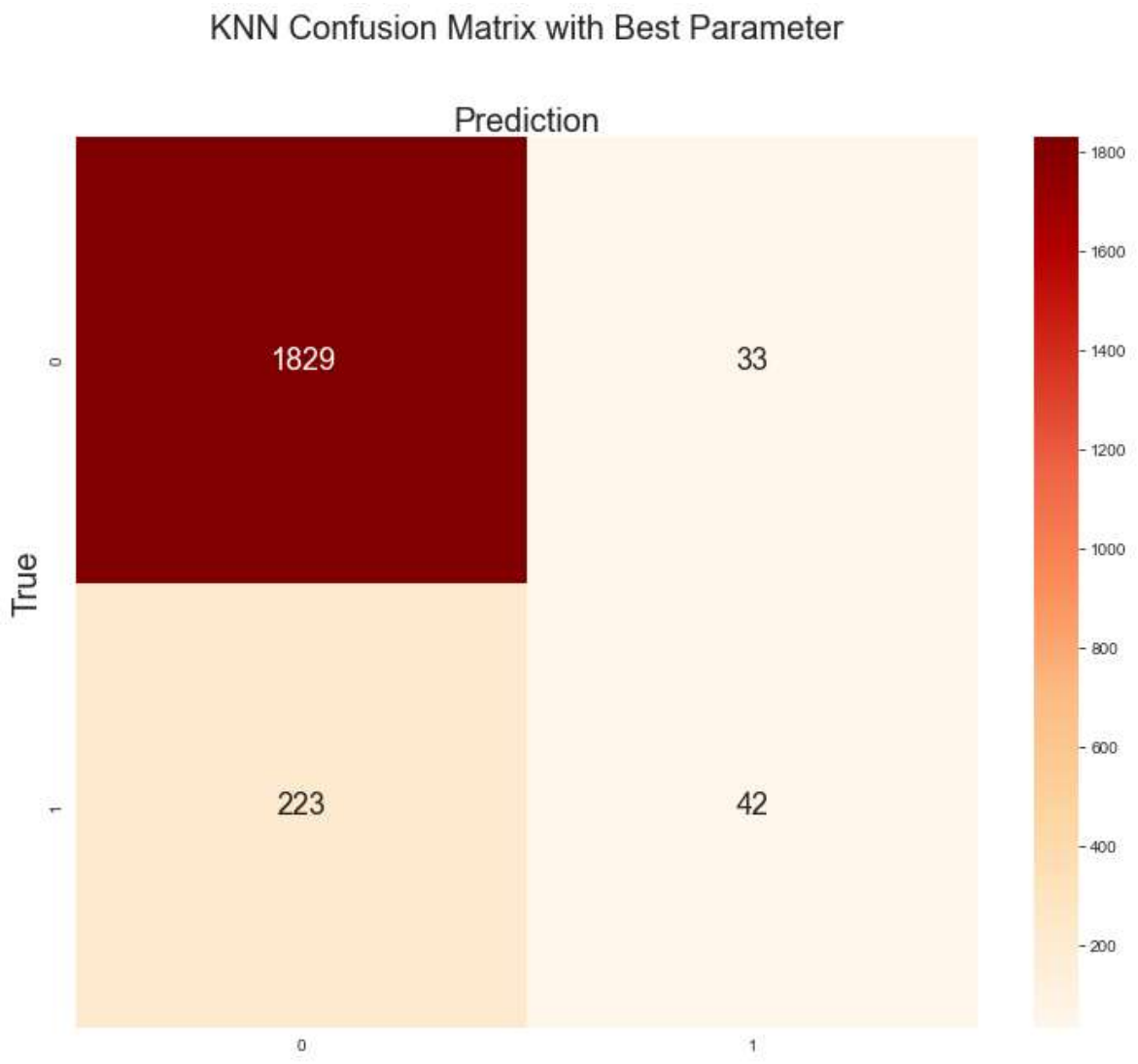
Out[27]: 0.7210566848387816

KNN with the Best Parameter

In [28]:
```
param_grid = [
    {
        'weights':['uniform'],
        'n_neighbors':[5,7,9]
    },
    {
        'weights':['distance'],
        'n_neighbors':[5,7,9],
        'p':[i for i in range(1,6)]
    }
]
```

In [29]:
```
knn_para = KNeighborsClassifier()
grid_search = GridSearchCV(knn_para,param_grid)
grid_search.fit(X_train,y_train)
y_pred_para =grid_search.predict(X_test)
```

In [30]:
```
Conf_matrix = confusion_matrix(y_test, y_pred_para)
plot_cnf_matirx(Conf_matrix,'KNN Confusion Matrix with Best Parameter')
```



In [31]:
```
accuracy = accuracy_score(y_test, y_pred_para)*100
print('Accuracy of our model is equal to ' + str(round(accuracy, 2)) + '%')
```

```
Accuracy of our model is equal to 87.96%
```

In [32]:
```
TN=Conf_matrix[0,0]
TP=Conf_matrix[1,1]
FN=Conf_matrix[1,0]
FP=Conf_matrix[0,1]
```

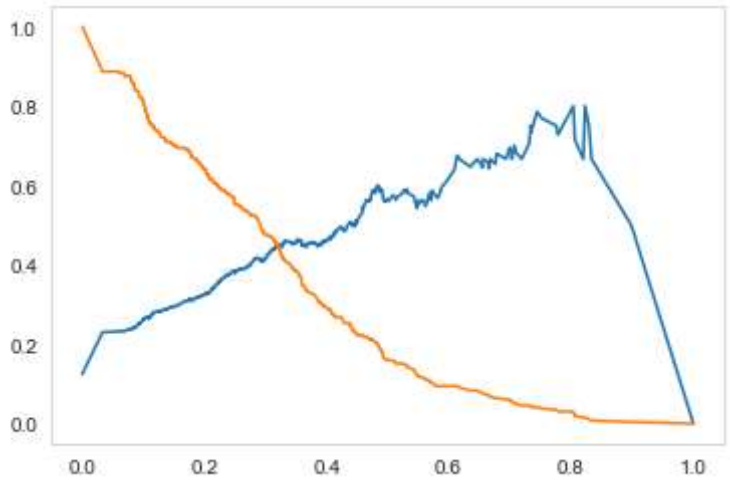
In [33]:
```
print('Sensitivity or True Positive Rate = TP/(TP+FN) = ', round(TP/float(TP+
print('Specificity or True Negative Rate = TN/(TN+FP) = ', round(TN/float(TN+
```

```
Sensitivity or True Positive Rate = TP/(TP+FN) =  0.1585
Specificity or True Negative Rate = TN/(TN+FP) =  0.9823
```

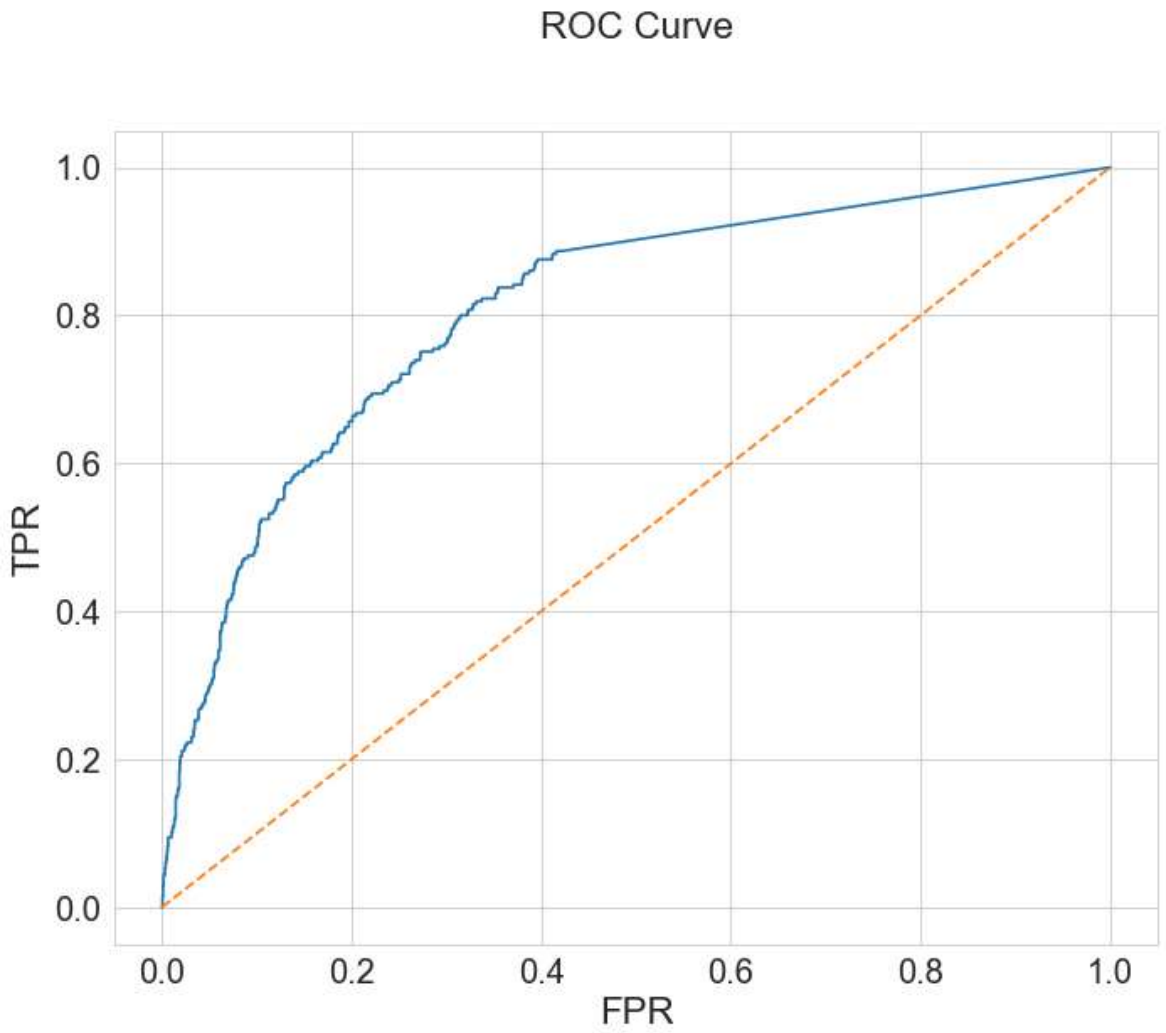
In [34]:
```
print('Precision: %.3f' % precision_score(y_test, y_pred_para))
print('F1 Score: %.3f' % f1_score(y_test, y_pred_para))
```

```
Precision: 0.560
F1 Score: 0.247
```

In [35]:
```
y_pred_para = grid_search.predict_proba(X_test)[:,1]
precisions,recalls,thresholds = precision_recall_curve(y_test,y_pred_para)
plt.plot(thresholds,precisions[:-1])
plt.plot(thresholds,recalls[:-1])
plt.grid()
plt.show()
```



In [36]:
```
fprs,tprs,thresholds = roc_curve(y_test,y_pred_para)
plot_roc_curve(fprs,tprs)
```



In [37]:
```
roc_auc_score(y_test,y_pred_para)
```

Out[37]: 0.8078086050706281

Imbalanced Data - undersampling

In [38]:
```
data2015_2016.groupby(['target']).size()
```

Out[38]:
```
target
0    6175
1     912
dtype: int64
```

In [39]:
```
undersampling = NearMiss(version = 2, n_neighbors = 5)
X,y = undersampling.fit_resample(X,y)
counter = Counter(y)
print(counter)
```

```
Counter({0: 912, 1: 912})
```

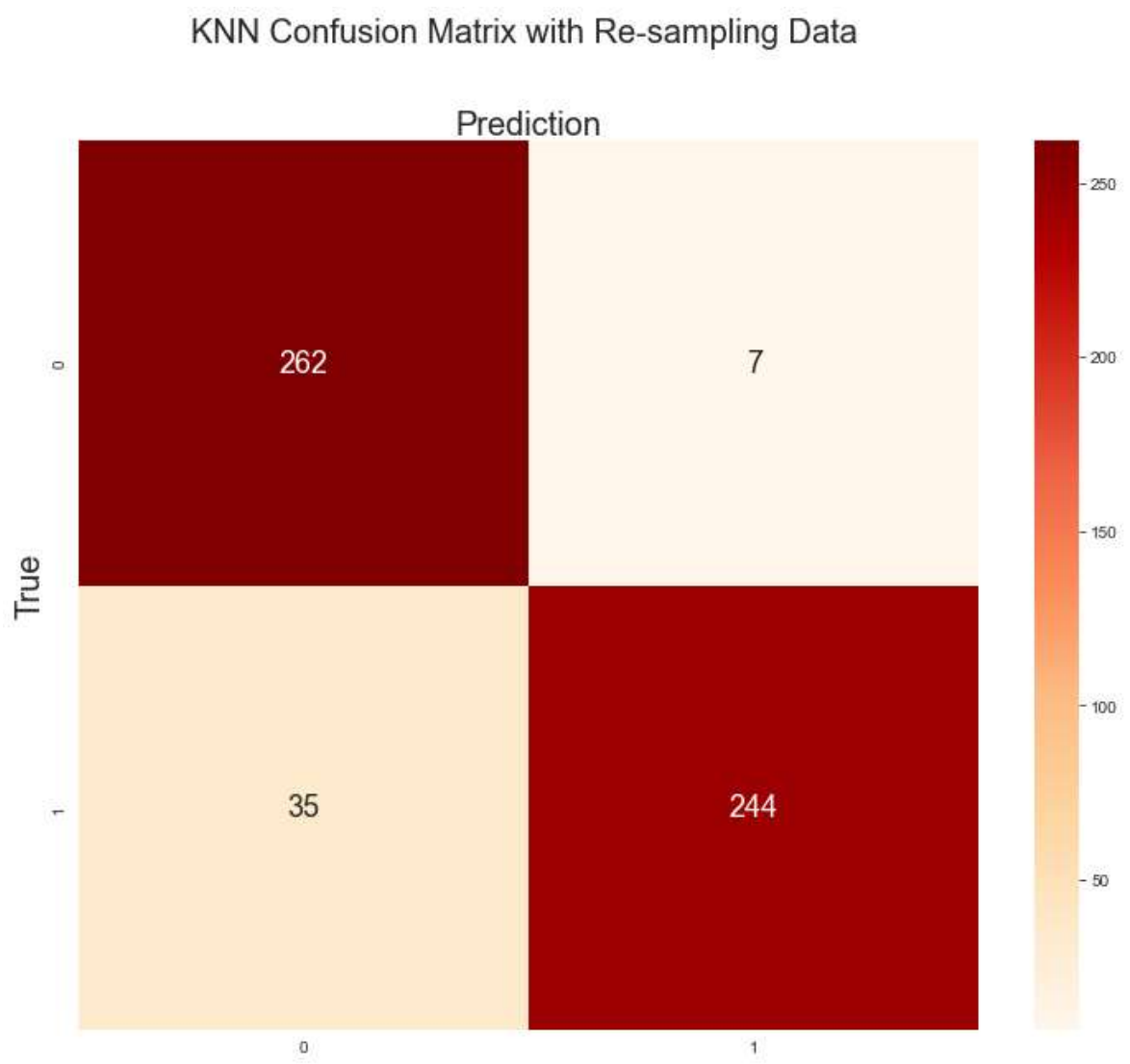
In [40]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, ra
```

Revised KNN with Best Parameter & Re-sampling data

In [41]:
```
param_grid_imb = [
    {
        'weights':['uniform'],
        'n_neighbors':[5]
    },
    {
        'weights':['distance'],
        'n_neighbors':[5],
        'p':[i for i in range(1,6)]
    }
]
```

In [42]:
```
knn_para_imb = KNeighborsClassifier()
grid_search = GridSearchCV(knn_para_imb,param_grid_imb)
grid_search.fit(X_train,y_train)
y_pred_para_imb =grid_search.predict(X_test)
```

In [43]:
```
Conf_matrix = confusion_matrix(y_test, y_pred_para_imb)
plot_cnf_matirx(Conf_matrix,'KNN Confusion Matrix with Re-sampling Data ')
```



In [44]:
```
accuracy = accuracy_score(y_test, y_pred_para_imb)*100
print('Accuracy of our model is equal to ' + str(round(accuracy, 2)) + '%')
```

```
Accuracy of our model is equal to 92.34%
```

In [45]:
```
TN=Conf_matrix[0,0]
TP=Conf_matrix[1,1]
FN=Conf_matrix[1,0]
FP=Conf_matrix[0,1]
```

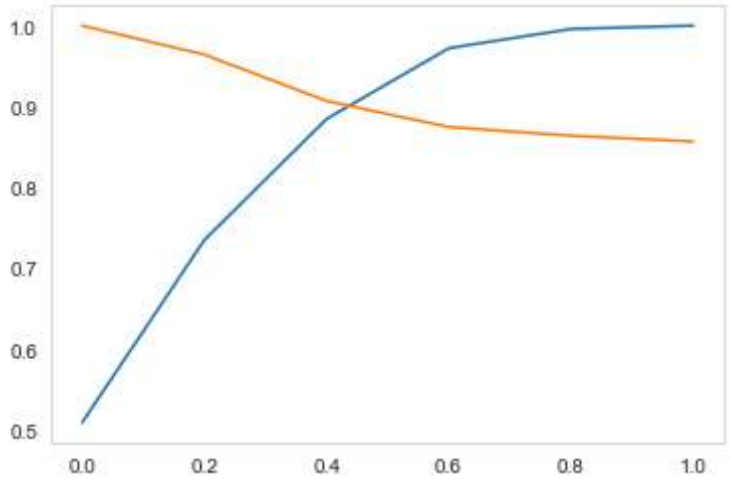
In [46]:
```
print('Sensitivity or True Positive Rate = TP/(TP+FN) = ', round(TP/float(TP+
print('Specificity or True Negative Rate = TN/(TN+FP) = ', round(TN/float(TN+
```

```
Sensitivity or True Positive Rate = TP/(TP+FN) =  0.8746
Specificity or True Negative Rate = TN/(TN+FP) =  0.974
```

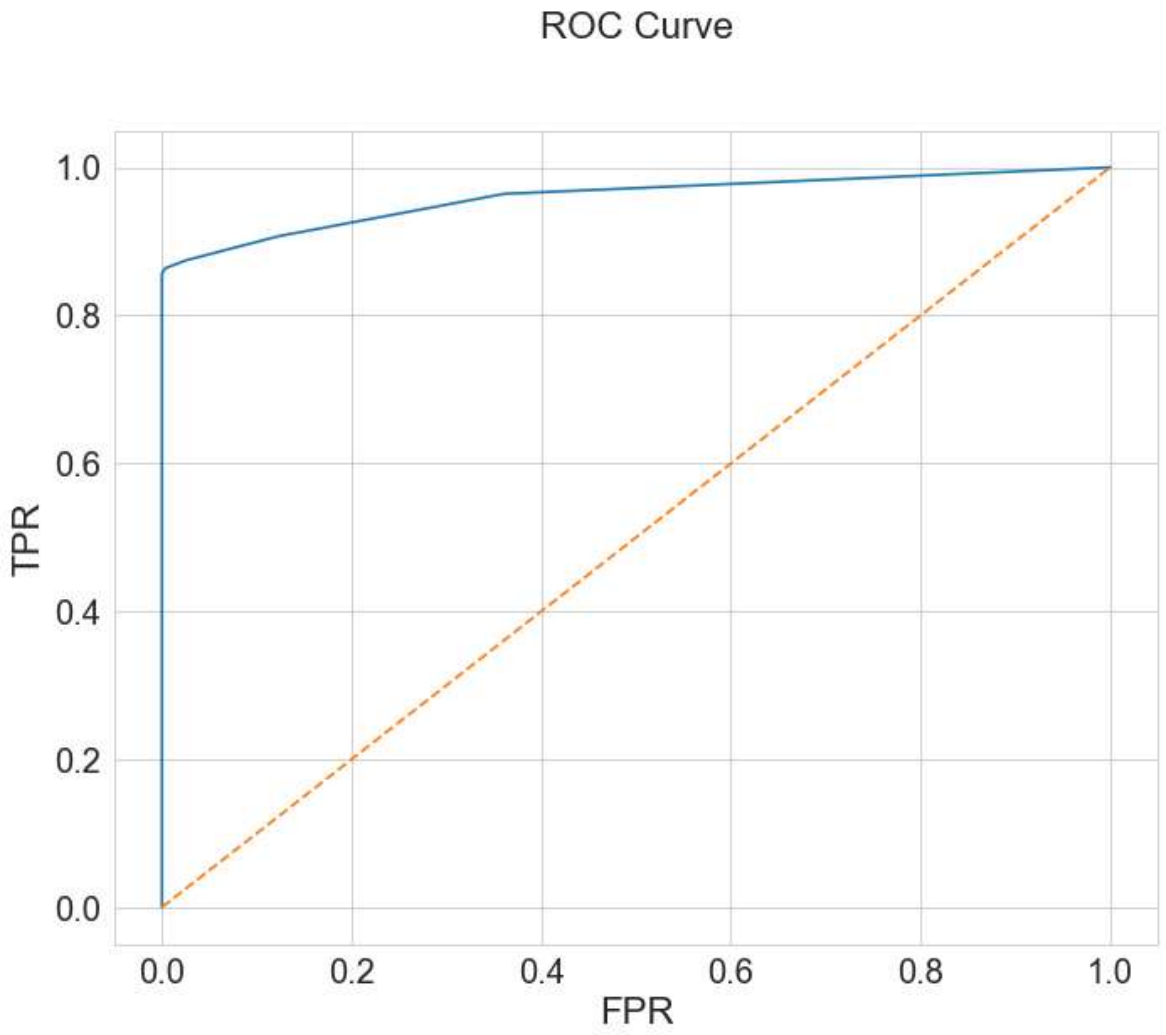
In [47]:
```
print('Precision: %.3f' % precision_score(y_test, y_pred_para_imb))
print('F1 Score: %.3f' % f1_score(y_test, y_pred_para_imb))
```

```
Precision: 0.972
F1 Score: 0.921
```

In [48]:
```
y_pred_para_imb = grid_search.predict_proba(X_test)[:,1]
precisions,recalls,thresholds = precision_recall_curve(y_test,y_pred_para_imb
plt.plot(thresholds,precisions[:-1])
plt.plot(thresholds,recalls[:-1])
plt.grid()
plt.show()
```



In [49]:
```
fprs,tprs,thresholds = roc_curve(y_test,y_pred_para_imb)
plot_roc_curve(fprs,tprs)
```



In [50]:
```
roc_auc_score(y_test,y_pred_para_imb)
```

Out[50]: 0.9591877523284167