In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_curve
from sklearn.metrics import roc_auc_score
```

In [5]:
```
# Importing the dataset
bank = pd.read_csv('bank-full.csv')
bank
```

Out[5]:

	age	job	marital	education	default	balance	housing	loan	contact	day	mor
0	58	management	married	tertiary	no	2143	yes	no	unknown	5	m
1	44	technician	single	secondary	no	29	yes	no	unknown	5	m
2	33	entrepreneur	married	secondary	no	2	yes	yes	unknown	5	m
3	47	blue-collar	married	unknown	no	1506	yes	no	unknown	5	m
4	33	unknown	single	unknown	no	1	no	no	unknown	5	m
...	...	...	...	...	...	...	...	...	...	...	
45206	51	technician	married	tertiary	no	825	no	no	cellular	17	r
45207	71	retired	divorced	primary	no	1729	no	no	cellular	17	r
45208	72	retired	married	secondary	no	5715	no	no	cellular	17	r
45209	57	blue-collar	married	secondary	no	668	no	no	telephone	17	r
45210	37	entrepreneur	married	secondary	no	2971	no	no	cellular	17	r

45211 rows × 17 columns

EDA

In [6]:
```
bank.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 45211 entries, 0 to 45210
Data columns (total 17 columns):
 #   Column     Non-Null Count  Dtype 
---  ------     --------------  ----- 
 0   age        45211 non-null  int64 
 1   job        45211 non-null  object
 2   marital    45211 non-null  object
 3   education  45211 non-null  object
 4   default    45211 non-null  object
 5   balance    45211 non-null  int64 
 6   housing    45211 non-null  object
 7   loan       45211 non-null  object
 8   contact    45211 non-null  object
 9   day        45211 non-null  int64 
 10  month      45211 non-null  object
 11  duration   45211 non-null  int64 
 12  campaign   45211 non-null  int64 
 13  pdays      45211 non-null  int64 
 14  previous   45211 non-null  int64 
 15  poutcome   45211 non-null  object
 16  y          45211 non-null  object
dtypes: int64(7), object(10)
memory usage: 5.9+ MB
```

In [7]:
```
# One-Hot Encoding of categrical variables
data1=pd.get_dummies(bank,columns=['job','marital','education','contact','poutcom
data1
```

Out[7]:

	age	default	balance	housing	loan	day	duration	campaign	pdays	previous	...	month
0	58	no	2143	yes	no	5	261	1	-1	0	...	
1	44	no	29	yes	no	5	151	1	-1	0	...	
2	33	no	2	yes	yes	5	76	1	-1	0	...	
3	47	no	1506	yes	no	5	92	1	-1	0	...	
4	33	no	1	no	no	5	198	1	-1	0	...	
...	...	...	...	...	...	...	...	...	...	...	...	
45206	51	no	825	no	no	17	977	3	-1	0	...	
45207	71	no	1729	no	no	17	456	2	-1	0	...	
45208	72	no	5715	no	no	17	1127	5	184	3	...	
45209	57	no	668	no	no	17	508	4	-1	0	...	
45210	37	no	2971	no	no	17	361	2	188	11	...	

45211 rows × 49 columns

In [8]:
```
# To see all columns
pd.set_option("display.max.columns", None)
data1
```

Out[8]:

	age	default	balance	housing	loan	day	duration	campaign	pdays	previous	y	job_
0	58	no	2143	yes	no	5	261	1	-1	0	no	
1	44	no	29	yes	no	5	151	1	-1	0	no	
2	33	no	2	yes	yes	5	76	1	-1	0	no	
3	47	no	1506	yes	no	5	92	1	-1	0	no	
4	33	no	1	no	no	5	198	1	-1	0	no	
...	...	...	...	...	...	...	...	...	...	...	...	
45206	51	no	825	no	no	17	977	3	-1	0	yes	
45207	71	no	1729	no	no	17	456	2	-1	0	yes	
45208	72	no	5715	no	no	17	1127	5	184	3	yes	
45209	57	no	668	no	no	17	508	4	-1	0	no	
45210	37	no	2971	no	no	17	361	2	188	11	no	

45211 rows × 49 columns

In [9]:
```
data1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 45211 entries, 0 to 45210
Data columns (total 49 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   age                   45211 non-null  int64
 1   default               45211 non-null  object
 2   balance               45211 non-null  int64
 3   housing               45211 non-null  object
 4   loan                  45211 non-null  object
 5   day                   45211 non-null  int64
 6   duration              45211 non-null  int64
 7   campaign              45211 non-null  int64
 8   pdays                 45211 non-null  int64
 9   previous              45211 non-null  int64
 10  y                     45211 non-null  object
 11  job_admin.            45211 non-null  uint8
 12  job_blue-collar       45211 non-null  uint8
 13  job_entrepreneur      45211 non-null  uint8
 14  job_housemaid         45211 non-null  uint8
 15  job_management        45211 non-null  uint8
 16  job_retired           45211 non-null  uint8
 17  job_self-employed     45211 non-null  uint8
 18  job_services          45211 non-null  uint8
 19  job_student           45211 non-null  uint8
 20  job_technician        45211 non-null  uint8
 21  job_unemployed        45211 non-null  uint8
 22  job_unknown           45211 non-null  uint8
 23  marital_divorced      45211 non-null  uint8
 24  marital_married       45211 non-null  uint8
 25  marital_single        45211 non-null  uint8
 26  education_primary     45211 non-null  uint8
 27  education_secondary   45211 non-null  uint8
 28  education_tertiary    45211 non-null  uint8
 29  education_unknown     45211 non-null  uint8
 30  contact_cellular      45211 non-null  uint8
 31  contact_telephone     45211 non-null  uint8
 32  contact_unknown       45211 non-null  uint8
 33  poutcome_failure      45211 non-null  uint8
 34  poutcome_other        45211 non-null  uint8
 35  poutcome_success      45211 non-null  uint8
 36  poutcome_unknown      45211 non-null  uint8
 37  month_apr             45211 non-null  uint8
 38  month_aug             45211 non-null  uint8
 39  month_dec             45211 non-null  uint8
 40  month_feb             45211 non-null  uint8
 41  month_jan             45211 non-null  uint8
 42  month_jul             45211 non-null  uint8
 43  month_jun             45211 non-null  uint8
 44  month_mar             45211 non-null  uint8
 45  month_may             45211 non-null  uint8
 46  month_nov             45211 non-null  uint8
 47  month_oct             45211 non-null  uint8
 48  month_sep             45211 non-null  uint8
```

```
dtypes: int64(7), object(4), uint8(38)
memory usage: 5.4+ MB
```

In [10]:
```
# Custom Binary Encoding of Binary o/p variables
data1['default'] = np.where(data1['default'].str.contains("yes"), 1, 0)
data1['housing'] = np.where(data1['housing'].str.contains("yes"), 1, 0)
data1['loan'] = np.where(data1['loan'].str.contains("yes"), 1, 0)
data1['y'] = np.where(data1['y'].str.contains("yes"), 1, 0)
data1
```

Out[10]:

	age	default	balance	housing	loan	day	duration	campaign	pdays	previous	y	job_ad
0	58	0	2143	1	0	5	261	1	-1	0	0	
1	44	0	29	1	0	5	151	1	-1	0	0	
2	33	0	2	1	1	5	76	1	-1	0	0	
3	47	0	1506	1	0	5	92	1	-1	0	0	
4	33	0	1	0	0	5	198	1	-1	0	0	
...	...	...	...	...	...	...	...	...	...	...	...	
45206	51	0	825	0	0	17	977	3	-1	0	1	
45207	71	0	1729	0	0	17	456	2	-1	0	1	
45208	72	0	5715	0	0	17	1127	5	184	3	1	
45209	57	0	668	0	0	17	508	4	-1	0	0	
45210	37	0	2971	0	0	17	361	2	188	11	0	

45211 rows × 49 columns

In [12]:
```
data1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 45211 entries, 0 to 45210
Data columns (total 49 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   age                   45211 non-null  int64
 1   default               45211 non-null  int32
 2   balance               45211 non-null  int64
 3   housing               45211 non-null  int32
 4   loan                  45211 non-null  int32
 5   day                   45211 non-null  int64
 6   duration              45211 non-null  int64
 7   campaign              45211 non-null  int64
 8   pdays                 45211 non-null  int64
 9   previous              45211 non-null  int64
 10  y                     45211 non-null  int32
 11  job_admin.            45211 non-null  uint8
 12  job_blue-collar       45211 non-null  uint8
 13  job_entrepreneur      45211 non-null  uint8
 14  job_housemaid         45211 non-null  uint8
 15  job_management        45211 non-null  uint8
 16  job_retired           45211 non-null  uint8
 17  job_self-employed     45211 non-null  uint8
 18  job_services          45211 non-null  uint8
 19  job_student           45211 non-null  uint8
 20  job_technician        45211 non-null  uint8
 21  job_unemployed        45211 non-null  uint8
 22  job_unknown           45211 non-null  uint8
 23  marital_divorced      45211 non-null  uint8
 24  marital_married       45211 non-null  uint8
 25  marital_single        45211 non-null  uint8
 26  education_primary     45211 non-null  uint8
 27  education_secondary   45211 non-null  uint8
 28  education_tertiary    45211 non-null  uint8
 29  education_unknown     45211 non-null  uint8
 30  contact_cellular      45211 non-null  uint8
 31  contact_telephone     45211 non-null  uint8
 32  contact_unknown       45211 non-null  uint8
 33  poutcome_failure      45211 non-null  uint8
 34  poutcome_other        45211 non-null  uint8
 35  poutcome_success      45211 non-null  uint8
 36  poutcome_unknown      45211 non-null  uint8
 37  month_apr             45211 non-null  uint8
 38  month_aug             45211 non-null  uint8
 39  month_dec             45211 non-null  uint8
 40  month_feb             45211 non-null  uint8
 41  month_jan             45211 non-null  uint8
 42  month_jul             45211 non-null  uint8
 43  month_jun             45211 non-null  uint8
 44  month_mar             45211 non-null  uint8
 45  month_may             45211 non-null  uint8
 46  month_nov             45211 non-null  uint8
 47  month_oct             45211 non-null  uint8
 48  month_sep             45211 non-null  uint8
```

```
dtypes: int32(4), int64(7), uint8(38)
memory usage: 4.7 MB
```

Model Building

In [13]:
```
# Dividing our data into input and output variables
x=pd.concat([data1.iloc[:,0:10],data1.iloc[:,11:]],axis=1)
y=data1.iloc[:,10]
```

In [14]:
```
# Logistic regression model
classifier=LogisticRegression()
classifier.fit(x,y)
```

```
C:\Users\Lenovo\anaconda3\lib\site-packages\sklearn\linear_model\_logistic.py:7
63: 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 (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-regressi
on (https://scikit-learn.org/stable/modules/linear_model.html#logistic-regressi
on)
  n_iter_i = _check_optimize_result(
```

Out[14]:
```
LogisticRegression()
```

Model Predictions

In [17]:
```
# Predict for x dataset
y_pred = classifier.predict(x)
y_pred
```

Out[17]:
```
array([0, 0, 0, ..., 1, 0, 0])
```

In [18]:
```
y_pred_df = pd.DataFrame({'actual_y':y,'y_pred_prob':y_pred})
y_pred_df
```

Out[18]:

	actual_y	y_pred_prob
0	0	0
1	0	0
2	0	0
3	0	0
4	0	0
...	...	...
45206	1	1
45207	1	0
45208	1	1
45209	0	0
45210	0	0

45211 rows × 2 columns

Testing Model Accuracy

In [19]:
```
# Confusion Matrix for the model accuracy
confusion_matrix = confusion_matrix(y,y_pred)
confusion_matrix
```

Out[19]:
```
array([[39159,   763],
       [ 4140,  1149]], dtype=int64)
```

In [20]:
```
# The model accuracy is calculated by (a+d)/(a+b+c+d)
(39156+1162)/(39156+766+4127+1162)
```

Out[20]:
```
0.8917741257658535
```

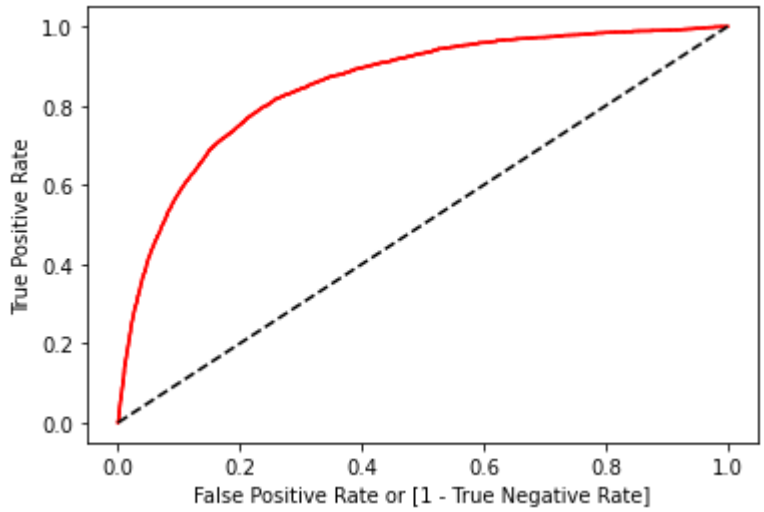
In [21]:
```
# As accuracy = 0.8933, which is greater than 0.5; Thus [:,1] Threshold value>0.5
classifier.predict_proba(x)[:,1]
```

Out[21]:
```
array([0.03564107, 0.02150632, 0.01710036, ..., 0.63604954, 0.06555453,
       0.13937723])
```

In [22]:
```
# ROC Curve plotting and finding AUC value
fpr,tpr,thresholds=roc_curve(y,classifier.predict_proba(x)[:,1])
plt.plot(fpr,tpr,color='red')
auc=roc_auc_score(y,y_pred)

plt.plot(fpr,tpr,color='red',label='logit model(area  = %0.2f)'%auc)
plt.plot([0,1],[0,1],'k--')
plt.xlabel('False Positive Rate or [1 - True Negative Rate]')
plt.ylabel('True Positive Rate')
plt.show()

print('auc accuracy:',auc)
```




```
auc accuracy: 0.5990655331498237
```

In [ ]: