Loan Default Prediction Model

By: Aditya Vikram Singh

In [110]:
```
import pandas as pd                    #import basic libraries
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

In [111]:
```
#Import models from scikit learn module:
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.model_selection import KFold
# from sklearn.model_selection import KFold #For K-fold cross valid
ation
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier, export_graphviz
from sklearn import metrics
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.model_selection import cross_val_score
```

In [112]:
```
loan = pd.read_csv('Loan.csv', usecols = [0,1,2,3,4,5,6,7,8,9,10])
#read csv file
```

In [113]:
```
loan.head()
```

Out[113]:

	Client ID	Loan_purpose	Loan Amount	Working Year	Applicant Income	Co-applicant Income	Account Balance	Delinq_2	inter r
0	110045	Animal Husbandry	34636	7	14453	7679	52301	2	1
1	110046	Animal Husbandry	65646	7	14953	3679	47343	1	1
2	110047	Animal Husbandry	44206	7	13916	12186	29691	1	1
3	110048	Animal Husbandry	36417	5	18345	6546	45237	0	1
4	110049	Animal Husbandry	45161	2	9318	7370	66107	0	1

In [114]:
```
Pur = loan['Loan_purpose'].value_counts(ascending=True)
Pur.head()
```

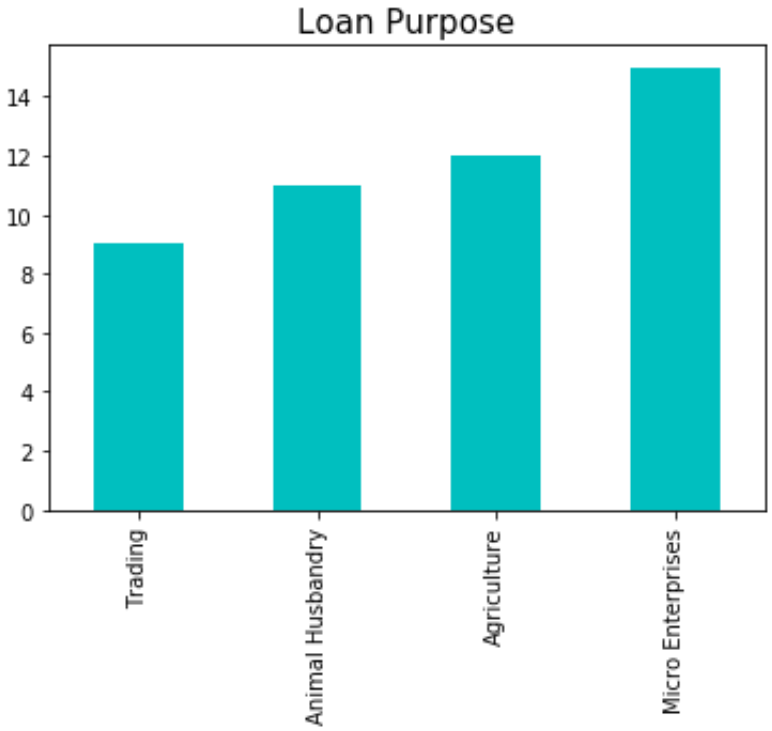
Out[114]:
```
Trading                9
Animal Husbandry      11
Agriculture           12
Micro Enterprises     15
Name: Loan_purpose, dtype: int64
```

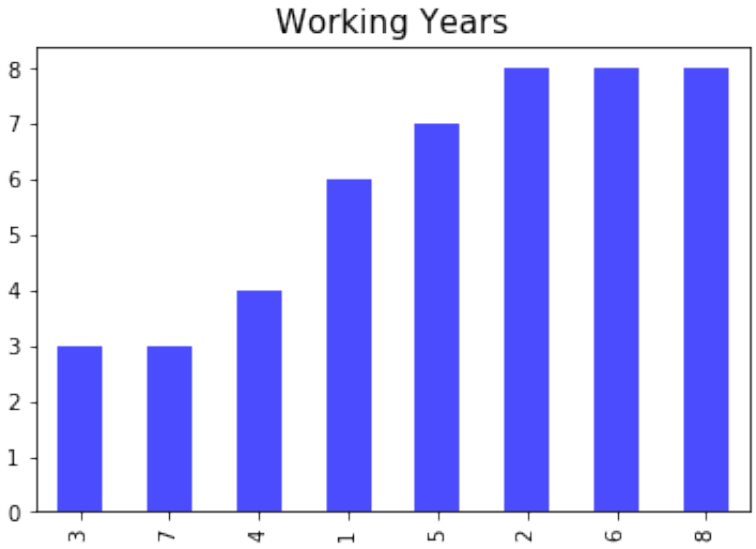
In [67]:
```
Pur.plot(kind='bar', color = 'c')
plt.title('Loan Purpose',size = 15)
plt.show()

print("")  #add blank gap

Workex = loan['Working Year'].value_counts(ascending=True)
Workex.head()

Workex.plot(kind='bar', color='blue', alpha=0.7)
plt.title('Working Years',size = 15)
plt.show()
```


Loan Purpose
14
12
10
8
6
4
2
0
Trading
Animal Husbandry
Agriculture
Micro Enterprises


Working Years
8
7
6
5
4
3
2
1
0
3
7
4
1
5
2
6
8

In [68]:
```
# exploring data type in the data frame
loan.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 47 entries, 0 to 46
Data columns (total 11 columns):
Client ID              47 non-null int64
Loan_purpose           47 non-null object
Loan Amount            47 non-null int64
Working Year           47 non-null int64
Applicant Income       47 non-null int64
Co-applicant Income    47 non-null int64
Account Balance        47 non-null int64
Delinq_2               47 non-null int64
interest rate          47 non-null float64
credit rating          47 non-null int64
default                47 non-null int64
dtypes: float64(1), int64(9), object(1)
memory usage: 4.2+ KB
```

In [115]:
```
loan['TotalIncome'] = loan['Applicant Income'] + loan['Co-applicant Income'] #adding total income column
```

In [116]:
```
list(loan.columns)
```

Out[116]:
```
['Client ID',
 'Loan_purpose',
 'Loan Amount',
 'Working Year',
 'Applicant Income',
 'Co-applicant Income',
 'Account Balance',
 'Delinq_2',
 'interest rate',
 'credit rating',
 'default',
 'TotalIncome']
```

In [117]:
```
#building predictive model
#we will use scikit-learn (sklearn), for which we need to convert t
he categorical values into numerical values
from sklearn.preprocessing import LabelEncoder
var_col = ['Loan_purpose']
le = LabelEncoder()  #Encode labels with value between 0 and n_clas
ses-1.
for i in var_col:
    loan[i] = le.fit_transform(loan[i]) #Fit label encoder and retu
rn encoded labels
loan.dtypes
```

Out[117]:
```
Client ID                int64
Loan_purpose             int64
Loan Amount              int64
Working Year             int64
Applicant Income         int64
Co-applicant Income      int64
Account Balance          int64
Delinq_2                 int64
interest rate          float64
credit rating            int64
default                  int64
TotalIncome              int64
dtype: object
```

In [118]:
```
loan.describe()
```

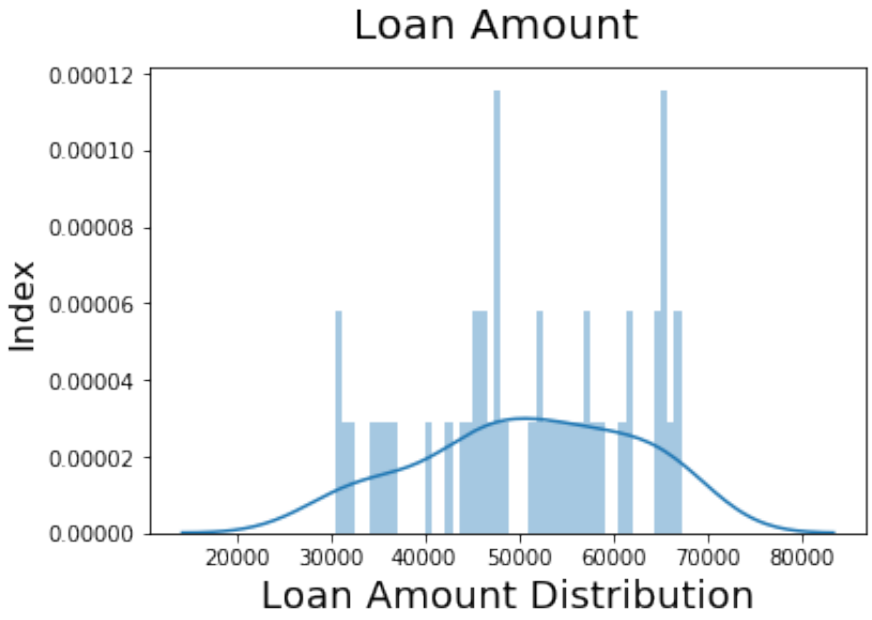
Out[118]:

	Client ID	Loan_purpose	Loan Amount	Working Year	Applicant Income	Co-applicant Income
count	47.000000	47.000000	47.000000	47.000000	47.000000	47.000000
mean	110068.000000	1.446809	51026.957447	4.574468	16209.893617	8270.957447
std	13.711309	1.079624	10989.148108	2.411428	5362.800863	3290.618258
min	110045.000000	0.000000	30447.000000	1.000000	6277.000000	3112.000000
25%	110056.500000	0.500000	44840.000000	2.000000	11590.000000	5743.500000
50%	110068.000000	2.000000	51890.000000	5.000000	15989.000000	7679.000000
75%	110079.500000	2.000000	59677.500000	6.000000	19777.500000	10764.000000
max	110091.000000	3.000000	67224.000000	8.000000	24814.000000	14702.000000

Distribution Plots

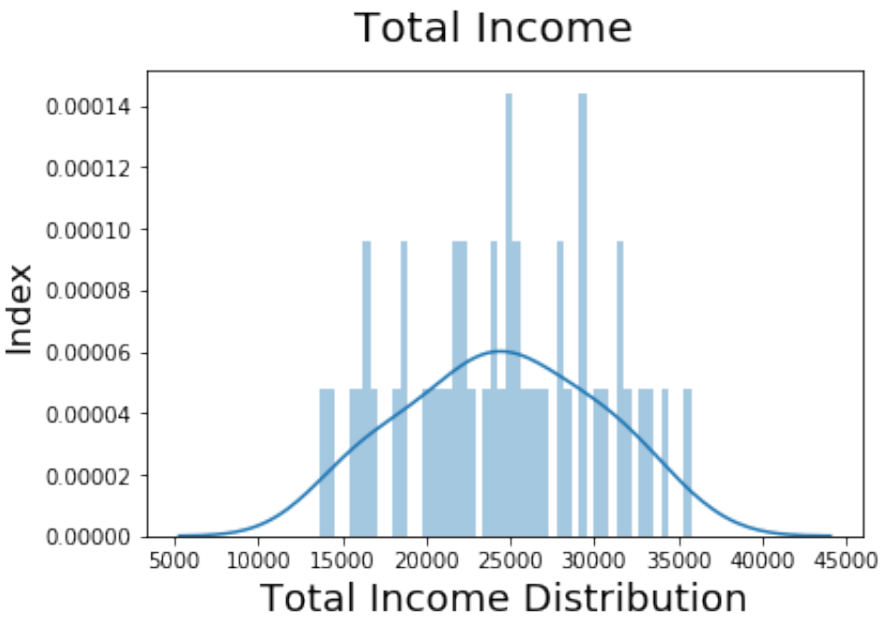
In [14]:
```
# Plotting terms to understand the distribution.
fig = plt.figure()
sns.distplot(loan['Loan Amount'],bins=50)
fig.suptitle('Loan Amount', fontsize=20)
# Plot heading
plt.xlabel('Loan Amount Distribution', fontsize=18)
# X-label
plt.ylabel('Index', fontsize=16)
```

Out[14]:
```
Text(0, 0.5, 'Index')
```



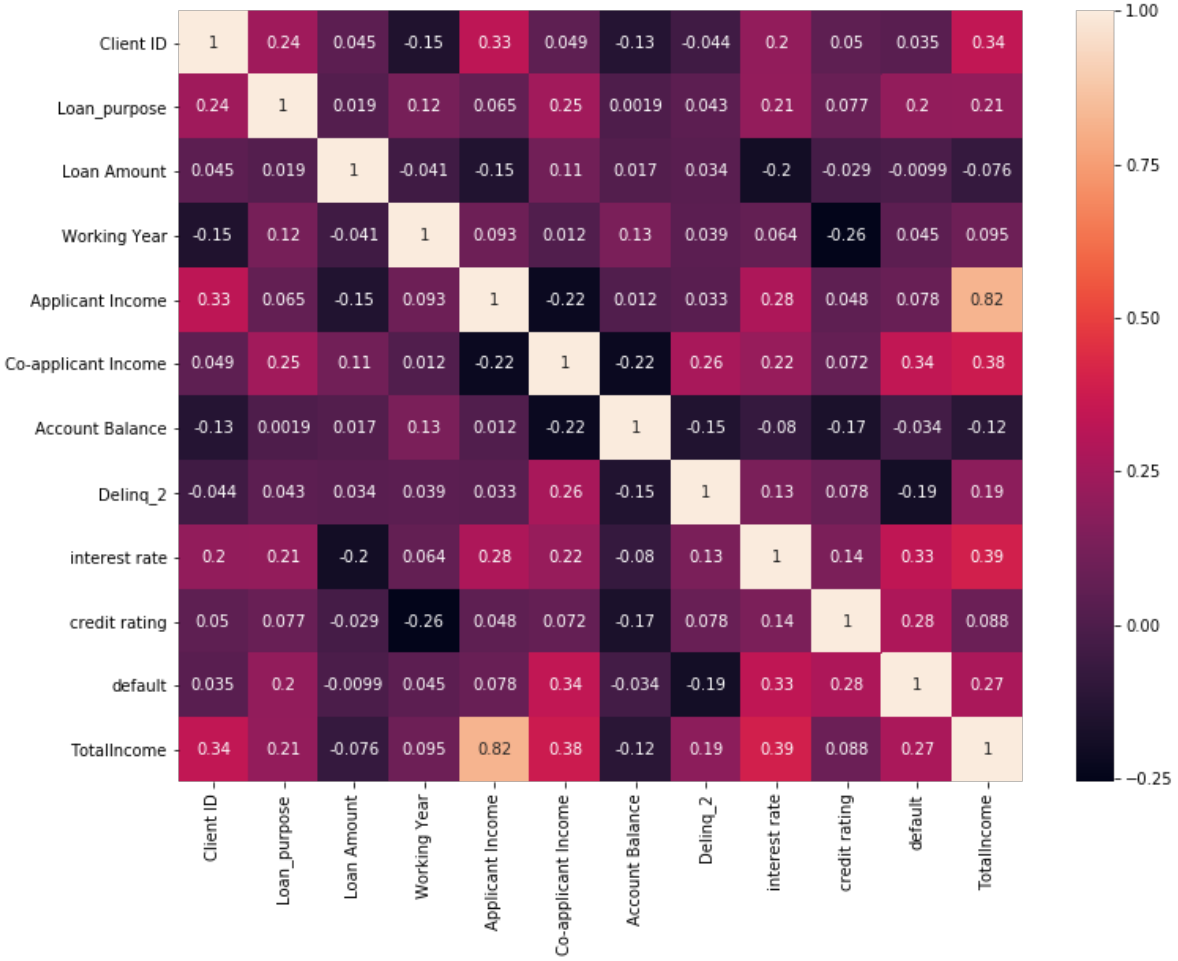
In [16]:
```
# Plotting terms to understand the distribution.
fig = plt.figure()
sns.distplot(loan['TotalIncome'],bins=50)
fig.suptitle('Total Income', fontsize=20)
# Plot heading
plt.xlabel('Total Income Distribution', fontsize=18)
# X-label
plt.ylabel('Index', fontsize=16)
```

Out[16]: Text(0, 0.5, 'Index')



In [72]:
```
plt.figure(figsize=(12,9))                    #correlation matrix
ax = sns.heatmap(loan.corr(),annot = True)
bottom, top = ax.get_ylim()                   #fixing seaborn plotting i
ssues
ax.set_ylim(bottom + 0.5, top - 0.5)
```

Out[72]: (12.0, 0.0)



In [119]:
```
# Putting feature variable to A
A = loan[['Loan_purpose','Loan Amount','Working Year','TotalIncome'
,'Account Balance','Deling_2','interest rate','credit rating']]

# Putting response variable to B
B = loan['default']
```

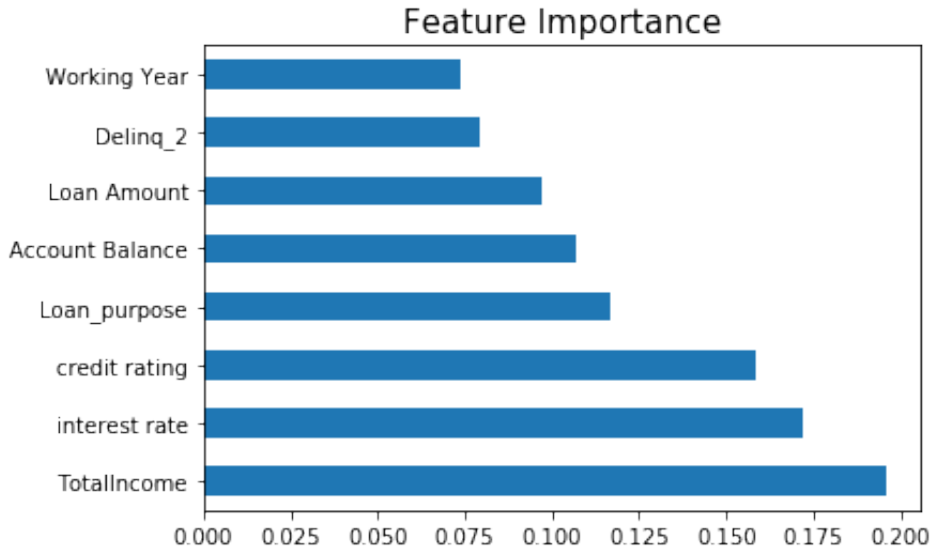
Feature Importance

In [120]:
```
from sklearn.ensemble import ExtraTreesClassifier
model = ExtraTreesClassifier()
model.fit(A,B)
print(model.feature_importances_) #use inbuilt class feature_import
ances of tree based classifiers
#plot graph of feature importances for better visualization
feat_importances = pd.Series(model.feature_importances_, index=A.co
lumns)
print("")                          #create a gap between presentatio
n
print(feat_importances)
feat_importances.nlargest(10).plot(kind='barh')
plt.title('Feature Importance',size = 15)
plt.show()
```

```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/ensemble/forest.py:245: FutureWarning: The def
ault value of n_estimators will change from 10 in version 0.20 to
100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)

[0.11669302 0.09681294 0.07391333 0.19575474 0.10717473 0.07909005
 0.17183366 0.15872754]

Loan_purpose        0.116693
Loan Amount         0.096813
Working Year        0.073913
TotalIncome         0.195755
Account Balance     0.107175
Delinq_2            0.079090
interest rate       0.171834
credit rating       0.158728
dtype: float64
```



Classificatio Model with KFolds Cross Validation

In [125]:
```
#Generic function for making a classification model and accessing p
erformance:
def classification_model(model, data, predictors, outcome):
    model.fit(data[predictors],data[outcome])
    predictions = model.predict(data[predictors])
    accuracy = metrics.accuracy_score(predictions,data[outcome])
    print("Accuracy :" "{0:.2%}".format(accuracy))
    print('Root Mean Squared Error:', np.sqrt(metrics.mean_squared_
error(predictions,data[outcome])))
    r_squared = metrics.r2_score(predictions,data[outcome])
    print('r_square_value :',"{0:.2%}".format(r_squared))

    plt.title('Confusion Matrix',size=14)
    ax = sns.heatmap(confusion_matrix(data[outcome],predictions), a
nnot=True,annot_kws={"size": 16},cmap="YlGnBu") #print(confusion_ma
trix(data[outcome],predictions))
    plt.xlabel('Predicted')
    plt.ylabel('Actual')
    bottom, top = ax.get_ylim()                                    #fixing
seaborn plotting issues
    ax.set_ylim(bottom + 0.5, top - 0.5)

    print(classification_report(data[outcome],predictions))


    kf = KFold(5,True,1)
    error = []

    for train, test in kf.split(data):
        train_predictors = (data[predictors].iloc[train,:])
        train_target = data[outcome].iloc[train]
        model.fit(train_predictors, train_target)
        error.append(model.score(data[predictors].iloc[test,:], dat
a[outcome].iloc[test]))

    print("Cross-Validation Score :" "{0:.2%}".format(np.mean(error
)))
    print("Cross-Validation Score :" "{0:.2%}".format(np.mean(cross
_val_score(model, data[predictors], data[outcome], cv=5))))
    #Fit the model again so that it can be refered outside the func
tion:
    model.fit(data[predictors],data[outcome])
```

Logistic Regression

In [126]:
```
#using Logistic reasoning
outcome_var = ['default']
model = LogisticRegression()
predictor_var = ['Loan_purpose','Loan Amount','Working Year','Total
Income','Account Balance','Delinq_2','interest rate','credit rating
']
classification_model(model,loan,predictor_var,outcome_var)
```

```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
efault solver will be changed to 'lbfgs' in 0.22. Specify a solver
to silence this warning.
  FutureWarning)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/utils/validation.py:724: DataConversionWarning
: A column-vector y was passed when a 1d array was expected. Pleas
e change the shape of y to (n_samples, ), for example using ravel(
).
  y = column_or_1d(y, warn=True)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
efault solver will be changed to 'lbfgs' in 0.22. Specify a solver
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/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
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/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
```

```
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
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  FutureWarning)
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  y = column_or_1d(y, warn=True)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
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  FutureWarning)
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te-packages/sklearn/utils/validation.py:724: DataConversionWarning
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).
  y = column_or_1d(y, warn=True)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
efault solver will be changed to 'lbfgs' in 0.22. Specify a solver
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  FutureWarning)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/utils/validation.py:724: DataConversionWarning
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).
  y = column_or_1d(y, warn=True)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
efault solver will be changed to 'lbfgs' in 0.22. Specify a solver
to silence this warning.
  FutureWarning)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/utils/validation.py:724: DataConversionWarning
: A column-vector y was passed when a 1d array was expected. Pleas
e change the shape of y to (n_samples, ), for example using ravel(
).
```

```
  y = column_or_1d(y, warn=True)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
efault solver will be changed to 'lbfgs' in 0.22. Specify a solver
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  FutureWarning)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/utils/validation.py:724: DataConversionWarning
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).
  y = column_or_1d(y, warn=True)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
efault solver will be changed to 'lbfgs' in 0.22. Specify a solver
to silence this warning.
  FutureWarning)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/utils/validation.py:724: DataConversionWarning
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).
  y = column_or_1d(y, warn=True)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/linear_model/logistic.py:432: FutureWarning: D
efault solver will be changed to 'lbfgs' in 0.22. Specify a solver
to silence this warning.
  FutureWarning)
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/sklearn/utils/validation.py:724: DataConversionWarning
: A column-vector y was passed when a 1d array was expected. Pleas
e change the shape of y to (n_samples, ), for example using ravel(
).
  y = column_or_1d(y, warn=True)

Accuracy :68.09%
Root Mean Squared Error: 0.564932682866032
r_square_value : -38.24%
              precision    recall  f1-score   support

           0       0.70      0.78      0.74        27
           1       0.65      0.55      0.59        20

    accuracy                           0.68        47
   macro avg       0.67      0.66      0.67        47
weighted avg       0.68      0.68      0.68        47

Cross-Validation Score :50.89%
Cross-Validation Score :56.00%
```
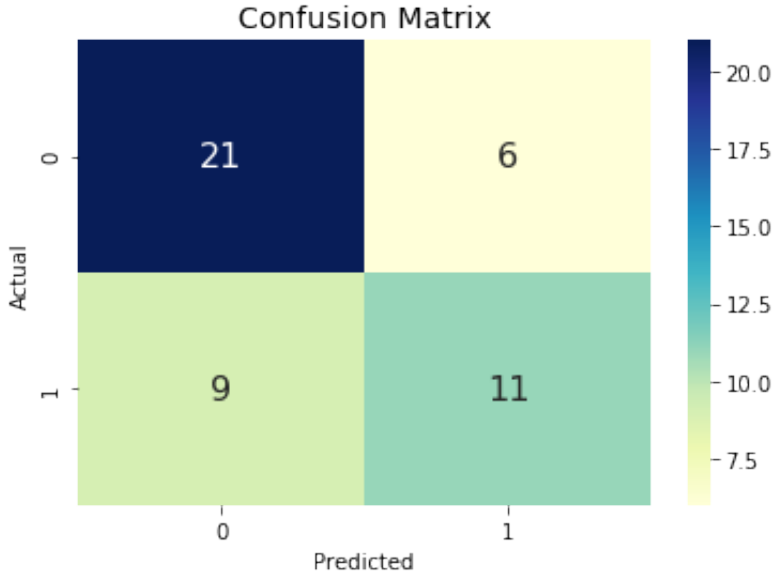
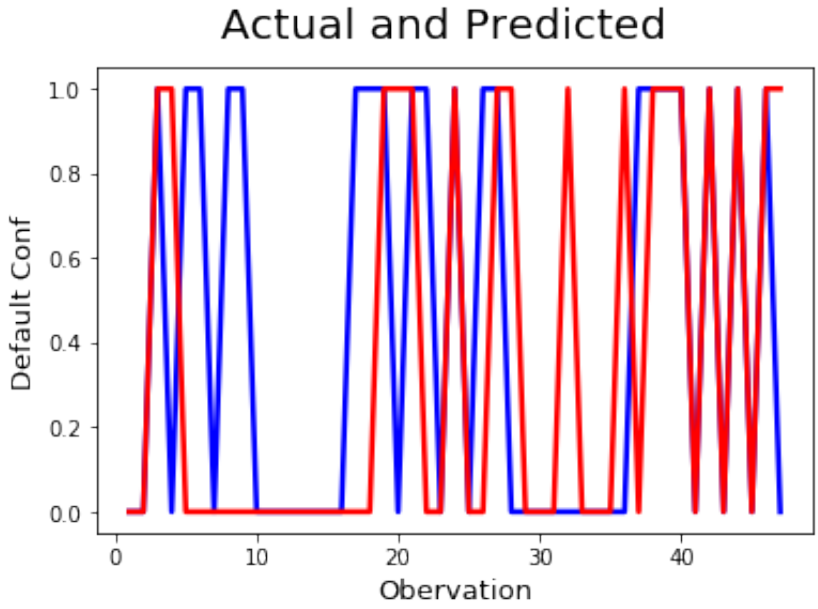



In [53]:
```
#Result Graph
f = np.arange(1,48,1)
fig = plt.figure()
plt.plot(f,B, color="blue", linewidth=2.5, linestyle="-")
plt.plot(f,model.predict(A), color="red",  linewidth=2.5, linestyle
="-")
fig.suptitle('Actual and Predicted', fontsize=20)
plt.xlabel('Obervation',size=13)
plt.ylabel('Default Conf',size=13)
```

Out[53]:
```
Text(0, 0.5, 'Default Conf')
```



In [43]:
```
Logistics = pd.DataFrame(model.predict(A),B,columns=['Predicted'])
#Result List
Logistics
```

Out[43]:

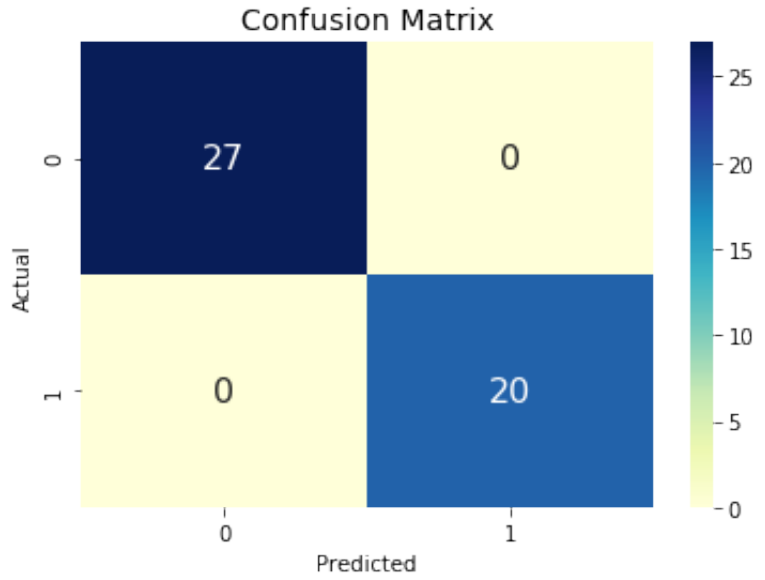
	Predicted
default	
0	0
0	0
1	1
0	1
1	0
1	0
0	0
1	0
1	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
1	0
1	0
1	1
0	1
1	1
1	0
0	0
1	1
0	0
1	0
1	1
0	1
0	0
0	0
0	0
0	1

0	0
0	0
0	0
0	1
1	0
1	1
1	1
1	1
0	0
1	1
0	0
1	1
0	0
1	1
0	1

Decision Tree

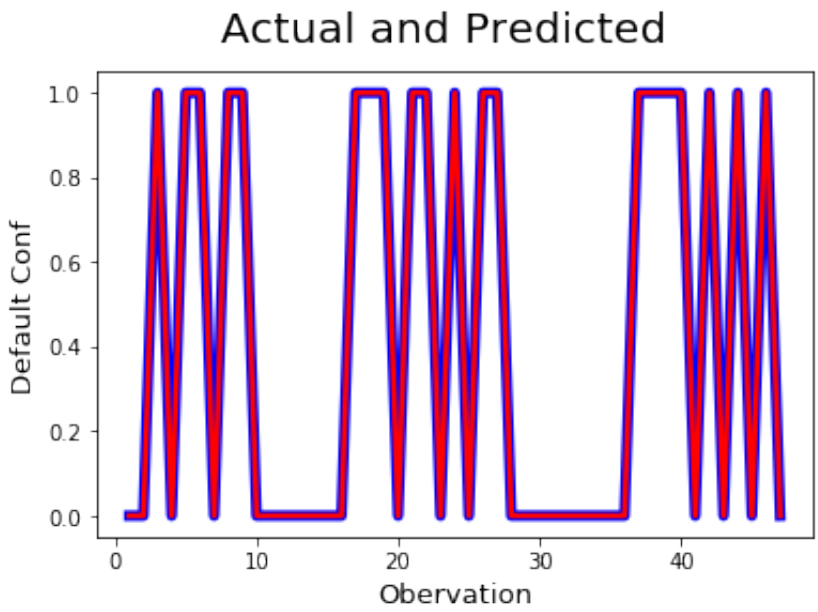
In [82]:
```
#using Decision Tree
model = DecisionTreeClassifier()
predictor_var = ['Loan_purpose','Loan Amount','Working Year','Total
Income','Account Balance','Delinq_2','interest rate','credit rating
']
classification_model(model,loan,predictor_var,outcome_var)
```

```
Accuracy :100.00%
Root Mean Squared Error: 0.0
r_square_value : 100.00%
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        27
           1       1.00      1.00      1.00        20

    accuracy                           1.00        47
   macro avg       1.00      1.00      1.00        47
weighted avg       1.00      1.00      1.00        47

Cross-Validation Score :57.33%
```



In [52]:
```
#Result Graph
f = np.arange(1,48,1)
fig = plt.figure()
plt.plot(f,B, color="blue", linewidth=5, linestyle="-")
plt.plot(f,model.predict(A), color="red",  linewidth=2.5, linestyle
="-")
fig.suptitle('Actual and Predicted', fontsize=20)
plt.xlabel('Obervation',size=13)
plt.ylabel('Default Conf',size=13)
```

Out[52]:
```
Text(0, 0.5, 'Default Conf')
```



In [53]:
```
Tree = pd.DataFrame(model.predict(A),B,columns=['Predicted'])  #Res
ult List
Tree
```

Out[53]:

default	Predicted
0	0
0	0
1	1
0	0
1	1
1	1
0	0
1	1
1	1

0	0
0	0
0	0
0	0
0	0
0	0
0	0
1	1
1	1
1	1
0	0
1	1
1	1
0	0
1	1
0	0
1	1
1	1
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
1	1
1	1
1	1
1	1
0	0
1	1
0	0

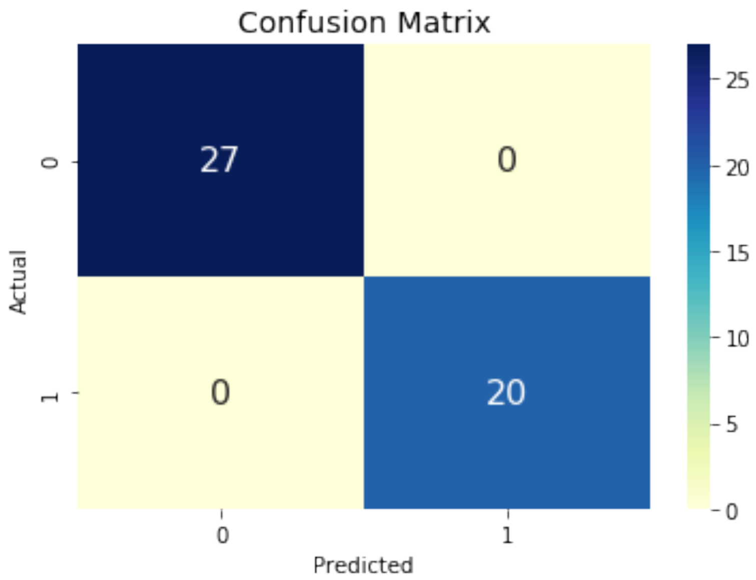
1	1
0	0
1	1
0	0

Random Forest

In [83]:
```
#using Random Forest
model = RandomForestClassifier(n_estimators=20)
predictor_var = ['Loan_purpose','Loan Amount','Working Year','Total Income','Account Balance','Delinq_2','interest rate','credit rating']
classification_model(model,loan,predictor_var,outcome_var)
```

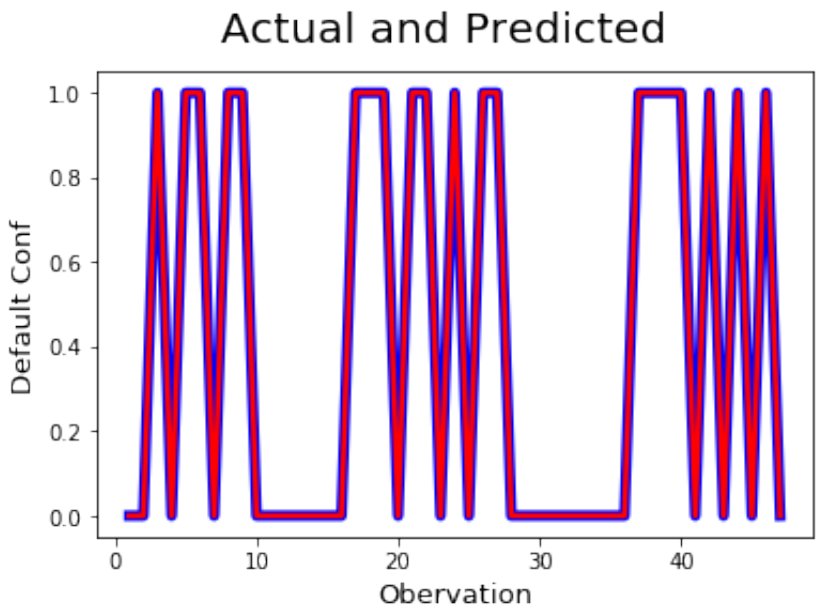
```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/site-packages/ipykernel_launcher.py:3: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().
  This is separate from the ipykernel package so we can avoid doing imports until
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/site-packages/ipykernel_launcher.py:27: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples,), for example using ravel().

Accuracy :100.00%
Root Mean Squared Error: 0.0
r_square_value : 100.00%
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        27
           1       1.00      1.00      1.00        20

    accuracy                           1.00        47
   macro avg       1.00      1.00      1.00        47
weighted avg       1.00      1.00      1.00        47
```

```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples,), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples,), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples,), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples,), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:32: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples,), for example using ravel().

Cross-Validation Score :62.22%
```



In [100]:
```
#Result Graph
f = np.arange(1,48,1)
fig = plt.figure()
plt.plot(f,B, color="blue", linewidth=5, linestyle="-")
plt.plot(f,model.predict(A), color="red",  linewidth=2.5, linestyle
="-")
fig.suptitle('Actual and Predicted', fontsize=20)
plt.xlabel('Obervation',size=13)
plt.ylabel('Default Conf',size=13)
```

Out[100]:
```
Text(0, 0.5, 'Default Conf')
```



In [60]:
```
Forest = pd.DataFrame(model.predict(A),B,columns=['Predicted'])  #R
esult List
Forest
```

Out[60]:

default	Predicted
0	0
0	0
1	1
0	0
1	1
1	1
0	0
1	1
1	1

0	0
0	0
0	0
0	0
0	0
0	0
0	0
1	1
1	1
1	1
0	0
1	1
1	1
0	0
1	1
0	0
1	1
1	1
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
1	0
1	1
1	1
1	1
0	0
1	1
0	0

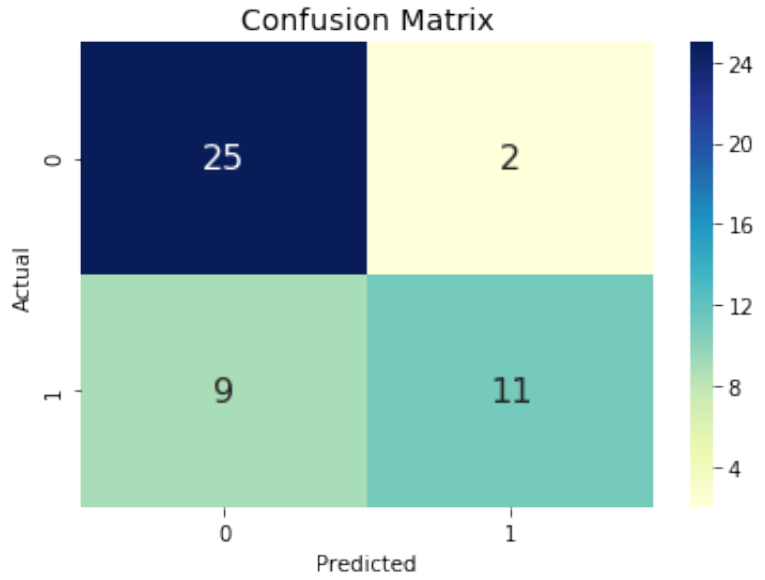
1	1
0	0
1	1
0	0

KNearest Neighbours

In [84]:
```
model = KNeighborsClassifier(n_neighbors=5)
predictor_var = ['Loan_purpose','Loan Amount','Working Year','Total
Income','Account Balance','Delinq_2','interest rate','credit rating
']
classification_model(model,loan,predictor_var,outcome_var)
```

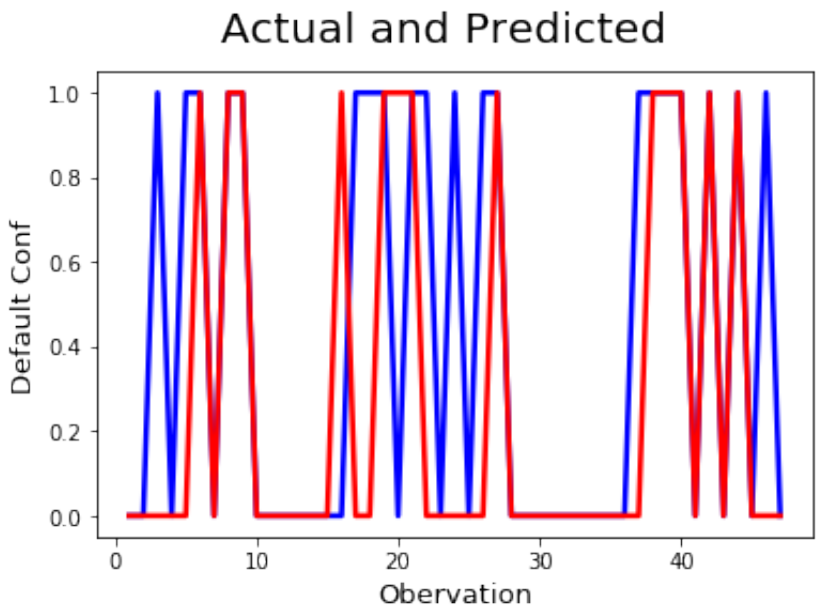
```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:3: DataConversionWarning: A colu
mn-vector y was passed when a 1d array was expected. Please change
the shape of y to (n_samples, ), for example using ravel().
  This is separate from the ipykernel package so we can avoid doin
g imports until
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples, ), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples, ), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples, ), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples, ), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:27: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples, ), for example using ravel().
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/si
te-packages/ipykernel_launcher.py:32: DataConversionWarning: A col
umn-vector y was passed when a 1d array was expected. Please chang
e the shape of y to (n_samples, ), for example using ravel().
```

```
Accuracy :76.60%
Root Mean Squared Error: 0.4837794468468967
r_square_value : -16.97%
              precision    recall  f1-score   support

           0       0.74      0.93      0.82        27
           1       0.85      0.55      0.67        20

    accuracy                           0.77        47
   macro avg       0.79      0.74      0.74        47
weighted avg       0.78      0.77      0.75        47

Cross-Validation Score :57.33%
```



In [18]:
```
#Result Graph
f = np.arange(1,48,1)
fig = plt.figure()
plt.plot(f,B, color="blue", linewidth=2.5, linestyle="-")
plt.plot(f,model.predict(A), color="red",  linewidth=2.5, linestyle
="-")
fig.suptitle('Actual and Predicted', fontsize=20)
plt.xlabel('Obervation',size=13)
plt.ylabel('Default Conf',size=13)
```

Out[18]:
```
Text(0, 0.5, 'Default Conf')
```



In [19]:
```
KNN = pd.DataFrame(model.predict(A),B,columns=['Predicted'])  #Resu
lt List
KNN
```

Out[19]:

default	Predicted
0	0
0	0
1	0
0	0
1	0
1	1
0	0
1	1
1	1

0	0
0	0
0	0
0	0
0	0
0	0
0	1
1	0
1	0
1	1
0	1
1	1
1	0
0	0
1	0
0	0
1	0
1	1
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
1	0
1	1
1	1
1	1
0	0
1	1
0	0

1	1
0	0
1	0
0	0

In [84]:
```
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()

x = np.array(A) #Prepare data for neural network engine
y = np.array(B)

X = sc.fit_transform(x) #nomalizing x
Y = y
```

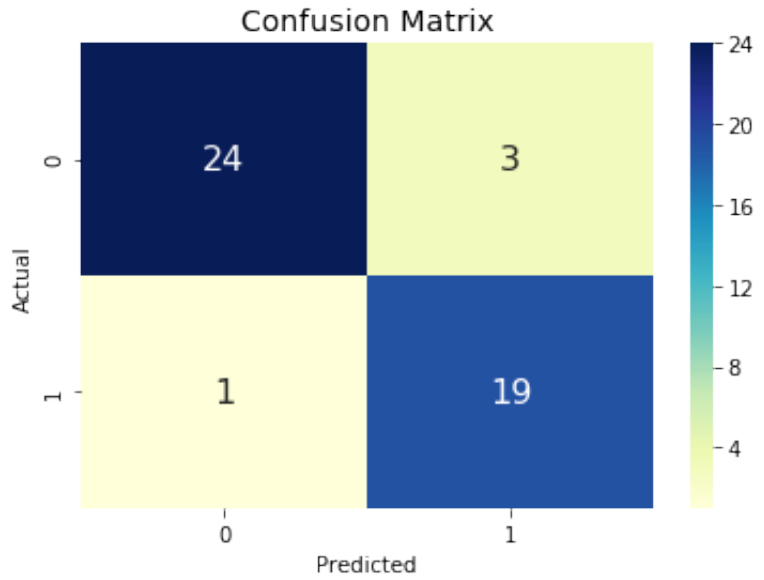
Neural Network

In [87]:
```
# first neural network with keras make predictions
from keras.models import Sequential
from keras.layers import Dense

# define the keras model
model = Sequential()
model.add(Dense(12,input_dim=8, activation='relu'))
model.add(Dense(8, activation='relu'))
model.add(Dense(1, activation='sigmoid'))

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

# fit the keras model on the dataset
model.fit(X,Y, epochs=150, batch_size=10, verbose=0)

# make class predictions with the model
predictions = model.predict_classes(X)

model.summary()

print("") #blank gap

accuracy = metrics.accuracy_score(predictions,Y)
print("Accuracy :" "{0:.2%}".format(accuracy))
print('Root Mean Squared Error:', np.sqrt(metrics.mean_squared_erro
r(predictions,Y)))
```

```
Model: "sequential_49"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_138 (Dense)            (None, 12)                108
_________________________________________________________________
dense_139 (Dense)            (None, 8)                 104
_________________________________________________________________
dense_140 (Dense)            (None, 1)                 9
=================================================================
Total params: 221
Trainable params: 221
Non-trainable params: 0
_________________________________________________________________

Accuracy :91.49%
Root Mean Squared Error: 0.2917299829957891
```

In [88]:
```
plt.title('Confusion Matrix',size=14)
ax = sns.heatmap(confusion_matrix(Y,predictions), annot=True,annot_
kws={"size": 16},cmap="YlGnBu") #print(confusion_matrix(data[outcom
e],predictions))
plt.xlabel('Predicted')
plt.ylabel('Actual')
bottom, top = ax.get_ylim()                                    #fixing sea
born plotting issues
ax.set_ylim(bottom + 0.5, top - 0.5)

print(classification_report(Y,predictions))
```

```
              precision    recall  f1-score   support

           0       0.96      0.89      0.92        27
           1       0.86      0.95      0.90        20

    accuracy                           0.91        47
   macro avg       0.91      0.92      0.91        47
weighted avg       0.92      0.91      0.92        47
```



In [89]:
```
Result = pd.DataFrame(predictions,Y,columns=['Predicted'])  #Result
List
Result
```

Out[89]:

	Predicted
0	0
0	0
1	1
0	1
1	1

1	1
0	0
1	0
1	1
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
1	1
1	1
1	1
0	0
1	1
1	1
0	0
1	1
0	0
1	1
1	1
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	1
0	0
0	0
1	1
1	1
1	1

1	1
0	0
1	1
0	0
1	1
0	1
1	1
0	0