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

In [2]:
```
import seaborn as sns
```

In [3]:
```
df=pd.read_csv("Bank.csv")
```

In [4]:
```
df
```

Out[4]:

	ID	Age	Experience	Income	ZIP Code	Family	CCAvg	Education	Mortgage	Personal Loan	S
0	1	25	1	49	91107	4	1.6	1	0	0	
1	2	45	19	34	90089	3	1.5	1	0	0	
2	3	39	15	11	94720	1	1.0	1	0	0	
3	4	35	9	100	94112	1	2.7	2	0	0	
4	5	35	8	45	91330	4	1.0	2	0	0	
...	...	...	...	...	...	...	...	...	...	...	
4995	4996	29	3	40	92697	1	1.9	3	0	0	
4996	4997	30	4	15	92037	4	0.4	1	85	0	
4997	4998	63	39	24	93023	2	0.3	3	0	0	
4998	4999	65	40	49	90034	3	0.5	2	0	0	
4999	5000	28	4	83	92612	3	0.8	1	0	0	

5000 rows × 14 columns

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
ID                    0
Age                   0
Experience            0
Income                0
ZIP Code              0
Family                0
CCAvg                 0
Education             0
Mortgage              0
Personal Loan         0
Securities Account    0
CD Account            0
Online                0
CreditCard            0
dtype: int64
```

No null values

In [6]:
```
df.describe()
```

Out[6]:

	ID	Age	Experience	Income	ZIP Code	Family	CCA
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.0000
mean	2500.500000	45.338400	20.104600	73.774200	93152.503000	2.396400	1.9379
std	1443.520003	11.463166	11.467954	46.033729	2121.852197	1.147663	1.7476
min	1.000000	23.000000	-3.000000	8.000000	9307.000000	1.000000	0.0000
25%	1250.750000	35.000000	10.000000	39.000000	91911.000000	1.000000	0.7000
50%	2500.500000	45.000000	20.000000	64.000000	93437.000000	2.000000	1.5000
75%	3750.250000	55.000000	30.000000	98.000000	94608.000000	3.000000	2.5000
max	5000.000000	67.000000	43.000000	224.000000	96651.000000	4.000000	10.0000

In [7]:
```
nulls=df.isnull().sum()
nulls_percentage = nulls[nulls!=0]/df.shape[0]*100
print('the percentages of null values per feature:\n')
print(round(nulls_percentage,2))
```

```
the percentages of null values per feature:

Series([], dtype: float64)
```

Is it have no null features so it printed nothing,otherwise it would have printed the percentage of null values per feature.

In [8]:
```
#Now deleting the columns which are not required
del df['ID']
del df["ZIP Code"]
df.head()
```

Out[8]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Personal Loan	Securities Account	CD Accoun
0	25	1	49	4	1.6	1	0	0	1	0
1	45	19	34	3	1.5	1	0	0	1	0
2	39	15	11	1	1.0	1	0	0	0	0
3	35	9	100	1	2.7	2	0	0	0	0
4	35	8	45	4	1.0	2	0	0	0	0

In [9]:
```
df.groupby('CreditCard').CreditCard.count()
```

Out[9]:
```
CreditCard
0    3530
```

```
1    1470
Name: CreditCard, dtype: int64
```

In [10]:
```
#It is an imbalanced dataset will see if accuracy decreases.
```

In [11]:
```
df.rename(columns={"Personal Loan": "Personal_Loan","Securities Accoun
t":"Sec_Acc","CD Account":"CD_Acc"},inplace=True)
df.head()
```

Out[11]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Personal_Loan	Sec_Acc	CD
0	25	1	49	4	1.6	1	0	0	1	
1	45	19	34	3	1.5	1	0	0	1	
2	39	15	11	1	1.0	1	0	0	0	
3	35	9	100	1	2.7	2	0	0	0	
4	35	8	45	4	1.0	2	0	0	0	

In [12]:
```
df['Personal_Loan'].value_counts()
```

Out[12]:
```
0    4520
1     480
Name: Personal_Loan, dtype: int64
```

In [13]:
```
#it is also imbalanced we have to balance the dataset
```

Exploratory Data Analysis (EDA)

In [14]:
```
#Reordering Columns

df=df[['Age','Experience','Income',"Family","CCAvg","Education","Mortga
ge","Sec_Acc","CD_Acc","Online","CreditCard","Personal_Loan"]]
```

In [15]:
```
df.head()
```

Out[15]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Online	C
0	25	1	49	4	1.6	1	0	1	0	0	
1	45	19	34	3	1.5	1	0	1	0	0	
2	39	15	11	1	1.0	1	0	0	0	0	
3	35	9	100	1	2.7	2	0	0	0	0	
4	35	8	45	4	1.0	2	0	0	0	0	

In [16]:
```
df.describe()
```

Out[16]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgag
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.00000
mean	45.338400	20.104600	73.774200	2.396400	1.937938	1.881000	56.49880
std	11.463166	11.467954	46.033729	1.147663	1.747659	0.839869	101.71380
min	23.000000	-3.000000	8.000000	1.000000	0.000000	1.000000	0.00000
25%	35.000000	10.000000	39.000000	1.000000	0.700000	1.000000	0.00000
50%	45.000000	20.000000	64.000000	2.000000	1.500000	2.000000	0.00000
75%	55.000000	30.000000	98.000000	3.000000	2.500000	3.000000	101.00000
max	67.000000	43.000000	224.000000	4.000000	10.000000	3.000000	635.00000

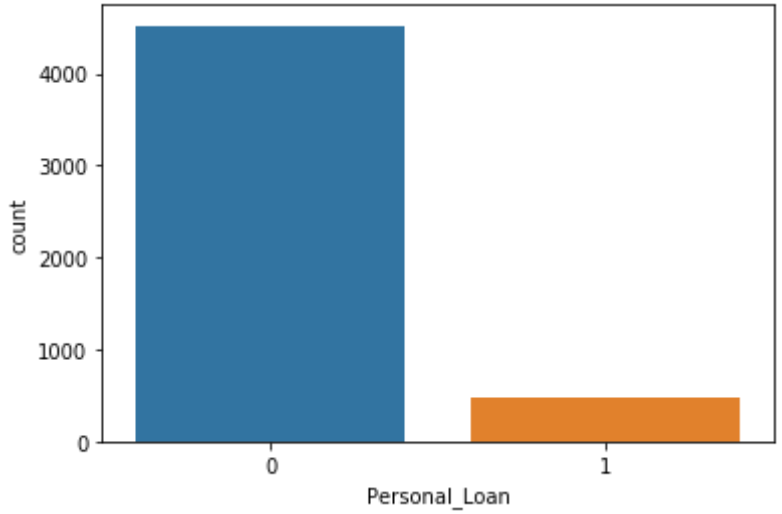
In [17]:
```
df.dtypes
```

Out[17]:
```
Age                 int64
Experience          int64
Income              int64
Family              int64
CCAvg             float64
```

```
Education          int64
Mortgage           int64
Sec_Acc            int64
CD_Acc             int64
Online             int64
CreditCard         int64
Personal_Loan      int64
dtype: object
```

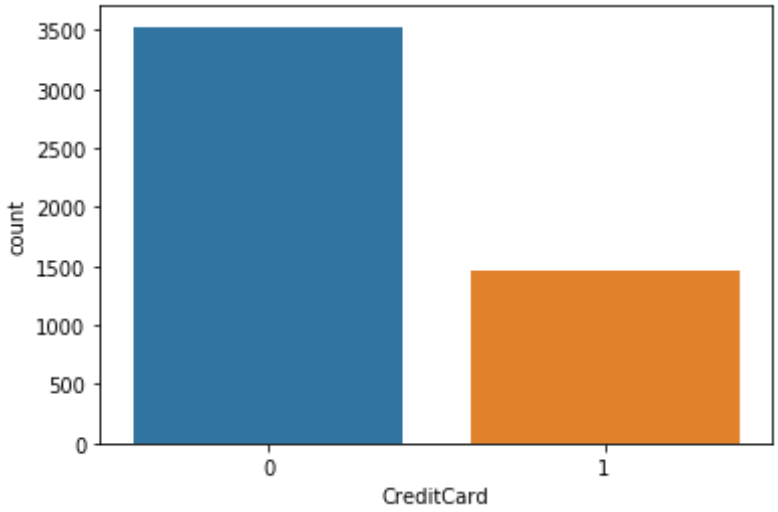
In [18]:
```
sns.countplot(data=df,x="Personal_Loan")
```

Out[18]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1795db43b08>
```



In [19]:
```
sns.countplot(data=df,x="CreditCard")
```

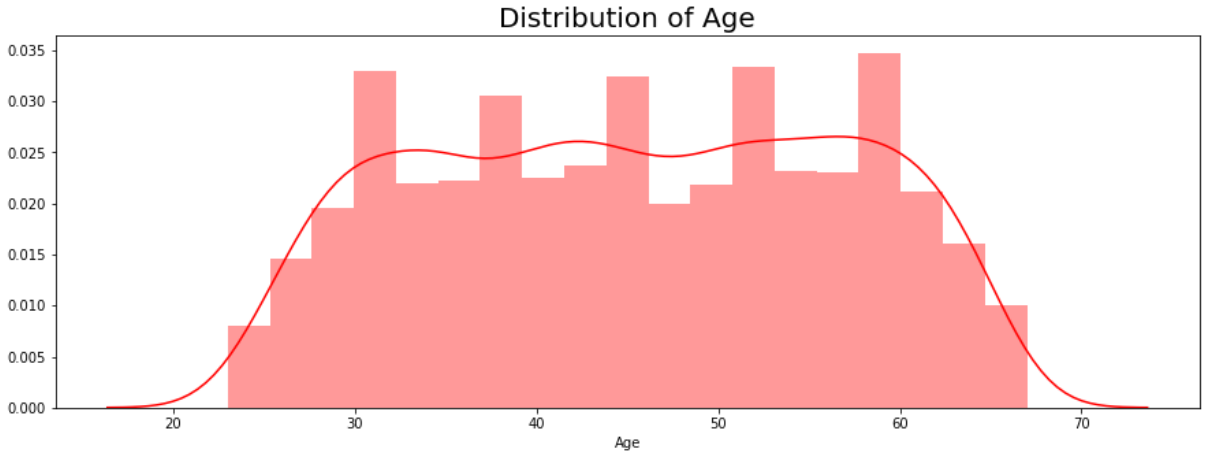
Out[19]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1795e257e48>
```



In [20]:
```
#pip install bubbly
```

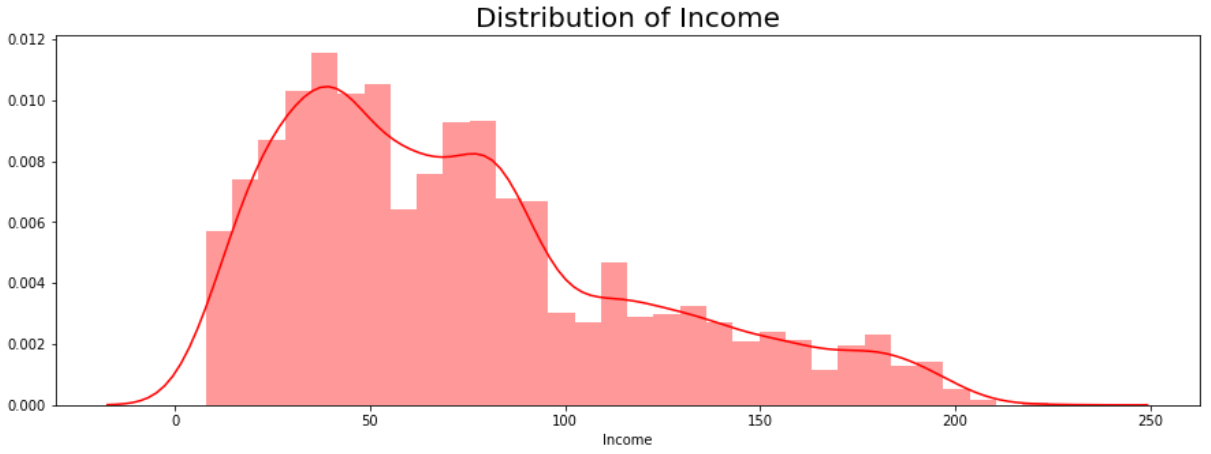
In [21]:
```
from bubbly.bubbly import bubbleplot
figure = bubbleplot(dataset = df, x_column = 'Experience', y_column =
'Income',
bubble_column = 'Personal_Loan', time_column = 'Age', size_column = 'Mo
rtgage', color_column = 'Personal_Loan',
x_title = "Experience", y_title = "Income", title = 'Experience vs Inco
me. vs Age vs Mortgage vs Personal Loan',
x_logscale = False, scale_bubble = 3, height = 650)
```

In [22]:
```
plt.rcParams['figure.figsize'] = (15, 5)
sns.distplot(df['Age'], color = 'red')
plt.title('Distribution of Age', fontsize = 20)
plt.show()
```



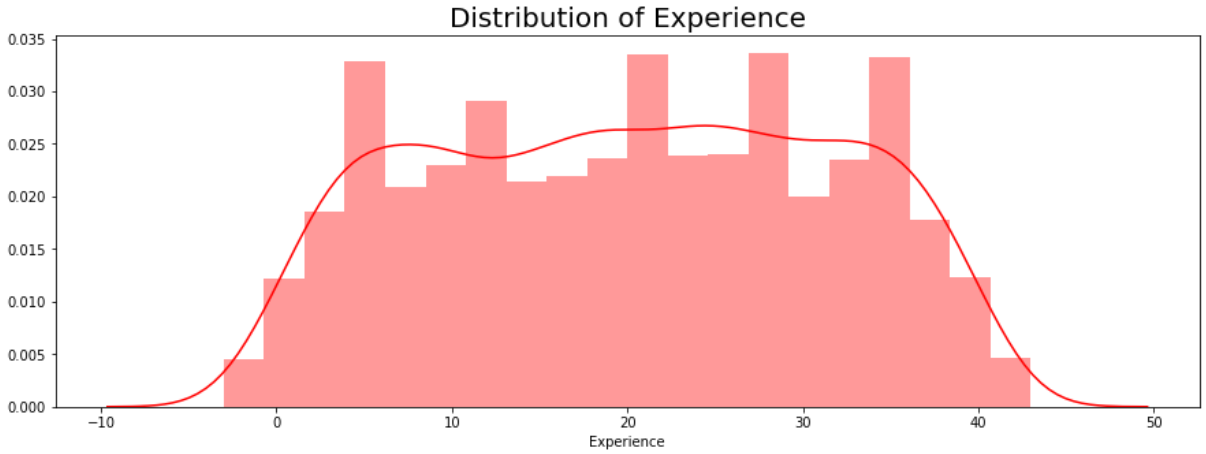
In [23]:
```
#Age is well managed or we can say more equally Balanced
```

In [24]:
```
plt.rcParams['figure.figsize'] = (15, 5)
sns.distplot(df['Income'], color = 'red',norm_hist=True)
plt.title('Distribution of Income', fontsize = 20)
plt.show()
```



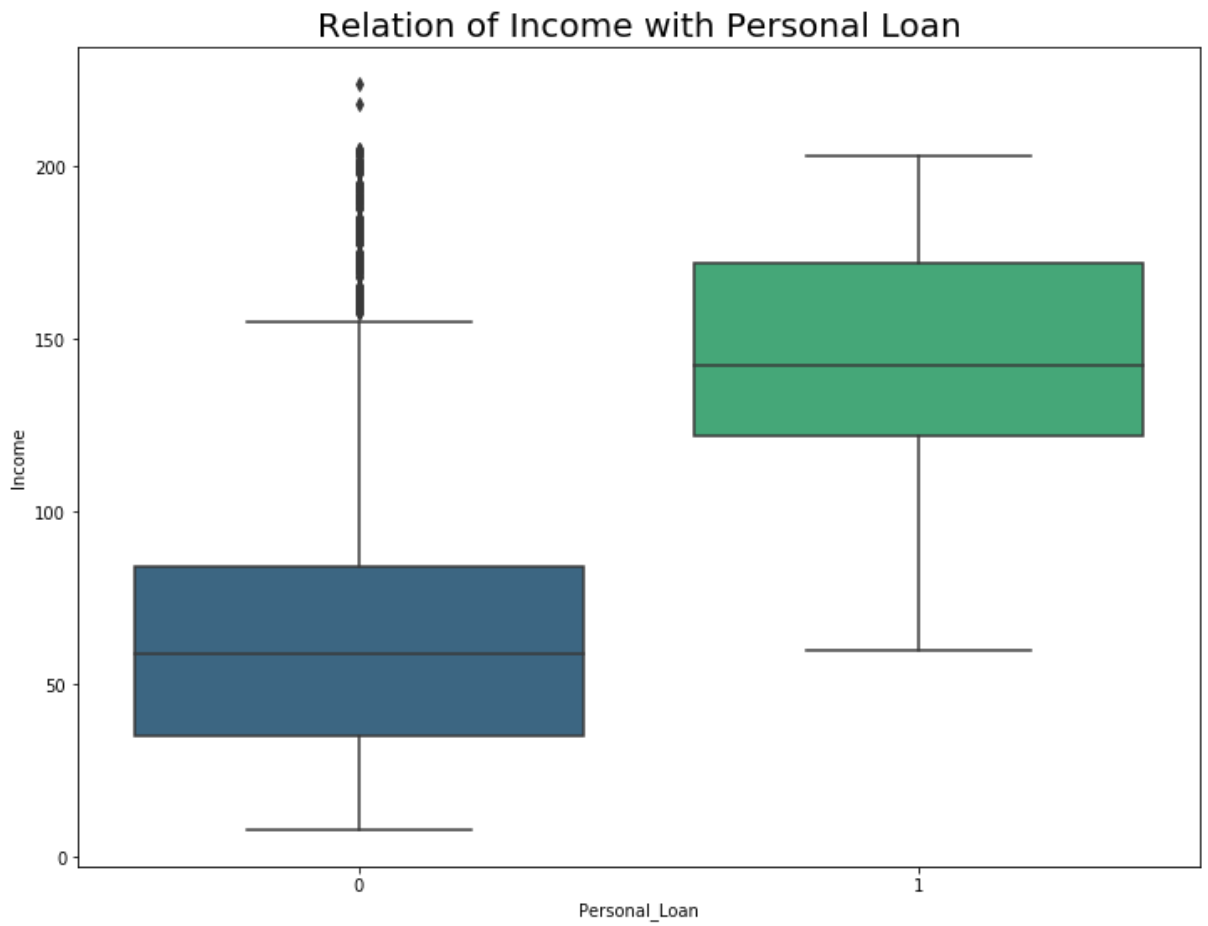
In [25]:
```
#Income is not well Balanced
```

In [26]:
```
plt.rcParams['figure.figsize'] = (15, 5)
sns.distplot(df['Experience'], color = 'red')
plt.title('Distribution of Experience', fontsize = 20)
plt.show()
```

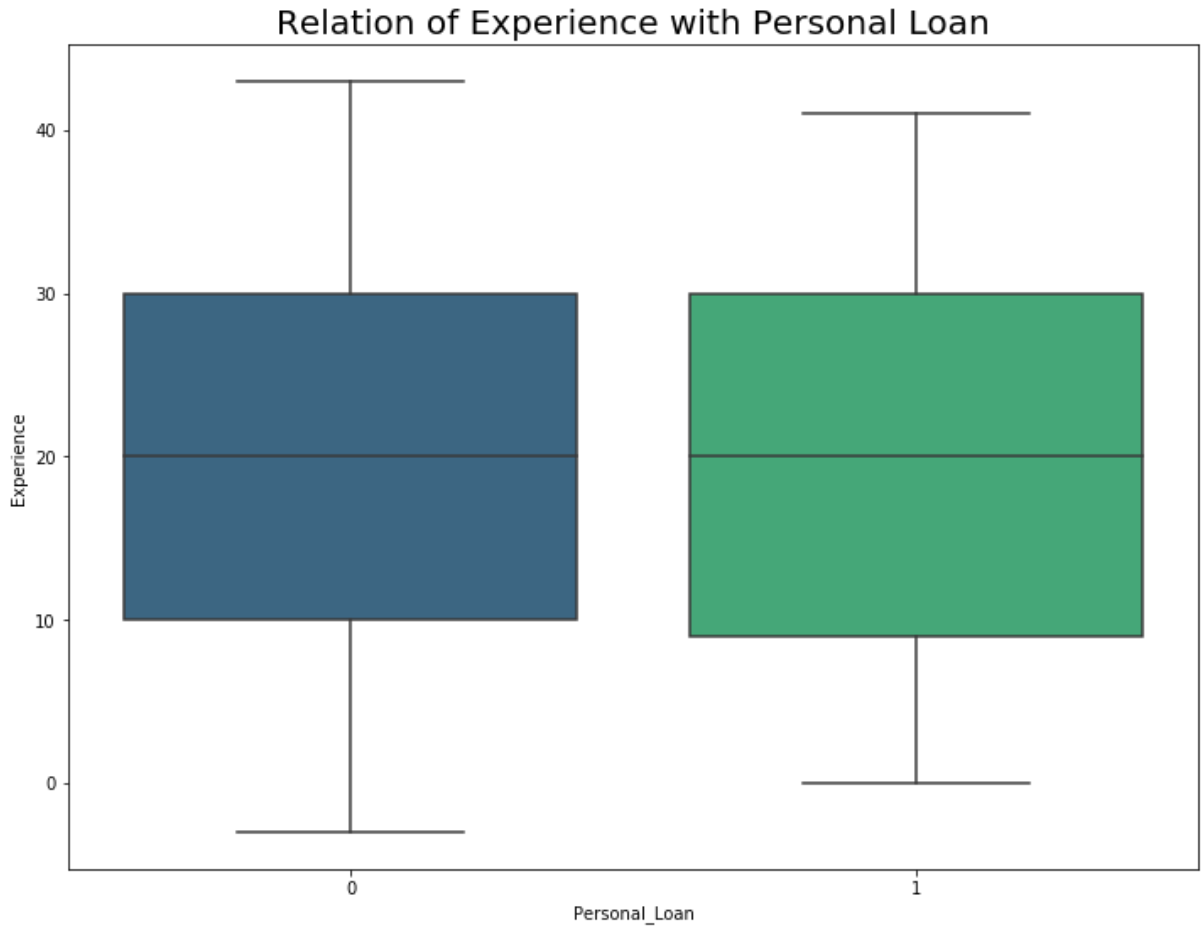


In [27]:
```
#Exeperiance is well managed or we can say more equally Balanced
```

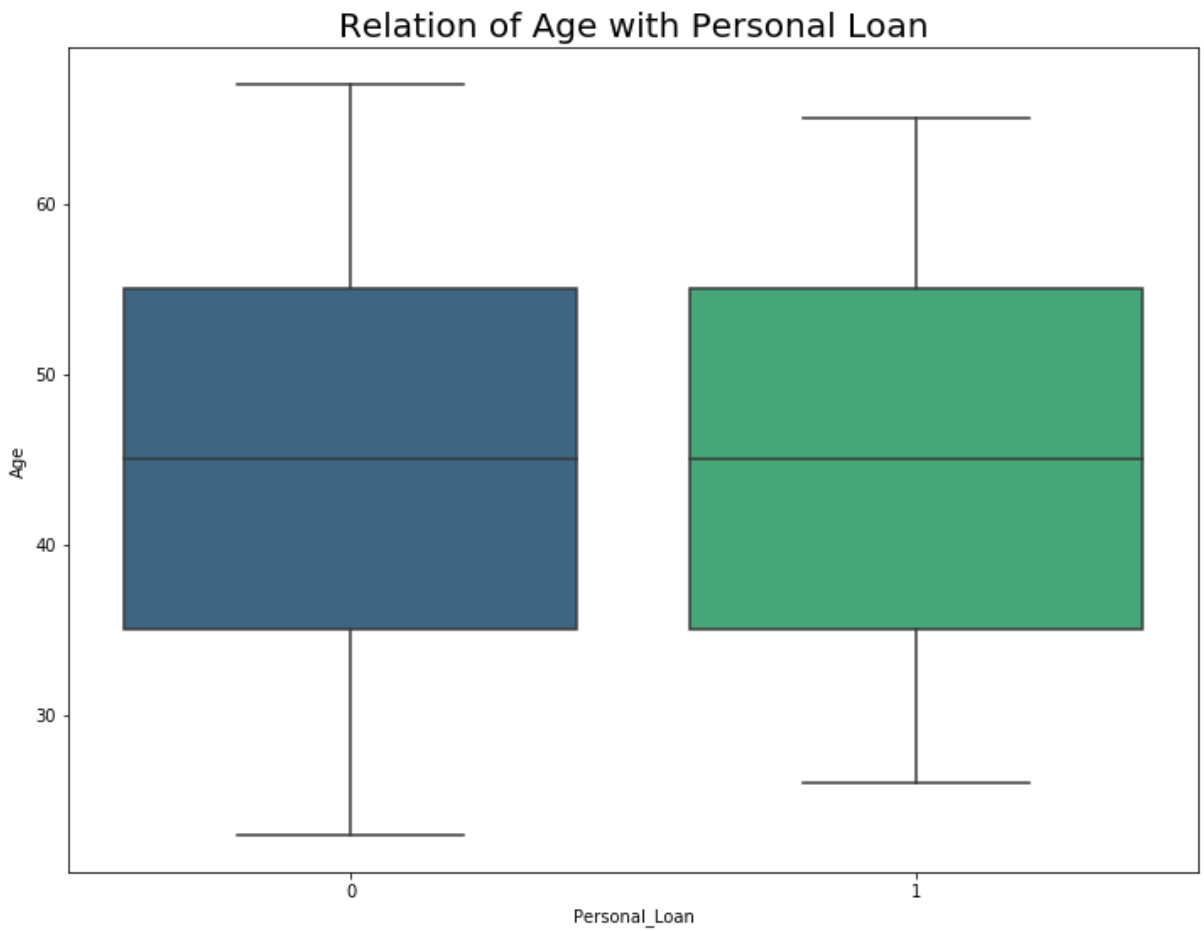
In [28]:
```
#Relation of Income with Personal Loan
plt.rcParams['figure.figsize'] = (12, 9)
sns.boxplot(df['Personal_Loan'], df['Income'], palette = 'viridis')
plt.title('Relation of Income with Personal Loan', fontsize = 20)
plt.show()
```



In [29]:
```
#Relation of Experience with Personal Loan
plt.rcParams['figure.figsize'] = (12, 9)
sns.boxplot(df['Personal_Loan'], df['Experience'], palette = 'viridis')
plt.title('Relation of Experience with Personal Loan', fontsize = 20)
plt.show()
```



In [30]:
```
#Relation of Age with Personal Loan
plt.rcParams['figure.figsize'] = (12, 9)
sns.boxplot(df['Personal_Loan'], df['Age'], palette = 'viridis')
plt.title('Relation of Age with Personal Loan', fontsize = 20)
plt.show()
```

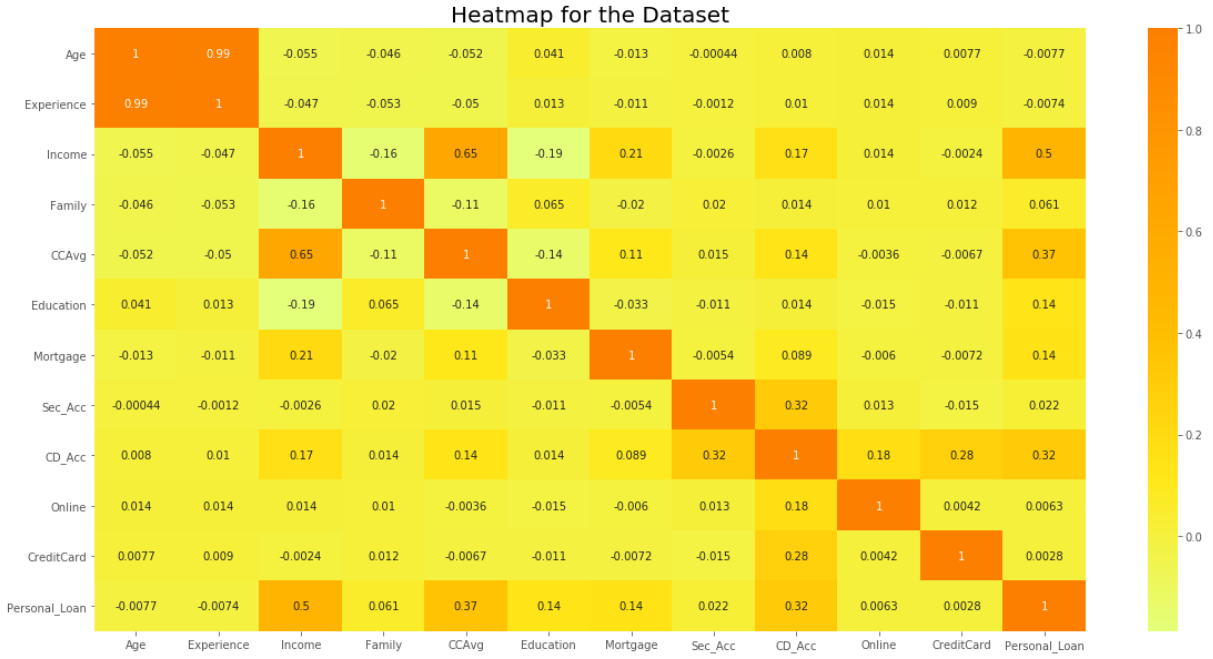


Feature Selection

Checking for correlation

In [31]:
```
#Checking Correlation using Heatmap

plt.rcParams['figure.figsize'] = (20, 10)
plt.style.use('ggplot')
```

```
sns.heatmap(df.corr(), annot = True, cmap = 'Wistia')
plt.title('Heatmap for the Dataset', fontsize = 20)
plt.show()
```



In [32]:
```
#Arranging the correlational value in descending order
corr=df.corr()
corr["Personal_Loan"].sort_values(ascending=False)
```

Out[32]:
```
Personal_Loan    1.000000
Income           0.502462
CCAvg            0.366889
CD_Acc           0.316355
Mortgage         0.142095
Education        0.136722
Family           0.061367
Sec_Acc          0.021954
Online           0.006278
CreditCard       0.002802
Experience      -0.007413
```

```
Age              -0.007726
Name: Personal_Loan, dtype: float64
```

In [33]:
```
x=df.drop('Personal_Loan',axis=1)
```

In [34]:
```
x
```

Out[34]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Online
0	25	1	49	4	1.6	1	0	1	0	0
1	45	19	34	3	1.5	1	0	1	0	0
2	39	15	11	1	1.0	1	0	0	0	0
3	35	9	100	1	2.7	2	0	0	0	0
4	35	8	45	4	1.0	2	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...
4995	29	3	40	1	1.9	3	0	0	0	1
4996	30	4	15	4	0.4	1	85	0	0	1
4997	63	39	24	2	0.3	3	0	0	0	0
4998	65	40	49	3	0.5	2	0	0	0	1
4999	28	4	83	3	0.8	1	0	0	0	1

5000 rows × 11 columns

In [35]:
```
y=df['Personal_Loan']
```

In [36]:
```
y
```

Out[36]:
```
0       0
1       0
2       0
3       0
```

```
4       0
       ..
4995    0
4996    0
4997    0
4998    0
4999    0
Name: Personal_Loan, Length: 5000, dtype: int64
```

Using Extra Trees Classifier

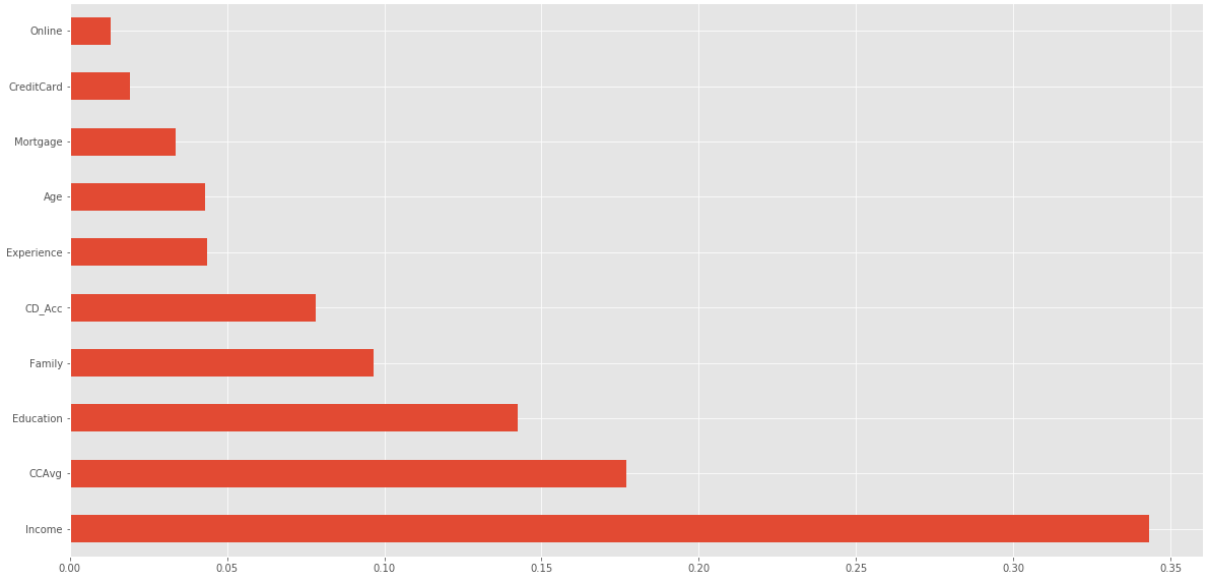
In [37]:
```
from sklearn.ensemble import ExtraTreesClassifier
import matplotlib.pyplot as plt
model = ExtraTreesClassifier()
model.fit(x,y)
```

Out[37]:
```
ExtraTreesClassifier()
```

In [38]:
```
print(model.feature_importances_)
```

```
[0.0429176  0.04360846 0.34310131 0.09648541 0.17710527 0.14245859
 0.03356031 0.01032624 0.07833124 0.0130914  0.01901416]
```

In [39]:
```
feat_importances = pd.Series(model.feature_importances_, index=x.column
s)
feat_importances.nlargest(10).plot(kind='barh')
plt.show()
```



Using ANOVA TEST

In [40]:
```
from sklearn.feature_selection import f_classif
select=f_classif(x,y)
select
```

Out[40]:
```
(array([2.98324239e-01, 2.74675302e-01, 1.68800458e+03, 1.88931888e+01,
        7.77413007e+02, 9.52061943e+01, 1.02994466e+02, 2.41006236e+00,
        5.55829340e+02, 1.96983772e-01, 3.92268699e-02]),
 array([5.84959264e-001, 6.00235883e-001, 3.56029139e-318, 1.40990407e-
005,
        3.83026616e-159, 2.70966319e-022, 5.73034172e-024, 1.20620879e-
001,
        1.27840285e-116, 6.57185766e-001, 8.43007940e-001]))
```

In [41]:
```
p_values=pd.Series(select[1])
p_values.index=x.columns
p_values.sort_values(ascending=True,inplace=True)
```

In [42]:
```
p_values
```

Out[42]:
```
Income         3.560291e-318
CCAvg          3.830266e-159
CD_Acc         1.278403e-116
Mortgage        5.730342e-24
Education       2.709663e-22
Family          1.409904e-05
Sec_Acc         1.206209e-01
Age             5.849593e-01
Experience      6.002359e-01
Online          6.571858e-01
CreditCard      8.430079e-01
dtype: float64
```

In [43]:
```
p_values=p_values[p_values<0.05]
p_values
```

Out[43]:
```
Income       3.560291e-318
CCAvg        3.830266e-159
CD_Acc       1.278403e-116
Mortgage      5.730342e-24
Education     2.709663e-22
Family        1.409904e-05
dtype: float64
```

From all the three feature selection techniques we have got the top features i.e Income,CCAvg,CC_Acc,Mortgage,Education

In [44]:
```
#Hence droping less coreleated features.
df.drop(['Online','CreditCard'],axis=1,inplace=True)
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\pandas\core\frame.py:3997: Se
ttingWithCopyWarning:
```

```
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  errors=errors,
```

In [45]:
```
df
```

Out[45]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
0	25	1	49	4	1.6	1	0	1	0	
1	45	19	34	3	1.5	1	0	1	0	
2	39	15	11	1	1.0	1	0	0	0	
3	35	9	100	1	2.7	2	0	0	0	
4	35	8	45	4	1.0	2	0	0	0	
...	...	...	...	...	...	...	...	...	...	
4995	29	3	40	1	1.9	3	0	0	0	
4996	30	4	15	4	0.4	1	85	0	0	
4997	63	39	24	2	0.3	3	0	0	0	
4998	65	40	49	3	0.5	2	0	0	0	
4999	28	4	83	3	0.8	1	0	0	0	

5000 rows × 10 columns

In [46]:
```
df['Personal_Loan'].value_counts()
```

Out[46]:
```
0    4520
1     480
Name: Personal_Loan, dtype: int64
```

In [47]:
```
#It seems to be a imbalanced dataset still trying different classification algorithms.
```

TRAIN TEST SPLIT

In [48]:
```
#importing the libraries to perform the train test split

from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
```

In [49]:
```
X_train,X_test,Y_train,Y_test = train_test_split(x,y,test_size=0.20,ran
dom_state=0)
```

In [50]:
```
np.bincount(Y_train)
```

Out[50]:
```
array([3610,  390], dtype=int64)
```

MODEL FITTING

In [51]:
```
pip install imblearn
```

```
Requirement already satisfied: imblearn in c:\users\kiit\anaconda3\lib
\site-packages (0.0)
Requirement already satisfied: imbalanced-learn in c:\users\kiit\anacon
da3\lib\site-packages (from imblearn) (0.7.0)
Requirement already satisfied: joblib>=0.11 in c:\users\kiit\anaconda3
\lib\site-packages (from imbalanced-learn->imblearn) (0.14.1)
Requirement already satisfied: scipy>=0.19.1 in c:\users\kiit\anaconda3
\lib\site-packages (from imbalanced-learn->imblearn) (1.4.1)
Requirement already satisfied: numpy>=1.13.3 in c:\users\kiit\anaconda3
\lib\site-packages (from imbalanced-learn->imblearn) (1.18.1)
Requirement already satisfied: scikit-learn>=0.23 in c:\users\kiit\anac
onda3\lib\site-packages (from imbalanced-learn->imblearn) (0.23.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\users\kiit\an
aconda3\lib\site-packages (from scikit-learn>=0.23->imbalanced-learn->i
```

```
mblearn) (2.1.0)
Note: you may need to restart the kernel to use updated packages.
```

In [52]:
```
from imblearn.over_sampling import SMOTE
```

LOGISTIC REGRESSION

In [56]:
```
from sklearn.linear_model import LogisticRegression

lr1 = LogisticRegression()

lr1.fit(X_train,Y_train)

Y_pred_lr1 = lr1.predict(X_test)
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown
in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

In [57]:
```
from sklearn.metrics import accuracy_score
```

In [58]:
```
score_lr1 = round(accuracy_score(Y_pred_lr1,Y_test)*100,2)

print("The accuracy score achieved using Logistic Regression is: "+str(
score_lr1)+" %")
```

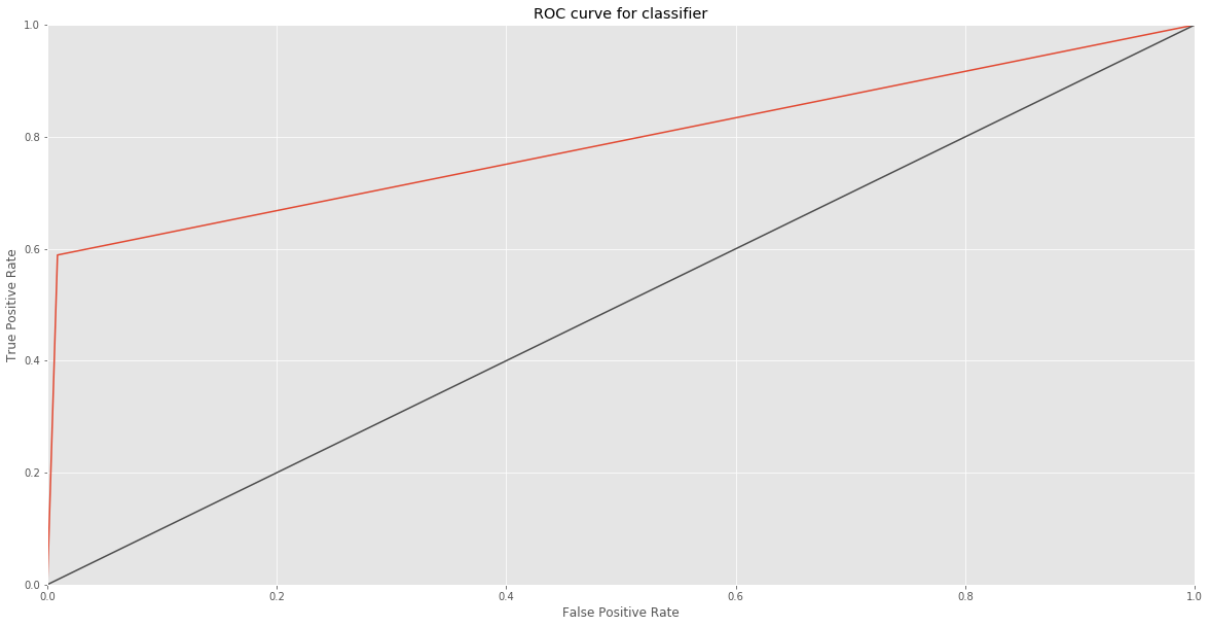
```
The accuracy score achieved using Logistic Regression is: 95.5 %
```

In [59]:
```
results = confusion_matrix(Y_test, Y_pred_lr1)
print(classification_report(Y_pred_lr1,Y_test))
```

```
              precision    recall  f1-score   support

           0       0.99      0.96      0.98       939
           1       0.59      0.87      0.70        61

    accuracy                           0.95      1000
   macro avg       0.79      0.91      0.84      1000
weighted avg       0.97      0.95      0.96      1000
```

In [61]:
```
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
```

In [62]:
```
fpr, tpr, thresholds = roc_curve(Y_test,Y_pred_lr1)

fig, ax = plt.subplots()
ax.plot(fpr, tpr)
ax.plot([0, 1], [0, 1], transform=ax.transAxes, ls="-", c=".3")
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])

plt.rcParams['figure.figsize'] = (5, 5)
plt.title('ROC curve for classifier', fontweight = 30)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.show()
```



TRYING K FOLD CROSS VALIDATION

In [63]:
```
from sklearn.model_selection import cross_val_score
```

In [64]:
```
score=cross_val_score(lr1,x,y,cv=10)
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown
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  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
```

```
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```

```
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```

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    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

In [65]:
```
score
```

Out[65]:
```
array([0.952, 0.942, 0.95 , 0.934, 0.948, 0.952, 0.96 , 0.938, 0.966,
       0.938])
```

In [66]:
```
score.mean()
```

Out[66]:
```
0.9480000000000001
```

So by k fold cross validation we get that our model's accuracy will lie from 93.4% to 96.6% with a mean of 94.7%

No we have to oversample the data by using SMOTE ALgorithm as our True negatives are less

In [67]:
```
smt=SMOTE()
x_new,y_new= smt.fit_sample(x, y)
X_train,X_test,Y_train,Y_test = train_test_split(x_new,y_new,test_size=
0.20,random_state=0)
```

In [68]:
```
from sklearn.linear_model import LogisticRegression

lr = LogisticRegression()

lr.fit(X_train,Y_train)

Y_pred_lr = lr.predict(X_test)
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

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    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

In [69]:
```
np.bincount(Y_train)
```

Out[69]:
```
array([3629, 3603], dtype=int64)
```

In [70]:
```
score_lr = round(accuracy_score(Y_pred_lr,Y_test)*100,2)

print("The accuracy score achieved using Logistic Regression is: "+str(
score_lr)+" %")
```

```
The accuracy score achieved using Logistic Regression is: 87.33 %
```

In [71]:
```
results = confusion_matrix(Y_test, Y_pred_lr)
```

```
results
```

Out[71]:
```
array([[766, 125],
       [104, 813]], dtype=int64)
```

In [72]:
```
print(classification_report(Y_pred_lr,Y_test))
```

```
              precision    recall  f1-score   support

           0       0.86      0.88      0.87       870
           1       0.89      0.87      0.88       938

    accuracy                           0.87      1808
   macro avg       0.87      0.87      0.87      1808
weighted avg       0.87      0.87      0.87      1808
```

HYPER PARAMETER TUNING FOR LOGISTIC REGRESSION MODEL

In [73]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import LogisticRegression
grid={"C":np.logspace(-3,3,7), "penalty":["l1","l2"]}
logreg=LogisticRegression()
logreg_cv=GridSearchCV(logreg,grid,cv=30)
logreg_cv.fit(X_train,Y_train)

print("tuned hpyerparameters :(best parameters) ",logreg_cv.best_params
_)
print("accuracy :",logreg_cv.best_score_)
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selection\_vali
dation.py:552: FitFailedWarning: Estimator fit failed. The score on thi
s train-test partition for these parameters will be set to nan. Detail
s:
Traceback (most recent call last):
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selecti
```

```
on\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 443, in _check_solver
    "got %s penalty." % (solver, penalty))
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1
penalty.

  FitFailedWarning)
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

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STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown
in:
```

```
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
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  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logistic.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
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C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
```

```
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```
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```

```
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
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C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selection\_vali
dation.py:552: FitFailedWarning: Estimator fit failed. The score on thi
s train-test partition for these parameters will be set to nan. Detail
s:
Traceback (most recent call last):
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selecti
on\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 1304, in fit
```

```
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 443, in _check_solver
    "got %s penalty." % (solver, penalty))
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1
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    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
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C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selection\_vali
dation.py:552: FitFailedWarning: Estimator fit failed. The score on thi
s train-test partition for these parameters will be set to nan. Detail
s:
Traceback (most recent call last):
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selecti
on\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 443, in _check_solver
    "got %s penalty." % (solver, penalty))
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1
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C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selection\_vali
dation.py:552: FitFailedWarning: Estimator fit failed. The score on thi
s train-test partition for these parameters will be set to nan. Detail
s:
Traceback (most recent call last):
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selecti
on\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 443, in _check_solver
    "got %s penalty." % (solver, penalty))
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1
 penalty.

  FitFailedWarning)
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  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
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    "got %s penalty." % (solver, penalty))
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C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selection\_vali
dation.py:552: FitFailedWarning: Estimator fit failed. The score on thi
s train-test partition for these parameters will be set to nan. Detail
s:
Traceback (most recent call last):
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\model_selecti
on\_validation.py", line 531, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 1304, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model
\_logistic.py", line 443, in _check_solver
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c.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown
 in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
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Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
```

```
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
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```

```
Increase the number of iterations (max_iter) or scale the data as shown
 in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
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regression
```

```
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```

```
 in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
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C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logistic.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
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    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
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Increase the number of iterations (max_iter) or scale the data as shown in:
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```

```
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
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    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

```
tuned hpyerparameters :(best parameters)  {'C': 10.0, 'penalty': 'l2'}
accuracy : 0.8957471737366117
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown
in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

In [75]:
```
logreg2=LogisticRegression(C=1000,penalty="l2")
logreg2.fit(X_train,Y_train)
print("score",logreg2.score(X_test,Y_test))
```

```
score 0.8849557522123894
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py:764: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown
in:
```

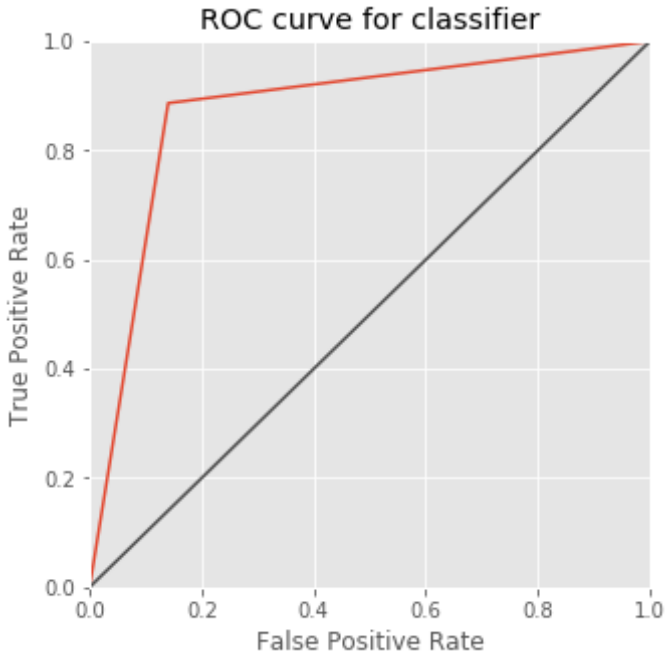
```
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

In [76]:
```
Y_pred_lr_2 = logreg2.predict(X_test)
```

In [77]:
```
score_lr = round(accuracy_score(Y_pred_lr_2,Y_test)*100,2)

print("The accuracy score achieved using Logistic Regression is: "+str(
score_lr)+" %")
```

```
The accuracy score achieved using Logistic Regression is: 88.5 %
```

In [78]:
```
fpr, tpr, thresholds = roc_curve(Y_test,Y_pred_lr)

fig, ax = plt.subplots()
ax.plot(fpr, tpr)
ax.plot([0, 1], [0, 1], transform=ax.transAxes, ls="-", c=".3")
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])

plt.rcParams['figure.figsize'] = (5, 5)
plt.title('ROC curve for classifier', fontweight = 30)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.show()
```



Now our true negatives are also more so it now predicting well.

NAIVE BAYES

In [79]:
```
from sklearn.naive_bayes import GaussianNB

nb = GaussianNB()

nb.fit(X_train,Y_train)

Y_pred_nb = nb.predict(X_test)
```

In [80]:
```
score_nb = round(accuracy_score(Y_pred_nb,Y_test)*100,2)
```

```
print("The accuracy score achieved using Naive Bayes is: "+str(score_nb
)+" %")
```

```
The accuracy score achieved using Naive Bayes is: 87.78 %
```

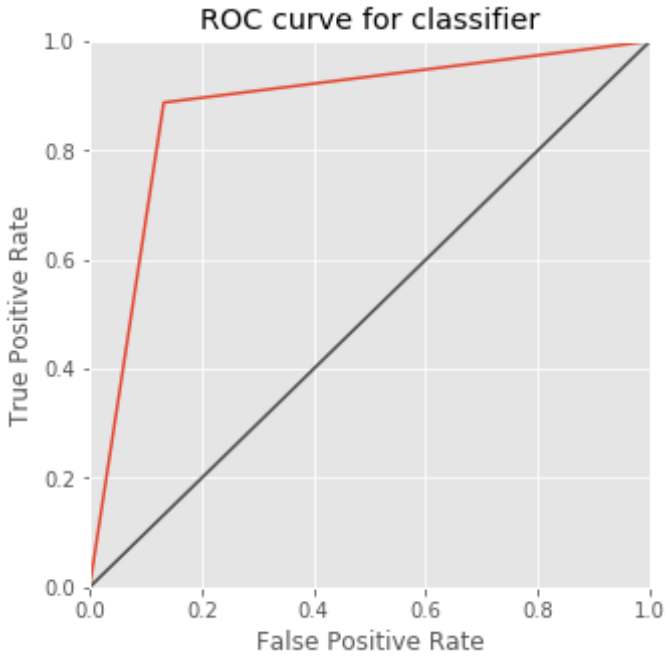
In [81]:
```
results = confusion_matrix(Y_test, Y_pred_nb)
results
```

Out[81]:
```
array([[773, 118],
       [103, 814]], dtype=int64)
```

In [82]:
```
print(classification_report(Y_pred_nb,Y_test))
```

```
              precision    recall  f1-score   support

           0       0.87      0.88      0.87       876
           1       0.89      0.87      0.88       932

    accuracy                           0.88      1808
   macro avg       0.88      0.88      0.88      1808
weighted avg       0.88      0.88      0.88      1808
```

In [83]:
```
fpr, tpr, thresholds = roc_curve(Y_test,Y_pred_nb)

fig, ax = plt.subplots()
ax.plot(fpr, tpr)
ax.plot([0, 1], [0, 1], transform=ax.transAxes, ls="-", c=".3")
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])

plt.rcParams['figure.figsize'] = (5, 5)
plt.title('ROC curve for classifier', fontweight = 30)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.show()
```



K NEAREST NEIGHBORS

In [84]:
```
from sklearn.neighbors import KNeighborsClassifier

knn = KNeighborsClassifier(n_neighbors=7)
knn.fit(X_train,Y_train)
Y_pred_knn=knn.predict(X_test)
```

In [85]:
```
score_knn = round(accuracy_score(Y_pred_knn,Y_test)*100,2)

print("The accuracy score achieved using KNN is: "+str(score_knn)+" %")
```

```
The accuracy score achieved using KNN is: 91.48 %
```

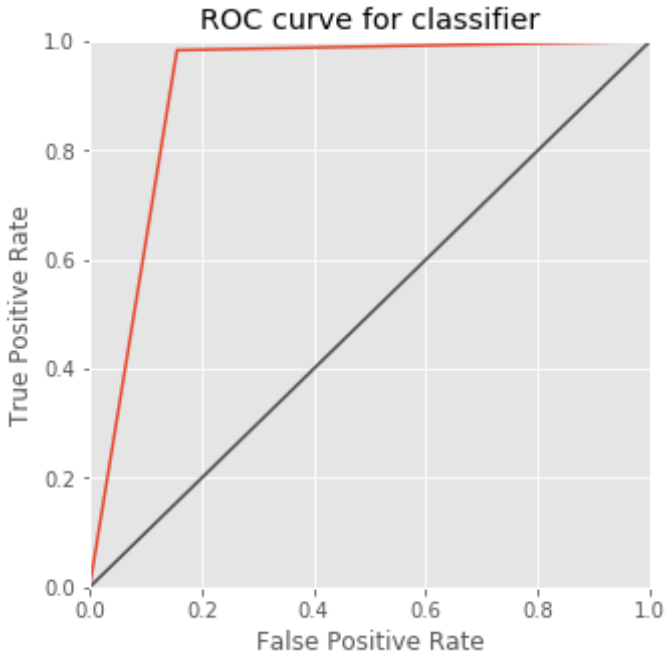
In [86]:
```
results = confusion_matrix(Y_test, Y_pred_knn)
results
```

Out[86]:
```
array([[752, 139],
       [ 15, 902]], dtype=int64)
```

In [87]:
```
print(classification_report(Y_pred_knn,Y_test))
```

```
              precision    recall  f1-score   support

           0       0.84      0.98      0.91       767
           1       0.98      0.87      0.92      1041

    accuracy                           0.91      1808
   macro avg       0.91      0.92      0.91      1808
weighted avg       0.92      0.91      0.92      1808
```

In [88]:
```
fpr, tpr, thresholds = roc_curve(Y_test,Y_pred_knn)

fig, ax = plt.subplots()
ax.plot(fpr, tpr)
ax.plot([0, 1], [0, 1], transform=ax.transAxes, ls="-", c=".3")
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])

plt.rcParams['figure.figsize'] = (5, 5)
plt.title('ROC curve for classifier', fontweight = 30)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.show()
```



DECISION TREE

In [89]:
```
from sklearn.tree import DecisionTreeClassifier
```

In [90]:
```
max_accuracy = 0


for x in range(200):
    dt = DecisionTreeClassifier(random_state=x)
    dt.fit(X_train,Y_train)
    Y_pred_dt = dt.predict(X_test)
    current_accuracy = round(accuracy_score(Y_pred_dt,Y_test)*100,2)
    if(current_accuracy>max_accuracy):
        max_accuracy = current_accuracy
        best_x = x
```

```
dt = DecisionTreeClassifier(random_state=best_x)
dt.fit(X_train,Y_train)
Y_pred_dt = dt.predict(X_test)
```

In [91]:
```
score_dt = round(accuracy_score(Y_pred_dt,Y_test)*100,2)

print("The accuracy score achieved using Decision Tree is: "+str(score_
dt)+" %")
```

```
The accuracy score achieved using Decision Tree is: 97.51 %
```

In [92]:
```
results = confusion_matrix(Y_test, Y_pred_dt)
results
```

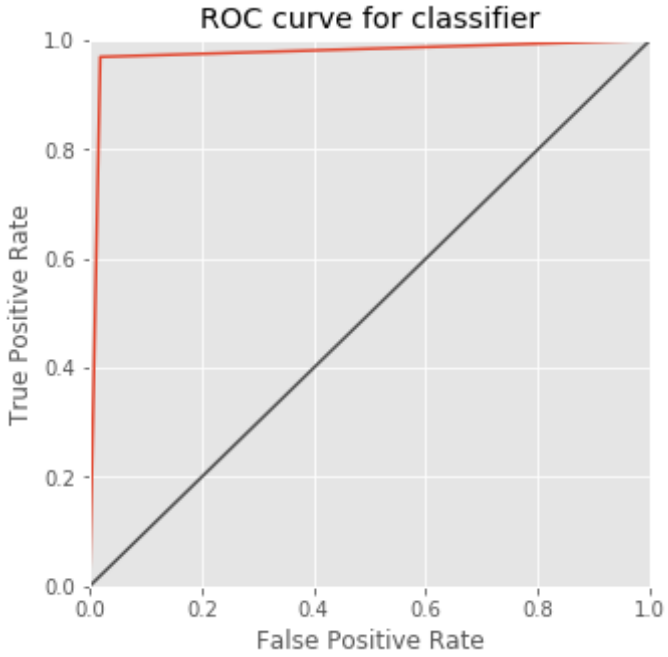
Out[92]:
```
array([[874,  17],
       [ 28, 889]], dtype=int64)
```

In [93]:
```
print(classification_report(Y_pred_dt,Y_test))
```

```
              precision    recall  f1-score   support

           0       0.98      0.97      0.97       902
           1       0.97      0.98      0.98       906

    accuracy                           0.98      1808
   macro avg       0.98      0.98      0.98      1808
weighted avg       0.98      0.98      0.98      1808
```

In [94]:
```
fpr, tpr, thresholds = roc_curve(Y_test,Y_pred_dt)

fig, ax = plt.subplots()
ax.plot(fpr, tpr)
ax.plot([0, 1], [0, 1], transform=ax.transAxes, ls="-", c=".3")
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])
```

```
plt.rcParams['figure.figsize'] = (5, 5)
plt.title('ROC curve for classifier', fontweight = 30)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.show()
```



RANDOM FOREST

In [95]:
```
from sklearn.ensemble import RandomForestClassifier
```

In [96]:
```
model=RandomForestClassifier()
model.fit(X_train,Y_train)
```

Out[96]:
```
RandomForestClassifier()
```

In [97]:
```
Y_pred_rf=model.predict(X_test)
```

In [98]:
```
score_rf = round(accuracy_score(Y_pred_rf,Y_test)*100,2)

print("The accuracy score achieved using Random Forest is: "+str(score_
rf)+" %")
```

```
The accuracy score achieved using Random Forest is: 98.56 %
```

In [99]:
```
confusion_matrix(Y_test,Y_pred_rf)
```

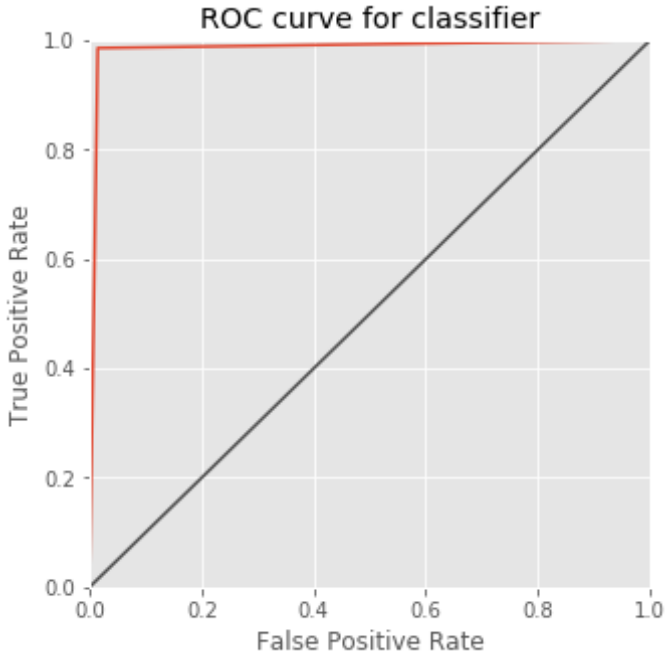
Out[99]:
```
array([[878,  13],
       [ 13, 904]], dtype=int64)
```

In [100]:
```
print(classification_report(Y_pred_rf,Y_test))
```

```
              precision    recall  f1-score   support

           0       0.99      0.99      0.99       891
           1       0.99      0.99      0.99       917

    accuracy                           0.99      1808
   macro avg       0.99      0.99      0.99      1808
weighted avg       0.99      0.99      0.99      1808
```

In [101]:
```
fpr, tpr, thresholds = roc_curve(Y_test,Y_pred_rf)

fig, ax = plt.subplots()
ax.plot(fpr, tpr)
ax.plot([0, 1], [0, 1], transform=ax.transAxes, ls="-", c=".3")
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])

plt.rcParams['figure.figsize'] = (5, 5)
plt.title('ROC curve for classifier', fontweight = 30)
plt.xlabel('False Positive Rate')
```

```
plt.ylabel('True Positive Rate')
plt.show()
```



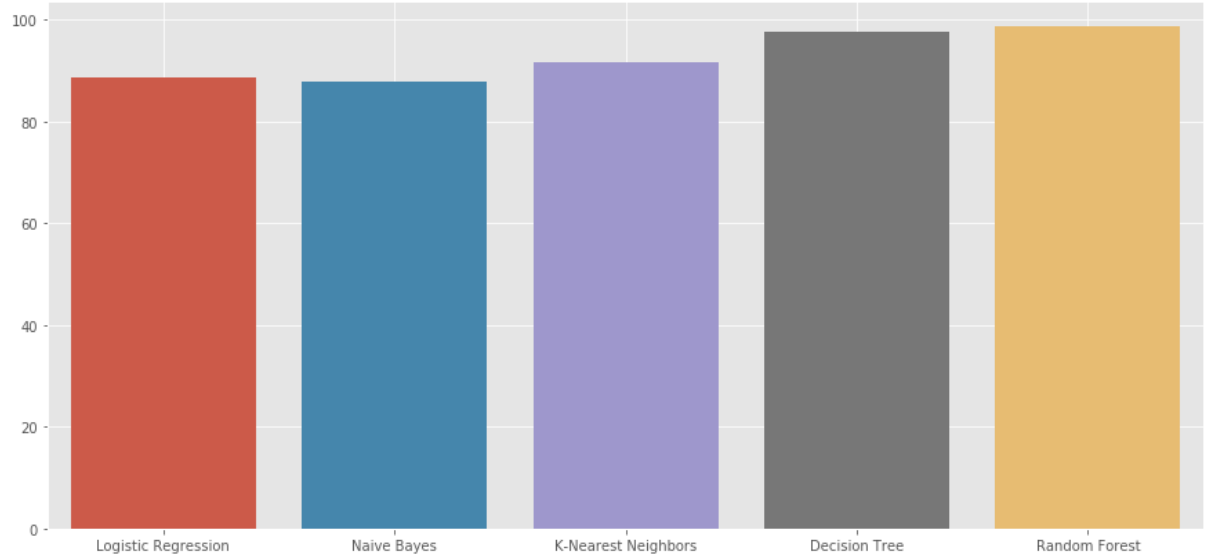
FINDING THE MOST ACCURATE ALGORITHM

In [102]:
```
scores = [score_lr,score_nb,score_knn,score_dt,score_rf]

algorithms = ["Logistic Regression","Naive Bayes","K-Nearest Neighbors"
,"Decision Tree","Random Forest"]

for i in range(len(algorithms)):
    print("The accuracy score achieved using "+algorithms[i]+" is: "+st
r(scores[i])+" %")
```

```
The accuracy score achieved using Logistic Regression is: 88.5 %
The accuracy score achieved using Naive Bayes is: 87.78 %
The accuracy score achieved using K-Nearest Neighbors is: 91.48 %
```

```
The accuracy score achieved using K-Nearest Neighbors is: 91.48 %
The accuracy score achieved using Decision Tree is: 97.51 %
The accuracy score achieved using Random Forest is: 98.56 %
```

In [104]:
```
sns.barplot(x=algorithms,y=scores)
plt.rcParams['figure.figsize'] = (15, 15)
plt.grid(True)
```



SO RANDOM FOREST MODEL GAVE US THE HIGHEST ACCURACY..

In [106]:
```
df
```

Out[106]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
0	25	1	49	4	1.6	1	0	1	0	
1	45	19	34	3	1.5	1	0	1	0	

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
2	39	15	11	1	1.0	1	0	0	0	
3	35	9	100	1	2.7	2	0	0	0	
4	35	8	45	4	1.0	2	0	0	0	
...	...	...	...	...	...	...	...	...	...	
4995	29	3	40	1	1.9	3	0	0	0	
4996	30	4	15	4	0.4	1	85	0	0	
4997	63	39	24	2	0.3	3	0	0	0	
4998	65	40	49	3	0.5	2	0	0	0	
4999	28	4	83	3	0.8	1	0	0	0	

5000 rows × 10 columns

Questions

Q.1) In the list of all people who recieved a personal loan, what was the highest and the lowest income? Also find the average income of this list.

In [108]:
```
df2=df[(df["Personal_Loan"]==1)]
```

In [109]:
```
df2
```

Out[109]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
9	34	9	180	1	8.9	3	0	0	0	

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
16	38	14	130	4	4.7	3	134	0	0	
18	46	21	193	2	8.1	3	0	0	0	
29	38	13	119	1	3.3	2	0	0	1	
38	42	18	141	3	5.0	3	0	1	1	
...	...	...	...	...	...	...	...	...	...	...
4883	38	13	129	3	4.1	3	0	0	1	
4927	43	19	121	1	0.7	2	0	0	1	
4941	28	4	112	2	1.6	2	0	0	0	
4962	46	20	122	3	3.0	3	0	0	1	
4980	29	5	135	3	5.3	1	0	0	1	

480 rows × 10 columns

In [111]:
```
df2.sort_values(["Income"],inplace=True,axis=0,ascending=True)
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\ipykernel_launcher.py:1: Sett
ingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """Entry point for launching an IPython kernel.
```

In [112]:
```
df2
```

Out[112]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
349	26	2	60	2	3.00	1	132	0	0	
1518	43	17	64	4	3.00	3	221	0	0	

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
1577	34	8	65	1	3.00	1	227	0	0	
505	36	12	69	3	3.10	2	0	0	0	
1177	28	3	71	1	3.30	2	149	1	1	
...	...	...	...	...	...	...	...	...	...	
4282	26	0	195	3	6.33	3	0	1	1	
2956	62	38	195	4	5.20	3	522	0	1	
2337	43	16	201	1	10.00	2	0	0	0	
787	45	15	202	3	10.00	3	0	0	0	
2101	35	5	203	1	10.00	3	0	0	0	

480 rows × 10 columns

In [113]:
```
df2["Income"].max()
```

Out[113]: 203

In [114]:
```
df2["Income"].min()
```

Out[114]: 60

As we can see from above that the Personal loan was approved to

HIGEST INCOME : 203

LOWEST INCOME : 60

In [115]:
```
df2["Income"].mean()
```

Out[115]: 144.74583333333334

And the average income of all the people who recieved a personal loan is 144.74583333333334

Q.2) Discuss the distribution of personal loan over the different age groups.

Also find the age groups with the minimum and maximum number of personal loans

In [116]:
```
df[(df["Personal_Loan"]==1)]
```

Out[116]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
9	34	9	180	1	8.9	3	0	0	0	
16	38	14	130	4	4.7	3	134	0	0	
18	46	21	193	2	8.1	3	0	0	0	
29	38	13	119	1	3.3	2	0	0	1	
38	42	18	141	3	5.0	3	0	1	1	
...	...	...	...	...	...	...	...	...	...	
4883	38	13	129	3	4.1	3	0	0	1	
4927	43	19	121	1	0.7	2	0	0	1	
4941	28	4	112	2	1.6	2	0	0	0	
4962	46	20	122	3	3.0	3	0	0	1	
4980	29	5	135	3	5.3	1	0	0	1	

480 rows × 10 columns

In [132]:
```
df1=df[(df["Personal_Loan"]==1)]
```

In [133]:
```
df1
```

Out[133]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
9	34	9	180	1	8.9	3	0	0	0	
16	38	14	130	4	4.7	3	134	0	0	
18	46	21	193	2	8.1	3	0	0	0	
29	38	13	119	1	3.3	2	0	0	1	
38	42	18	141	3	5.0	3	0	1	1	
...	...	...	...	...	...	...	...	...	...	
4883	38	13	129	3	4.1	3	0	0	1	
4927	43	19	121	1	0.7	2	0	0	1	
4941	28	4	112	2	1.6	2	0	0	0	
4962	46	20	122	3	3.0	3	0	0	1	
4980	29	5	135	3	5.3	1	0	0	1	

480 rows × 10 columns

In [134]:
```
df1["Age"].describe()
```

Out[134]:
```
count    480.000000
mean      45.066667
std       11.590964
min       26.000000
25%       35.000000
50%       45.000000
75%       55.000000
max       65.000000
Name: Age, dtype: float64
```

In [135]:
```
df["Age"].unique()
```

Out[135]:
```
array([25, 45, 39, 35, 37, 53, 50, 34, 65, 29, 48, 59, 67, 60, 38, 42,
46,
       55, 56, 57, 44, 36, 43, 40, 30, 31, 51, 32, 61, 41, 28, 49, 47,
62,
       58, 54, 33, 27, 66, 24, 52, 26, 64, 63, 23], dtype=int64)
```

In [136]:
```
df1.sort_values(["Age"],axis=0,ascending=True,inplace=True)
```

```
C:\Users\KIIT\anaconda3\lib\site-packages\ipykernel_launcher.py:1: Sett
ingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """Entry point for launching an IPython kernel.
```

In [137]:
```
df1
```

Out[137]:

	Age	Experience	Income	Family	CCAvg	Education	Mortgage	Sec_Acc	CD_Acc	Perso
4425	26	0	164	2	4.0	3	301	0	0	
151	26	0	132	3	6.5	3	0	0	0	
2951	26	2	132	2	2.4	3	0	0	0	
4345	26	1	184	2	4.2	3	577	0	1	
4337	26	2	182	2	3.2	2	0	0	0	
...	...	...	...	...	...	...	...	...	...	
914	65	41	195	3	0.4	1	0	1	1	
4310	65	41	170	4	6.1	2	0	0	1	
2345	65	40	89	1	4.1	1	299	0	1	
1418	65	41	154	2	4.6	2	0	1	1	
662	65	41	185	3	2.0	2	0	0	0	

480 rows × 10 columns

In [139]:
```
df1["Age"].unique()
```

Out[139]:
```
array([26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41,
42,
       43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58,
59,
       60, 61, 62, 63, 64, 65], dtype=int64)
```

In [142]:
```
df1["Age"].value_counts()
```

Out[142]:
```
34    18
30    17
63    16
35    16
36    16
29    15
33    15
54    15
43    15
52    15
65    14
56    14
42    14
44    14
46    13
45    13
26    13
50    13
38    12
27    12
61    12
32    12
57    12
48    12
53    11
60    10
```

```
58    10
49    10
51    10
47    10
59     9
55     9
62     9
28     9
40     8
41     8
64     8
37     8
31     7
39     6
Name: Age, dtype: int64
```

Age groups with the minimum and maximum no. of personal loans are 34 and 39 respectively.

SUMMARY OF THE PROJECT

I have the Dataset named "Bank.csv". It has the information about the personal loan given to an individual on the basis of the Age, Exeperiance, Income etc. In the start the data set had 5000 rows and 14 columns. After loking into it i found out it has no missing values, so I skipped that part and went straight to EDA. There I found out that the distribution of age and experience were balanced but that of Income was not balanced

Then I looked for correlation between the different variables with the help of Heatmap.After applying 2 more feature selection techniques(Extra Trees Classifier & ANOVA TEST), we have got the top features i.e Income,CCAvg,CC_Acc,Mortgage,Education. And then dropped less correlated features. After splitting the trainning and testing data, I moved to model fitting

I have used 5 classification algorithms, which are given below along with their accuracy Logistic Regression: 88.5% Naive Bayes: 87.78% K-Nearest Neighbors: 91.48% Decision Tree: 97.51% Random Forest: 98.56%

From above, the Algorithm with the highest Accuracy was found out to be RANDOM FOREST.

QUESTIONS ASKED ON THE DATA SET:

Q.1) In the list of all people who recieved a personal loan, what was the highest and the lowest income? Also find the average income of this list.

As we can see from above that the Personal loan was approved to

HIGEST INCOME : 203

LOWEST INCOME : 60

And the average income of all the people who recieved a personal loan is 144.74583333333334

Q.2) Discuss the distribution of personal loan over the different age groups. Also find the age groups with the minimum and maximum number of personal loans

for the first part u can refer the value count above Age groups with the minimum and maximum no. of personal loans are 34 and 39 respectively.