In [1]:

```
# Importing useful libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

Data Preparation

In [2]:

```
df = pd.read_csv("E:/UCI_Credit_Card.csv", index_col = "ID")
```

In [3]:

```
df.head()
```

Out[3]:

	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_0	PAY_2	PAY_3	PAY_4	PAY_5	...
ID											
1	20000.0	2	2	1	24	2	2	-1	-1	-2	...
2	120000.0	2	2	2	26	-1	2	0	0	0	...
3	90000.0	2	2	2	34	0	0	0	0	0	...
4	50000.0	2	2	1	37	0	0	0	0	0	...
5	50000.0	1	2	1	57	-1	0	-1	0	0	...

5 rows × 24 columns

In [4]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 30000 entries, 1 to 30000
Data columns (total 24 columns):
 #   Column                      Non-Null Count  Dtype  
---  ------                      --------------  -----  
 0   LIMIT_BAL                   30000 non-null  float64
 1   SEX                         30000 non-null  int64  
 2   EDUCATION                   30000 non-null  int64  
 3   MARRIAGE                    30000 non-null  int64  
 4   AGE                         30000 non-null  int64  
 5   PAY_0                       30000 non-null  int64  
 6   PAY_2                       30000 non-null  int64  
 7   PAY_3                       30000 non-null  int64  
 8   PAY_4                       30000 non-null  int64  
 9   PAY_5                       30000 non-null  int64  
 10  PAY_6                       30000 non-null  int64  
 11  BILL_AMT1                   30000 non-null  float64
 12  BILL_AMT2                   30000 non-null  float64
 13  BILL_AMT3                   30000 non-null  float64
 14  BILL_AMT4                   30000 non-null  float64
 15  BILL_AMT5                   30000 non-null  float64
 16  BILL_AMT6                   30000 non-null  float64
 17  PAY_AMT1                    30000 non-null  float64
 18  PAY_AMT2                    30000 non-null  float64
 19  PAY_AMT3                    30000 non-null  float64
 20  PAY_AMT4                    30000 non-null  float64
 21  PAY_AMT5                    30000 non-null  float64
 22  PAY_AMT6                    30000 non-null  float64
 23  default.payment.next.month  30000 non-null  int64  
dtypes: float64(13), int64(11)
memory usage: 5.7 MB
```

In [5]:

```
df[['LIMIT_BAL', 'SEX', 'EDUCATION', 'MARRIAGE', 'AGE', 'PAY_0', 'PAY_2', 'PAY_3', 'PAY_4',
```

Out[5]:

	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_0
count	30000.000000	30000.000000	30000.000000	30000.000000	30000.000000	30000.000000
mean	167484.322667	1.603733	1.853133	1.551867	35.485500	-0.016700
std	129747.661567	0.489129	0.790349	0.521970	9.217904	1.123802
min	10000.000000	1.000000	0.000000	0.000000	21.000000	-2.000000
25%	50000.000000	1.000000	1.000000	1.000000	28.000000	-1.000000
50%	140000.000000	2.000000	2.000000	2.000000	34.000000	0.000000
75%	240000.000000	2.000000	2.000000	2.000000	41.000000	0.000000
max	1000000.000000	2.000000	6.000000	3.000000	79.000000	8.000000

In [6]:

```
# Data preprocessing
df = df.rename(columns={'PAY_0': 'PAY_1'}) # Renaming the column

# The 0 in Marriage can be considered as same as 3 category (others)
df.loc[df.MARRIAGE == 0, 'MARRIAGE'] = 3

# The 0, 5 and 6 category in Education column can be considered as 4 category (others)
fil = (df.EDUCATION == 5) | (df.EDUCATION == 6) | (df.EDUCATION == 0)
df.loc[fil, 'EDUCATION'] = 4

# According to our documentation, the PAY_n variables indicate the number of
# months of delay and indicates "pay duly"with -1. Then what is -2?
# And what is 0? It seems to me the label has to be adjusted to 0 for pay duly.
fil = (df.PAY_1 == -2) | (df.PAY_1 == -1) | (df.PAY_1 == 0)
df.loc[fil, 'PAY_1'] = 0
fil = (df.PAY_2 == -2) | (df.PAY_2 == -1) | (df.PAY_2 == 0)
df.loc[fil, 'PAY_2'] = 0
fil = (df.PAY_3 == -2) | (df.PAY_3 == -1) | (df.PAY_3 == 0)
df.loc[fil, 'PAY_3'] = 0
fil = (df.PAY_4 == -2) | (df.PAY_4 == -1) | (df.PAY_4 == 0)
df.loc[fil, 'PAY_4'] = 0
fil = (df.PAY_5 == -2) | (df.PAY_5 == -1) | (df.PAY_5 == 0)
df.loc[fil, 'PAY_5'] = 0
fil = (df.PAY_6 == -2) | (df.PAY_6 == -1) | (df.PAY_6 == 0)
df.loc[fil, 'PAY_6'] = 0
```

In [7]:

```
df.head()
```

Out[7]:

	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_1	PAY_2	PAY_3	PAY_4	PAY_5	...
ID											
1	20000.0	2	2	1	24	2	2	0	0	0	...
2	120000.0	2	2	2	26	0	2	0	0	0	...
3	90000.0	2	2	2	34	0	0	0	0	0	...
4	50000.0	2	2	1	37	0	0	0	0	0	...
5	50000.0	1	2	1	57	0	0	0	0	0	...

5 rows × 24 columns

In [8]:

```
df = pd.get_dummies(df, columns = ['SEX', 'EDUCATION', 'MARRIAGE'], drop_first = True)
```

In [9]:

```
df.head()
```

Out[9]:

	LIMIT_BAL	AGE	PAY_1	PAY_2	PAY_3	PAY_4	PAY_5	PAY_6	BILL_AMT1	BILL_AMT:
ID										
1	20000.0	24	2	2	0	0	0	0	3913.0	3102.(
2	120000.0	26	0	2	0	0	0	2	2682.0	1725.(
3	90000.0	34	0	0	0	0	0	0	29239.0	14027.(
4	50000.0	37	0	0	0	0	0	0	46990.0	48233.(
5	50000.0	57	0	0	0	0	0	0	8617.0	5670.(

5 rows × 27 columns

In [10]:

```
df = df[["LIMIT_BAL", "AGE", "SEX_2", "EDUCATION_2", "EDUCATION_3", "EDUCATION_4", "MARRIAG
```

In [11]:

```
df.head()
```

Out[11]:

	LIMIT_BAL	AGE	SEX_2	EDUCATION_2	EDUCATION_3	EDUCATION_4	MARRIAGE_2	MAF
ID								
1	20000.0	24	1	1	0	0	0	
2	120000.0	26	1	1	0	0	1	
3	90000.0	34	1	1	0	0	1	
4	50000.0	37	1	1	0	0	0	
5	50000.0	57	0	1	0	0	0	

5 rows × 27 columns

In [12]:

```
# Dividing the dataset
X = df.iloc[:, 1:-1].values # Independent variables
y = df.iloc[:, -1].values # Dependent variable
```

In [13]:

```
# Splitting the dataset into the Training set and Test set
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.20, random_state =
```

In [14]:

```
# Feature Scaling
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
```

In [15]:

```
# Data frame for evaluation matrics
metric = pd.DataFrame(index = ['accuracy', 'precision', 'recall'],
                      columns = ['Logistic Regression', 'KNN', 'Decision Tree', 'Random For
```

Logistic regression

In [16]:

```
# Training the Logistic Regression model on the Training set
from sklearn.linear_model import LogisticRegression
logreg = LogisticRegression()
logreg.fit(X_train, y_train)
```

Out[16]:

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=None, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [17]:

```
# Predicting the Test set results
y_pred = logreg.predict(X_test)
y_pred_prob = logreg.predict_proba(X_test)[:, 1]
```

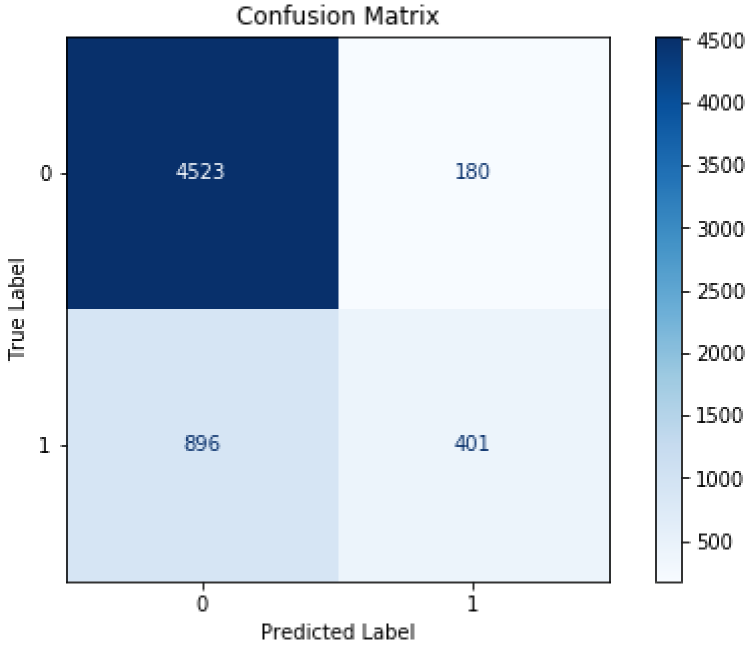
In [18]:

```
# Making the Confusion Matrix
from sklearn.metrics import accuracy_score, precision_score, recall_score, confusion_matrix
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy = accuracy_score(y_test, y_pred)
print(accuracy)
metric.loc['accuracy', 'Logistic Regression'] = accuracy_score(y_pred = y_pred, y_true = y_
metric.loc['precision', 'Logistic Regression'] = precision_score(y_pred = y_pred, y_true = 
metric.loc['recall', 'Logistic Regression'] = recall_score(y_pred = y_pred, y_true = y_test
```

```
[[4523  180]
 [ 896  401]]
0.8206666666666667
```

In [19]:

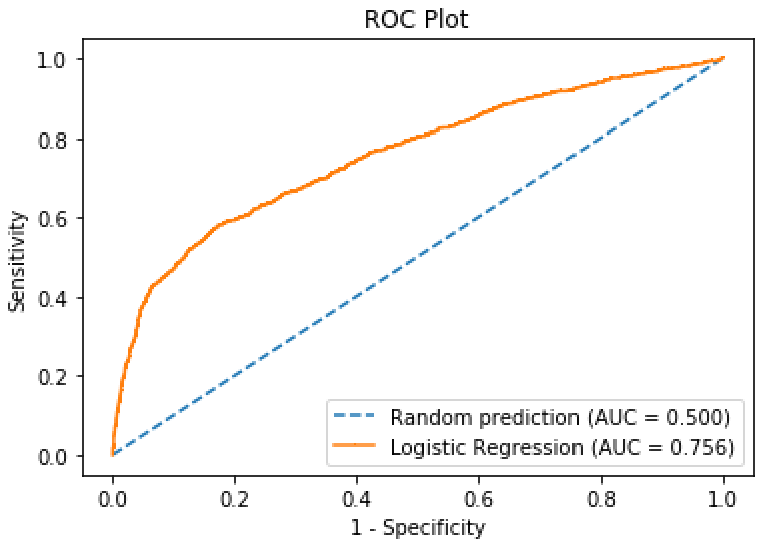
```
matrix = plot_confusion_matrix(logreg, X_test, y_test, values_format = 'd', cmap = plt.cm.B
matrix.ax_.set_title('Confusion Matrix', color = 'black')
plt.xlabel('Predicted Label', color = 'black')
plt.ylabel('True Label', color = 'black')
plt.gcf().axes[0].tick_params(color = 'black')
plt.gcf().axes[1].tick_params(color = 'black')
plt.gcf().set_size_inches(8, 5)
plt.show()
```



In [20]:

```
r_probs = [0 for _ in range(len(y_test))]
LR_probs = logreg.predict_proba(X_test)


LR_probs = LR_probs[:, 1]

from sklearn.metrics import roc_curve, roc_auc_score


r_auc = roc_auc_score(y_test, r_probs)
LR_auc = roc_auc_score(y_test, LR_probs)


print('Random (chance) Prediction: AUC = %.3f' % (r_auc))
print('Logistic Regression: AUC = %.3f' % (LR_auc))

r_fpr, r_tpr, _ = roc_curve(y_test, r_probs)
LR_fpr, LR_tpr, _ = roc_curve(y_test, LR_probs)

plt.plot(r_fpr, r_tpr, linestyle='--', label='Random prediction (AUC = %0.3f)' % r_auc)
plt.plot(LR_fpr, LR_tpr, marker=',', label='Logistic Regression (AUC = %0.3f)' % LR_auc)

# Title
plt.title('ROC Plot')
# Axis labels
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
# Show legend
plt.legend() #
# Show plot
plt.show()
```

```
Random (chance) Prediction: AUC = 0.500
Logistic Regression: AUC = 0.756
```



KNN Classifier

In [21]:

```
# train your model using all data and the best known parameters
from sklearn.neighbors import KNeighborsClassifier
knn = KNeighborsClassifier(n_neighbors = 24)
knn.fit(X_train, y_train)
```

Out[21]:

```
KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski',
                     metric_params=None, n_jobs=None, n_neighbors=24, p=2,
                     weights='uniform')
```

In [22]:

```
# Predicting the Test set results
y_pred = knn.predict(X_test)
y_pred_prob = logreg.predict_proba(X_test)[:, 1]
```

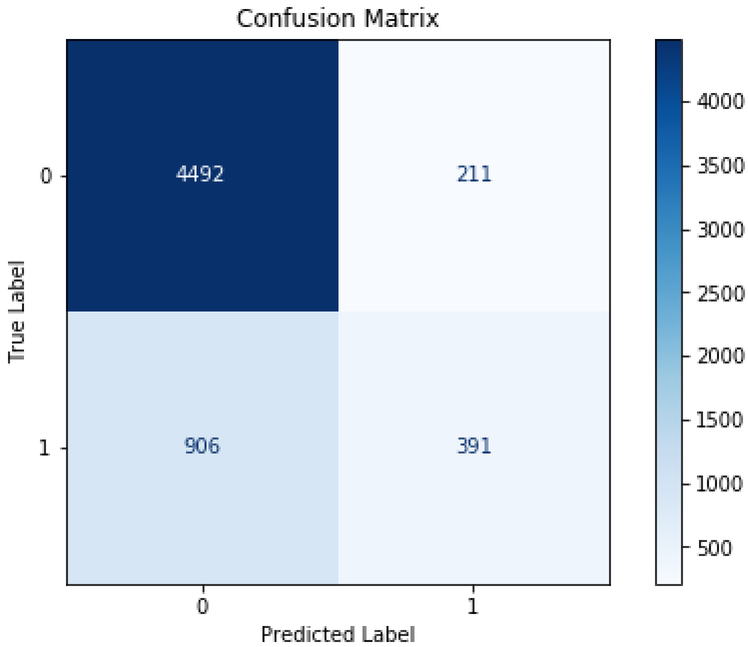
In [23]:

```
# Making the Confusion Matrix
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy = accuracy_score(y_test, y_pred)
print(accuracy)
metric.loc['accuracy', 'KNN'] = accuracy_score(y_pred = y_pred, y_true = y_test)
metric.loc['precision', 'KNN'] = precision_score(y_pred = y_pred, y_true = y_test)
metric.loc['recall', 'KNN'] = recall_score(y_pred = y_pred, y_true = y_test)
```

```
[[4492  211]
 [ 906  391]]
0.8138333333333333
```

In [24]:

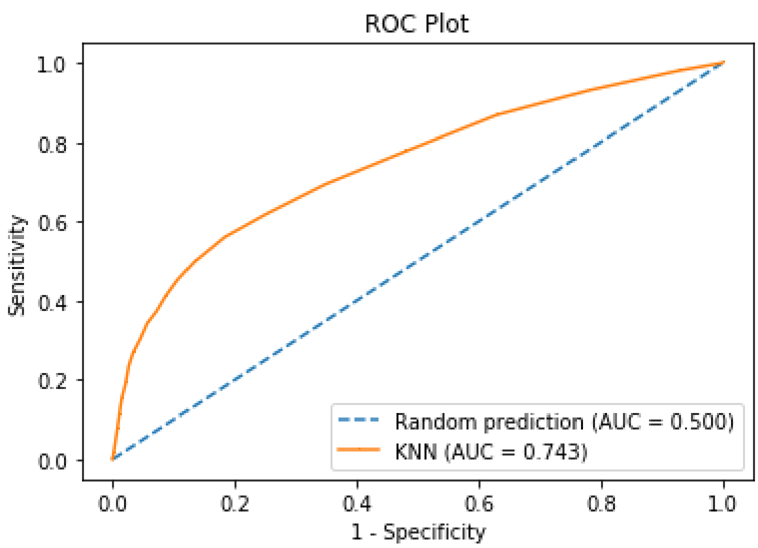
```
matrix = plot_confusion_matrix(knn, X_test, y_test, values_format = 'd', cmap = plt.cm.Blue
matrix.ax_.set_title('Confusion Matrix', color = 'black')
plt.xlabel('Predicted Label', color = 'black')
plt.ylabel('True Label', color = 'black')
plt.gcf().axes[0].tick_params(color = 'black')
plt.gcf().axes[1].tick_params(color = 'black')
plt.gcf().set_size_inches(8, 5)
plt.show()
```



In [25]:

```
r_probs = [0 for _ in range(len(y_test))]
KNN_probs = knn.predict_proba(X_test)


KNN_probs = KNN_probs[:, 1]

from sklearn.metrics import roc_curve, roc_auc_score


r_auc = roc_auc_score(y_test, r_probs)
KNN_auc = roc_auc_score(y_test, KNN_probs)


print('Random (chance) Prediction: AUC = %.3f' % (r_auc))
print('KNN: AUC = %.3f' % (KNN_auc))

r_fpr, r_tpr, _ = roc_curve(y_test, r_probs)
KNN_fpr, KNN_tpr, _ = roc_curve(y_test, KNN_probs)

plt.plot(r_fpr, r_tpr, linestyle='--', label='Random prediction (AUC = %0.3f)' % r_auc)
plt.plot(KNN_fpr, KNN_tpr, marker=',', label='KNN (AUC = %0.3f)' % KNN_auc)

# Title
plt.title('ROC Plot')
# Axis labels
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
# Show legend
plt.legend() #
# Show plot
plt.show()
```

```
Random (chance) Prediction: AUC = 0.500
KNN: AUC = 0.743
```



Decision Tree Classifier

In [26]:

```
# Training the Decision Tree model on the Training set
from sklearn.tree import DecisionTreeClassifier
DTC = DecisionTreeClassifier(min_samples_split = 30, min_samples_leaf = 10)
DTC.fit(X_train, y_train)
```

Out[26]:

```
DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None, criterion='gini',
                       max_depth=None, max_features=None, max_leaf_nodes=Non
e,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=10, min_samples_split=30,
                       min_weight_fraction_leaf=0.0, presort='deprecated',
                       random_state=None, splitter='best')
```

In [27]:

```
# Predicting the Test set results
y_pred = DTC.predict(X_test)
```

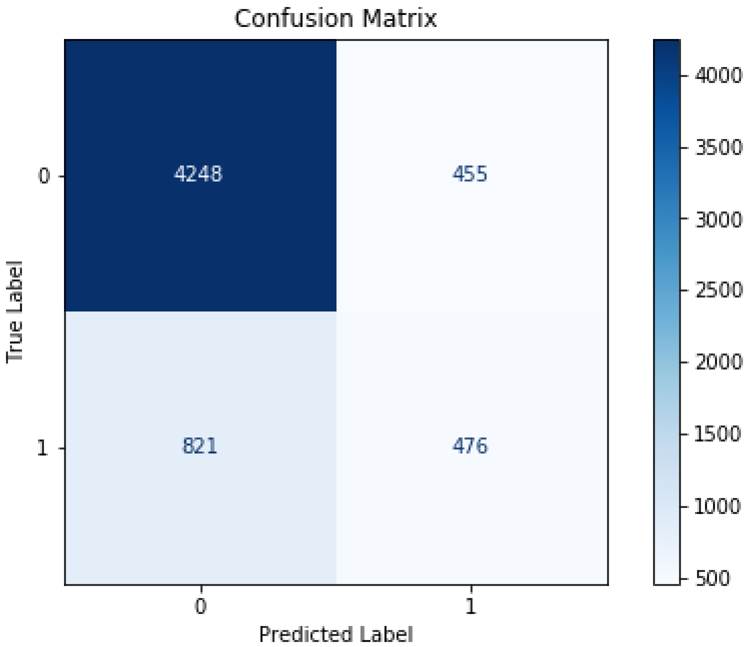
In [28]:

```
# Making the Confusion Matrix
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy = accuracy_score(y_test, y_pred)
print(accuracy)
metric.loc['accuracy', 'Decision Tree'] = accuracy_score(y_pred = y_pred, y_true = y_test)
metric.loc['precision', 'Decision Tree'] = precision_score(y_pred = y_pred, y_true = y_test
metric.loc['recall', 'Decision Tree'] = recall_score(y_pred = y_pred, y_true = y_test)
```

```
[[4248  455]
 [ 821  476]]
0.7873333333333333
```

In [29]:

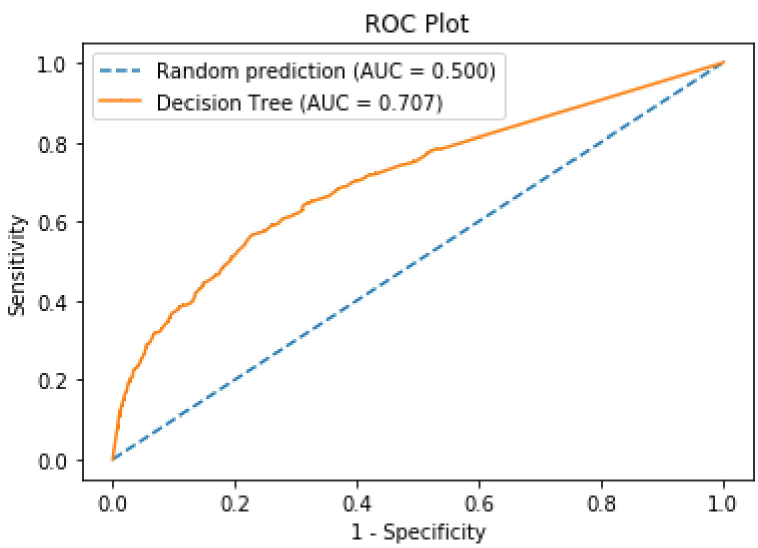
```
matrix = plot_confusion_matrix(DTC, X_test, y_test, values_format = 'd', cmap = plt.cm.Blue
matrix.ax_.set_title('Confusion Matrix', color = 'black')
plt.xlabel('Predicted Label', color = 'black')
plt.ylabel('True Label', color = 'black')
plt.gcf().axes[0].tick_params(color = 'black')
plt.gcf().axes[1].tick_params(color = 'black')
plt.gcf().set_size_inches(8, 5)
plt.show()
```



In [30]:

```
r_probs = [0 for _ in range(len(y_test))]
DT_probs = DTC.predict_proba(X_test)


DT_probs = DT_probs[:, 1]

from sklearn.metrics import roc_curve, roc_auc_score


r_auc = roc_auc_score(y_test, r_probs)
DT_auc = roc_auc_score(y_test, DT_probs)


print('Random (chance) Prediction: AUC = %.3f' % (r_auc))
print('Decision Tree: AUC = %.3f' % (DT_auc))

r_fpr, r_tpr, _ = roc_curve(y_test, r_probs)
DT_fpr, DT_tpr, _ = roc_curve(y_test, DT_probs)

plt.plot(r_fpr, r_tpr, linestyle='--', label='Random prediction (AUC = %0.3f)' % r_auc)
plt.plot(DT_fpr, DT_tpr, marker=',', label='Decision Tree (AUC = %0.3f)' % DT_auc)

# Title
plt.title('ROC Plot')
# Axis labels
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
# Show legend
plt.legend() #
# Show plot
plt.show()
```

```
Random (chance) Prediction: AUC = 0.500
Decision Tree: AUC = 0.707
```



Random Forest classifier

In [31]:

```
# Training the Random Forest model on the Training set
from sklearn.ensemble import RandomForestClassifier
RFC = RandomForestClassifier(n_estimators = 100, min_samples_split = 30, min_samples_leaf =
RFC.fit(X_train, y_train)
```

Out[31]:

```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=None, max_features='aut
o',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=10, min_samples_split=30,
                       min_weight_fraction_leaf=0.0, n_estimators=100,
                       n_jobs=None, oob_score=False, random_state=None,
                       verbose=0, warm_start=False)
```

In [32]:

```
# Predicting the Test set results
y_pred = RFC.predict(X_test)
```

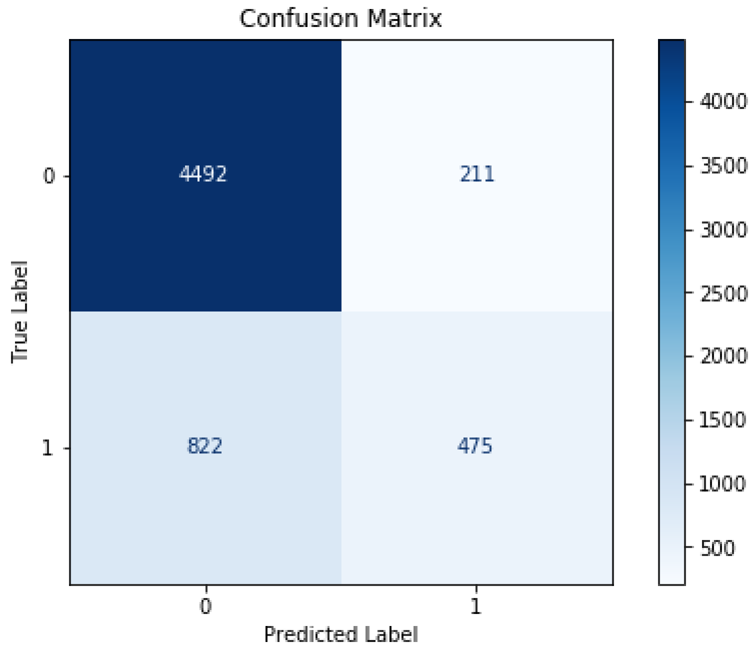
In [33]:

```
# Making the Confusion Matrix
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy = accuracy_score(y_test, y_pred)
print(accuracy)
metric.loc['accuracy', 'Random Forest'] = accuracy_score(y_pred = y_pred, y_true = y_test)
metric.loc['precision', 'Random Forest'] = precision_score(y_pred = y_pred, y_true = y_test
metric.loc['recall', 'Random Forest'] = recall_score(y_pred = y_pred, y_true = y_test)
```

```
[[4492  211]
 [ 822  475]]
0.8278333333333333
```

In [34]:

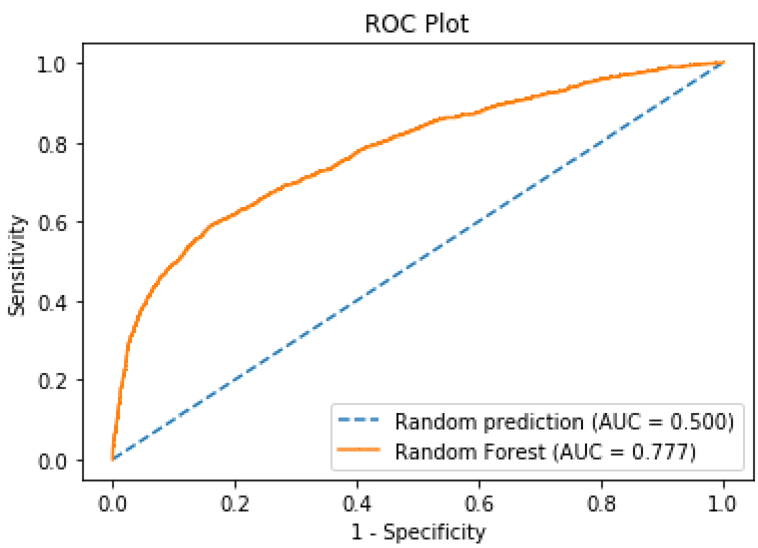
```
matrix = plot_confusion_matrix(RFC, X_test, y_test, values_format = 'd', cmap = plt.cm.Blue
matrix.ax_.set_title('Confusion Matrix', color = 'black')
plt.xlabel('Predicted Label', color = 'black')
plt.ylabel('True Label', color = 'black')
plt.gcf().axes[0].tick_params(color = 'black')
plt.gcf().axes[1].tick_params(color = 'black')
plt.gcf().set_size_inches(8, 5)
plt.show()
```



In [35]:

```
r_probs = [0 for _ in range(len(y_test))]
RF_probs = RFC.predict_proba(X_test)


RF_probs = RF_probs[:, 1]

from sklearn.metrics import roc_curve, roc_auc_score


r_auc = roc_auc_score(y_test, r_probs)
RF_auc = roc_auc_score(y_test, RF_probs)


print('Random (chance) Prediction: AUC = %.3f' % (r_auc))
print('Random Forest: AUC = %.3f' % (RF_auc))

r_fpr, r_tpr, _ = roc_curve(y_test, r_probs)
RF_fpr, RF_tpr, _ = roc_curve(y_test, RF_probs)

plt.plot(r_fpr, r_tpr, linestyle='--', label='Random prediction (AUC = %0.3f)' % r_auc)
plt.plot(RF_fpr, RF_tpr, marker=',', label='Random Forest (AUC = %0.3f)' % RF_auc)

# Title
plt.title('ROC Plot')
# Axis labels
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
# Show legend
plt.legend() #
# Show plot
plt.show()
```

```
Random (chance) Prediction: AUC = 0.500
Random Forest: AUC = 0.777
```



Naive Bayes Classifier

In [36]:

```
# Training the Naive Bayes model on the Training set
from sklearn.naive_bayes import GaussianNB
NBC = GaussianNB()
NBC.fit(X_train, y_train)
```

Out[36]:

```
GaussianNB(priors=None, var_smoothing=1e-09)
```

In [37]:

```
# Predicting the Test set results
y_pred = NBC.predict(X_test)
```

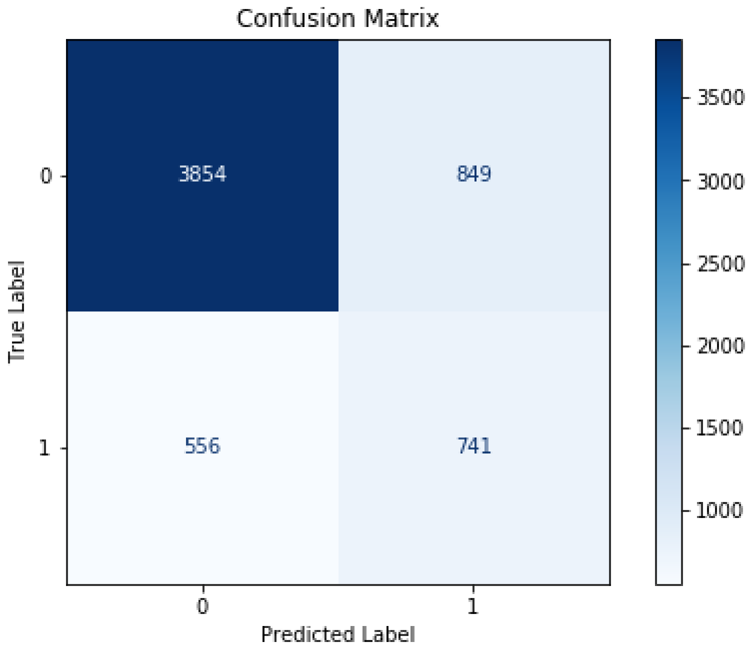
In [38]:

```
# Making the Confusion Matrix
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy = accuracy_score(y_test, y_pred)
print(accuracy)
metric.loc['accuracy', 'Naive Bayes'] = accuracy_score(y_pred = y_pred, y_true = y_test)
metric.loc['precision', 'Naive Bayes'] = precision_score(y_pred = y_pred, y_true = y_test)
metric.loc['recall', 'Naive Bayes'] = recall_score(y_pred = y_pred, y_true = y_test)
```

```
[[3854  849]
 [ 556  741]]
0.7658333333333334
```

In [39]:

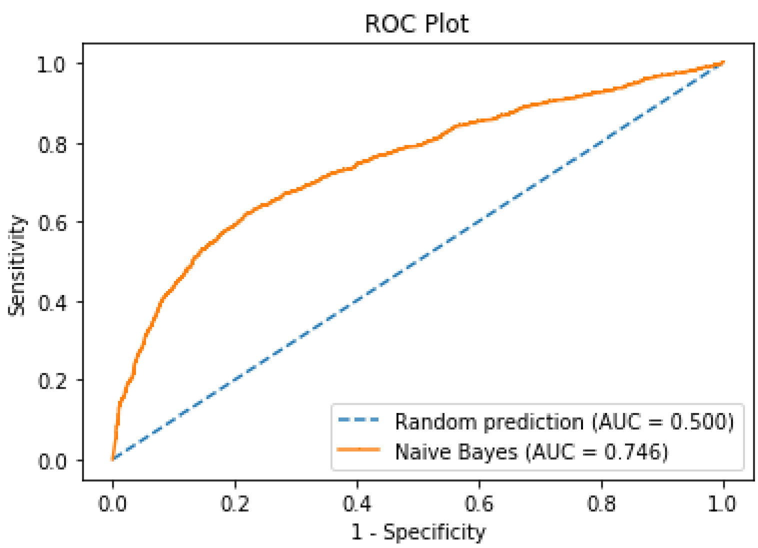
```
matrix = plot_confusion_matrix(NBC, X_test, y_test, values_format = 'd', cmap = plt.cm.Blue
matrix.ax_.set_title('Confusion Matrix', color = 'black')
plt.xlabel('Predicted Label', color = 'black')
plt.ylabel('True Label', color = 'black')
plt.gcf().axes[0].tick_params(color = 'black')
plt.gcf().axes[1].tick_params(color = 'black')
plt.gcf().set_size_inches(8, 5)
plt.show()
```



In [40]:

```
r_probs = [0 for _ in range(len(y_test))]
NB_probs = NBC.predict_proba(X_test)


NB_probs = NB_probs[:, 1]

from sklearn.metrics import roc_curve, roc_auc_score


r_auc = roc_auc_score(y_test, r_probs)
NB_auc = roc_auc_score(y_test, NB_probs)


print('Random (chance) Prediction: AUC = %.3f' % (r_auc))
print('Naive Bayes: AUC = %.3f' % (NB_auc))

r_fpr, r_tpr, _ = roc_curve(y_test, r_probs)
NB_fpr, NB_tpr, _ = roc_curve(y_test, NB_probs)

plt.plot(r_fpr, r_tpr, linestyle='--', label='Random prediction (AUC = %0.3f)' % r_auc)
plt.plot(NB_fpr, NB_tpr, marker=',', label='Naive Bayes (AUC = %0.3f)' % NB_auc)

# Title
plt.title('ROC Plot')
# Axis labels
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
# Show legend
plt.legend() #
# Show plot
plt.show()
```

```
Random (chance) Prediction: AUC = 0.500
Naive Bayes: AUC = 0.746
```



Neural Network Classifier

In [41]:

```
# Training the Naive Bayes model on the Training set
from sklearn.neural_network import MLPClassifier
NNC = MLPClassifier(solver='sgd', alpha=1e-5)
NNC.fit(X_train, y_train)
```

Out[41]:

```
MLPClassifier(activation='relu', alpha=1e-05, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(100,), learning_rate='constant',
              learning_rate_init=0.001, max_fun=15000, max_iter=200,
              momentum=0.9, n_iter_no_change=10, nesterovs_momentum=True,
              power_t=0.5, random_state=None, shuffle=True, solver='sgd',
              tol=0.0001, validation_fraction=0.1, verbose=False,
              warm_start=False)
```

In [42]:

```
# Predicting the Test set results
y_pred = NNC.predict(X_test)
```

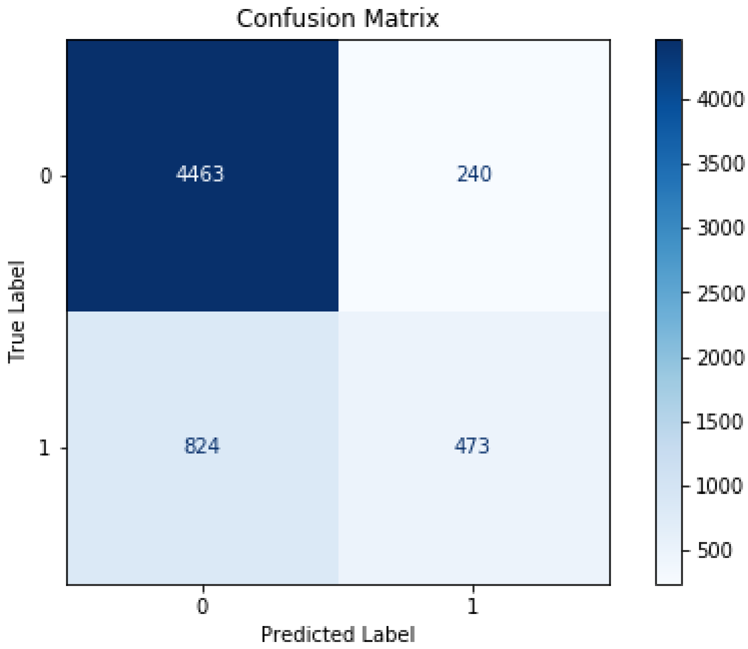
In [43]:

```
# Making the Confusion Matrix
cm = confusion_matrix(y_test, y_pred)
print(cm)
accuracy = accuracy_score(y_test, y_pred)
print(accuracy)
metric.loc['accuracy', 'Neural Network'] = accuracy_score(y_pred = y_pred, y_true = y_test)
metric.loc['precision', 'Neural Network'] = precision_score(y_pred = y_pred, y_true = y_tes
metric.loc['recall', 'Neural Network'] = recall_score(y_pred = y_pred, y_true = y_test)
```

```
[[4463  240]
 [ 824  473]]
0.8226666666666667
```

In [44]:

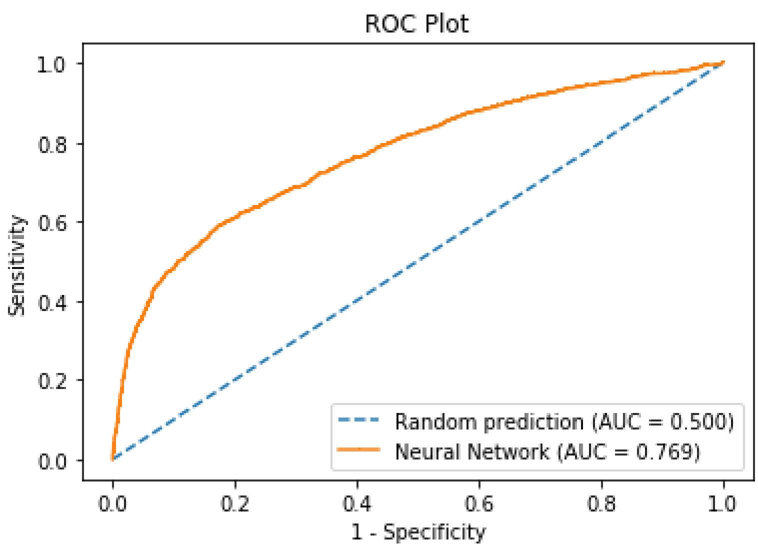
```
matrix = plot_confusion_matrix(NNC, X_test, y_test, values_format = 'd', cmap = plt.cm.Blue
matrix.ax_.set_title('Confusion Matrix', color = 'black')
plt.xlabel('Predicted Label', color = 'black')
plt.ylabel('True Label', color = 'black')
plt.gcf().axes[0].tick_params(color = 'black')
plt.gcf().axes[1].tick_params(color = 'black')
plt.gcf().set_size_inches(8, 5)
plt.show()
```



In [45]:

```
r_probs = [0 for _ in range(len(y_test))]
NN_probs = NNC.predict_proba(X_test)


NN_probs = NN_probs[:, 1]

from sklearn.metrics import roc_curve, roc_auc_score


r_auc = roc_auc_score(y_test, r_probs)
NN_auc = roc_auc_score(y_test, NN_probs)


print('Random (chance) Prediction: AUC = %.3f' % (r_auc))
print('Neural Network: AUC = %.3f' % (NN_auc))

r_fpr, r_tpr, _ = roc_curve(y_test, r_probs)
NN_fpr, NN_tpr, _ = roc_curve(y_test, NN_probs)

plt.plot(r_fpr, r_tpr, linestyle='--', label='Random prediction (AUC = %0.3f)' % r_auc)
plt.plot(NN_fpr, NN_tpr, marker=',', label='Neural Network (AUC = %0.3f)' % NN_auc)

# Title
plt.title('ROC Plot')
# Axis labels
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
# Show legend
plt.legend() #
# Show plot
plt.show()
```

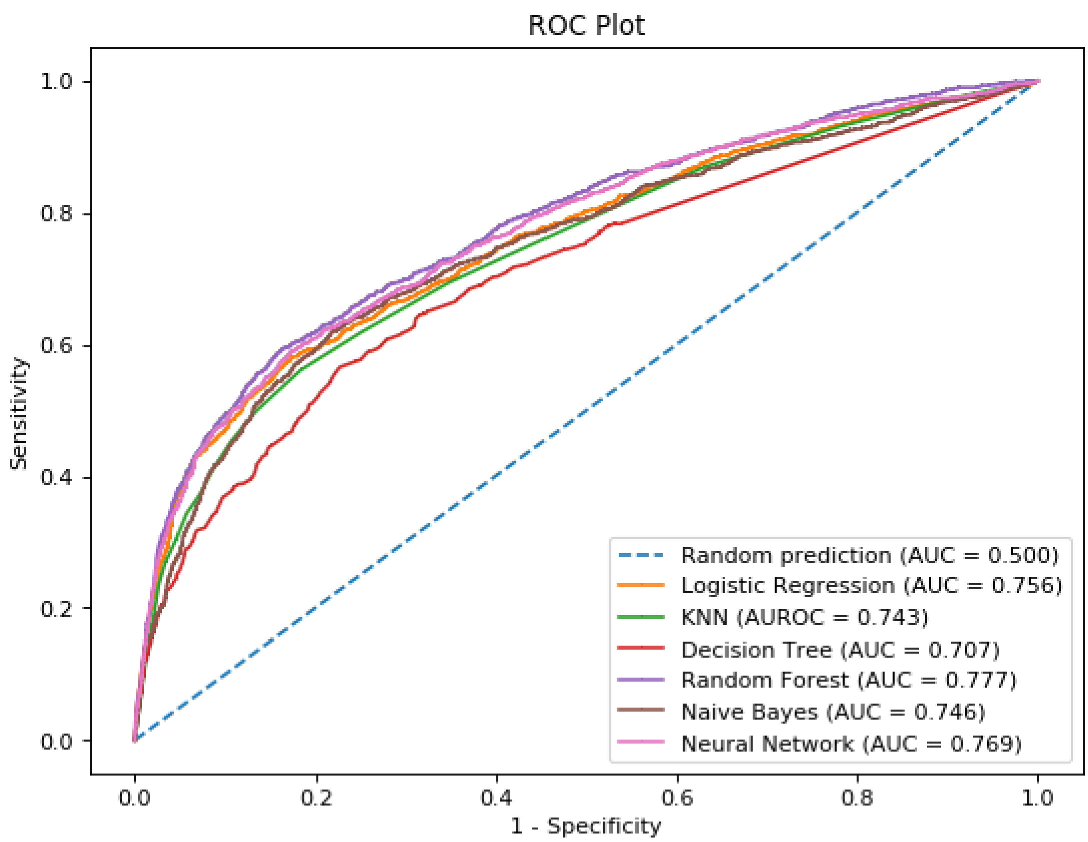
```
Random (chance) Prediction: AUC = 0.500
Neural Network: AUC = 0.769
```



Models comparison

In [48]:

```
from matplotlib.pyplot import figure
figure(num=None, figsize=(8, 6), dpi=80, facecolor='w', edgecolor='k')

plt.plot(r_fpr, r_tpr, linestyle='--', label='Random prediction (AUC = %0.3f)' % r_auc)
plt.plot(LR_fpr, LR_tpr, marker=',', label='Logistic Regression (AUC = %0.3f)' % LR_auc)
plt.plot(KNN_fpr, KNN_tpr, marker=',', label='KNN (AUROC = %0.3f)' % KNN_auc)
plt.plot(DT_fpr, DT_tpr, marker=',', label='Decision Tree (AUC = %0.3f)' % DT_auc)
plt.plot(RF_fpr, RF_tpr, marker=',', label='Random Forest (AUC = %0.3f)' % RF_auc)
plt.plot(NB_fpr, NB_tpr, marker=',', label='Naive Bayes (AUC = %0.3f)' % NB_auc)
plt.plot(NN_fpr, NN_tpr, marker=',', label='Neural Network (AUC = %0.3f)' % NN_auc)

# Title
plt.title('ROC Plot')
# Axis labels
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
# Show legend
plt.legend() #
# Show plot
plt.show()
```



In [47]:

```
100*metric
```

Out[47]:

	Logistic Regression	KNN	Decision Tree	Random Forest	Naive Bayes	Neural Network
accuracy	82.0667	81.3833	78.7333	82.7833	76.5833	82.2667
precision	69.0189	64.9502	51.1278	69.242	46.6038	66.3394
recall	30.9175	30.1465	36.7001	36.623	57.1318	36.4688