AmazonFineFoodReviewsAnalysisSupportVectorMachines

May 18, 2019

1 Amazon Fine Food Reviews Analysis

Data Source: https://www.kaggle.com/snap/amazon-fine-food-reviews

EDA: https://nycdatascience.com/blog/student-works/amazon-fine-foods-visualization/

The Amazon Fine Food Reviews dataset consists of reviews of fine foods from Amazon.

Number of reviews: 568,454 Number of users: 256,059 Number of products: 74,258 Timespan: Oct 1999 - Oct 2012 Number of Attributes/Columns in data: 10

Attribute Information:

1. Id
2. ProductId - unique identifier for the product
3. UserId - unqiue identifier for the user
4. ProfileName
5. HelpfulnessNumerator - number of users who found the review helpful
6. HelpfulnessDenominator - number of users who indicated whether they found the review helpful or not
7. Score - rating between 1 and 5
8. Time - timestamp for the review
9. Summary - brief summary of the review
10. Text - text of the review

Objective: Given a review, determine whether the review is positive (rating of 4 or 5) or negative (rating of 1 or 2).

[Q] How to determine if a review is positive or negative? [Ans] We could use Score/Rating. A rating of 4 or 5 can be cosnidered as a positive review. A rating of 1 or 2 can be considered as negative one. A review of rating 3 is considered nuetral and such reviews are ignored from our analysis. This is an approximate and proxy way of determining the polarity (positivity/negativity) of a review.

2 [1]. Reading Data

2.1 [1.1] Loading the data

The dataset is available in two forms 1. .csv file 2. SQLite Database

In order to load the data, We have used the SQLITE dataset as it is easier to query the data and visualise the data efficiently.

Here as we only want to get the global sentiment of the recommendations (positive or negative), we will purposefully ignore all Scores equal to 3. If the score is above 3, then the recommendation wil be set to "positive". Otherwise, it will be set to "negative".

```
In [1]: %matplotlib inline
        import warnings
        warnings.filterwarnings("ignore")


        import sqlite3
        import pandas as pd
        import numpy as np
        import nltk
        import string
        import matplotlib.pyplot as plt
        import seaborn as sns
        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer

        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.metrics import confusion_matrix
        from sklearn import metrics
        from sklearn.metrics import roc_curve, auc
        from nltk.stem.porter import PorterStemmer

        import re
        # Tutorial about Python regular expressions: https://pymotw.com/2/re/
        import string
        from nltk.corpus import stopwords
        from nltk.stem import PorterStemmer
        from nltk.stem.wordnet import WordNetLemmatizer

        from gensim.models import Word2Vec
        from gensim.models import KeyedVectors
        import pickle

        from tqdm import tqdm
        import os
```

```
In [2]: # using SQLite Table to read data.
        con = sqlite3.connect('database.sqlite')

        # filtering only positive and negative reviews i.e.
        # not taking into consideration those reviews with Score=3
        # SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000, will give top 500000 data point
        # you can change the number to any other number based on your computing power

        # filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 5
        # for tsne assignment you can take 5k data points

        filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 1000

        # Give reviews with Score>3 a positive rating(1), and reviews with a score<3 a negativ
        def partition(x):
            if x < 3:
                return 0
            return 1

        #changing reviews with score less than 3 to be positive and vice-versa
        actualScore = filtered_data['Score']
        positiveNegative = actualScore.map(partition)
        filtered_data['Score'] = positiveNegative
        print("Number of data points in our data", filtered_data.shape)
        filtered_data.head(3)
```

```
Number of data points in our data (100000, 10)
```

```
Out[2]:    Id   ProductId          UserId                      ProfileName  \
        0   1  B001E4KFG0  A3SGXH7AUHU8GW                       delmartian
        1   2  B00813GRG4  A1D87F6ZCVE5NK                           dll pa
        2   3  B000LQOCH0   ABXLMWJIXXAIN  Natalia Corres "Natalia Corres"

           HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
        0                     1                       1      1  1303862400
        1                     0                       0      0  1346976000
        2                     1                       1      1  1219017600

                         Summary                                              Text
        0  Good Quality Dog Food  I have bought several of the Vitality canned d...
        1      Not as Advertised  Product arrived labeled as Jumbo Salted Peanut...
        2  "Delight" says it all  This is a confection that has been around a fe...
```

```
In [3]: display = pd.read_sql_query("""
        SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
        FROM Reviews
        GROUP BY UserId
        HAVING COUNT(*)>1
        """, con)
```

```
In [4]: print(display.shape)
        display.head()
```

```
(80668, 7)
```

```
Out[4]:                UserId   ProductId             ProfileName        Time  Score  \
        0  #oc-R115TNMSPFT9I7  B007Y59HVM                 Breyton  1331510400      2
```

```
1  #oc-R11D9D7SHXIJB9  B005HG9ET0  Louis E. Emory "hoppy"  1342396800      5
2  #oc-R11DNU2NBKQ23Z  B007Y59HVM        Kim Cieszykowski  1348531200      1
3  #oc-R11O5J5ZVQE25C  B005HG9ET0           Penguin Chick  1346889600      5
4  #oc-R12KPBODL2B5ZD  B007OSBE1U   Christopher P. Presta  1348617600      1

                                                Text  COUNT(*)
0  Overall its just OK when considering the price...         2
1  My wife has recurring extreme muscle spasms, u...         3
2  This coffee is horrible and unfortunately not ...         2
3  This will be the bottle that you grab from the...         3
4  I didnt like this coffee. Instead of telling y...         2
```

```
In [5]: display[display['UserId']=='AZY10LLTJ71NX']
```

```
Out[5]:              UserId   ProductId                     ProfileName        Time  \
        80638  AZY10LLTJ71NX  B006P7E5ZI  undertheshrine "undertheshrine"  1334707200

               Score                                               Text  COUNT(*)
        80638      5  I was recommended to try green tea extract to ...         5
```

```
In [6]: display['COUNT(*)'].sum()
```

```
Out[6]: 393063
```

3 [2] Exploratory Data Analysis

3.1 [2.1] Data Cleaning: Deduplication

It is observed (as shown in the table below) that the reviews data had many duplicate entries. Hence it was necessary to remove duplicates in order to get unbiased results for the analysis of the data. Following is an example:

```
In [7]: display= pd.read_sql_query("""
        SELECT *
        FROM Reviews
        WHERE Score != 3 AND UserId="AR5J8UI46CURR"
        ORDER BY ProductID
        """, con)
        display.head()
```

```
Out[7]:        Id   ProductId         UserId      ProfileName  HelpfulnessNumerator  \
        0   78445  B000HDL1RQ  AR5J8UI46CURR  Geetha Krishnan                     2
        1  138317  B000HDOPYC  AR5J8UI46CURR  Geetha Krishnan                     2
        2  138277  B000HDOPYM  AR5J8UI46CURR  Geetha Krishnan                     2
        3   73791  B000HDOPZG  AR5J8UI46CURR  Geetha Krishnan                     2
        4  155049  B000PAQ75C  AR5J8UI46CURR  Geetha Krishnan                     2

           HelpfulnessDenominator  Score        Time  \
        0                       2      5  1199577600
```

```
1                       2      5  1199577600
2                       2      5  1199577600
3                       2      5  1199577600
4                       2      5  1199577600

                             Summary  \
0  LOACKER QUADRATINI VANILLA WAFERS
1  LOACKER QUADRATINI VANILLA WAFERS
2  LOACKER QUADRATINI VANILLA WAFERS
3  LOACKER QUADRATINI VANILLA WAFERS
4  LOACKER QUADRATINI VANILLA WAFERS

                                                Text
0  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
1  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
2  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
3  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
4  DELICIOUS WAFERS. I FIND THAT EUROPEAN WAFERS ...
```

As it can be seen above that same user has multiple reviews with same values for HelpfulnessNumerator, HelpfulnessDenominator, Score, Time, Summary and Text and on doing analysis it was found that ProductId=B000HDOPZG was Loacker Quadratini Vanilla Wafer Cookies, 8.82-Ounce Packages (Pack of 8) ProductId=B000HDL1RQ was Loacker Quadratini Lemon Wafer Cookies, 8.82-Ounce Packages (Pack of 8) and so on

It was inferred after analysis that reviews with same parameters other than ProductId belonged to the same product just having different flavour or quantity. Hence in order to reduce redundancy it was decided to eliminate the rows having same parameters.

The method used for the same was that we first sort the data according to ProductId and then just keep the first similar product review and delelte the others. for eg. in the above just the review for ProductId=B000HDL1RQ remains. This method ensures that there is only one representative for each product and deduplication without sorting would lead to possibility of different representatives still existing for the same product.

```
In [8]: #Sorting data according to ProductId in ascending order
        sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True, inplace=Fal
```

```
In [9]: #Deduplication of entries
        final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep=
        final.shape
```

```
Out[9]: (87775, 10)
```

```
In [10]: #Checking to see how much % of data still remains
         (final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

```
Out[10]: 87.775
```

Observation:- It was also seen that in two rows given below the value of HelpfulnessNumerator is greater than HelpfulnessDenominator which is not practically possible hence these two rows too are removed from calcualtions

```
In [11]: display= pd.read_sql_query("""
         SELECT *
         FROM Reviews
         WHERE Score != 3 AND Id=44737 OR Id=64422
         ORDER BY ProductID
         """, con)

         display.head()

Out[11]:       Id   ProductId          UserId             ProfileName  \
         0  64422  B000MIDROQ  A161DK06JJMCYF  J. E. Stephens "Jeanne"
         1  44737  B001EQ55RW  A2V0I904FH7ABY                      Ram

            HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
         0                     3                       1      5  1224892800
         1                     3                       2      4  1212883200

                                                 Summary  \
         0            Bought This for My Son at College
         1  Pure cocoa taste with crunchy almonds inside

                                                     Text
         0  My son loves spaghetti so I didn't hesitate or...
         1  It was almost a 'love at first bite' - the per...

In [12]: final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]

In [13]: #Before starting the next phase of preprocessing lets see the number of entries left
         print(final.shape)

         #How many positive and negative reviews are present in our dataset?
         final['Score'].value_counts()

(87773, 10)


Out[13]: 1    73592
         0    14181
         Name: Score, dtype: int64
```

4 [3] Preprocessing

4.1 [3.1]. Preprocessing Review Text

Now that we have finished deduplication our data requires some preprocessing before we go on further with analysis and making the prediction model.

Hence in the Preprocessing phase we do the following in the order below:-

1. Begin by removing the html tags

2. Remove any punctuations or limited set of special characters like , or . or # etc.
3. Check if the word is made up of english letters and is not alpha-numeric
4. Check to see if the length of the word is greater than 2 (as it was researched that there is no adjective in 2-letters)
5. Convert the word to lowercase
6. Remove Stopwords
7. Finally Snowball Stemming the word (it was obsereved to be better than Porter Stemming)

After which we collect the words used to describe positive and negative reviews

```
In [14]: # printing some random reviews
         sent_0 = final['Text'].values[0]
         print(sent_0)
         print("="*50)

         sent_1000 = final['Text'].values[1000]
         print(sent_1000)
         print("="*50)

         sent_1500 = final['Text'].values[1500]
         print(sent_1500)
         print("="*50)

         sent_4900 = final['Text'].values[4900]
         print(sent_4900)
         print("="*50)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little taste
==================================================
was way to hot for my blood, took a bite and did a jig  lol
==================================================
My dog LOVES these treats. They tend to have a very strong fish oil smell. So if you are afraid
==================================================
```

```
In [15]: # remove urls from text python: https://stackoverflow.com/a/40823105/4084039
         sent_0 = re.sub(r"http\S+", "", sent_0)
         sent_1000 = re.sub(r"http\S+", "", sent_1000)
         sent_150 = re.sub(r"http\S+", "", sent_1500)
         sent_4900 = re.sub(r"http\S+", "", sent_4900)

         print(sent_0)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its
```

```
In [16]: # https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all
         from bs4 import BeautifulSoup
         soup = BeautifulSoup(sent_0, 'lxml')
         text = soup.get_text()
         print(text)
         print("="*50)

         soup = BeautifulSoup(sent_1000, 'lxml')
         text = soup.get_text()
         print(text)
         print("="*50)

         soup = BeautifulSoup(sent_1500, 'lxml')
         text = soup.get_text()
         print(text)
         print("="*50)

         soup = BeautifulSoup(sent_4900, 'lxml')
         text = soup.get_text()
         print(text)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little taste
==================================================
was way to hot for my blood, took a bite and did a jig  lol
==================================================
My dog LOVES these treats. They tend to have a very strong fish oil smell. So if you are afrai
```

```
In [17]: # https://stackoverflow.com/a/47091490/4084039
         import re

         def decontracted(phrase):
             # specific
             phrase = re.sub(r"won't", "will not", phrase)
             phrase = re.sub(r"can\'t", "can not", phrase)

             # general
             phrase = re.sub(r"n\'t", " not", phrase)
             phrase = re.sub(r"\'re", " are", phrase)
             phrase = re.sub(r"\'s", " is", phrase)
             phrase = re.sub(r"\'d", " would", phrase)
             phrase = re.sub(r"\'ll", " will", phrase)
             phrase = re.sub(r"\'t", " not", phrase)
             phrase = re.sub(r"\'ve", " have", phrase)
             phrase = re.sub(r"\'m", " am", phrase)
             return phrase
```

```
In [18]: sent_1500 = decontracted(sent_1500)
```

```
         print(sent_1500)
         print("="*50)
```

```
was way to hot for my blood, took a bite and did a jig  lol
==================================================
```

```
In [19]: #remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
         sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
         print(sent_0)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its
```

```
In [20]: #remove spacial character: https://stackoverflow.com/a/5843547/4084039
         sent_1500 = re.sub('[^A-Za-z0-9]+', ' ', sent_1500)
         print(sent_1500)
```

```
was way to hot for my blood took a bite and did a jig lol
```

```
In [21]: # https://gist.github.com/sebleier/554280
         # we are removing the words from the stop words list: 'no', 'nor', 'not'
         # <br /><br /> ==> after the above steps, we are getting "br br"
         # we are including them into stop words list
         # instead of <br /> if we have <br/> these tags would have revmoved in the 1st step

         stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselve
                     "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him'
                     'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself',
                     'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "
                     'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', '
                     'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'a
                     'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'throug
                     'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', '
                     'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'a
                     'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'to
                     's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", '
                     've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't
                     "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mi
                     "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't",
                     'won', "won't", 'wouldn', "wouldn't"])
```

```
In [22]: # Combining all the above stundents
         from tqdm import tqdm
         preprocessed_reviews = []
         # tqdm is for printing the status bar
         for sentance in tqdm(final['Text'].values):
             sentance = re.sub(r"http\S+", "", sentance)
```

```
            sentance = BeautifulSoup(sentance, 'lxml').get_text()
            sentance = decontracted(sentance)
            sentance = re.sub("\S*\d\S*", "", sentance).strip()
            sentance = re.sub('[^A-Za-z]+', ' ', sentance)
            # https://gist.github.com/sebleier/554280
            sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopw
            preprocessed_reviews.append(sentance.strip())
```

```
100%|| 87773/87773 [00:53<00:00, 1632.72it/s]
```

```
In [23]: preprocessed_reviews[1500]
```

```
Out[23]: 'way hot blood took bite jig lol'
```

[3.2] Preprocessing Review Summary

```
In [24]: preprocessed_summary = []
        # tqdm is for printing the status bar
        for sentance in tqdm(final['Summary'].values):
            sentance = re.sub(r"http\S+", "", sentance)
            sentance = BeautifulSoup(sentance, 'lxml').get_text()
            sentance = decontracted(sentance)
            sentance = re.sub("\S*\d\S*", "", sentance).strip()
            sentance = re.sub('[^A-Za-z]+', ' ', sentance)
            # https://gist.github.com/sebleier/554280
            sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopw
            preprocessed_summary.append(sentance.strip())
```

```
 37%|                                             | 32660/87773 [00:12<00:19, 2850.36it/s]C:\
  ' Beautiful Soup.' % markup)
 70%|                      | 61180/87773 [00:22<00:09, 2818.18it/s]C:\Users\rites\Anaconda3\li
  ' Beautiful Soup.' % markup)
 75%|                  | 65533/87773 [00:24<00:10, 2106.13it/s]C:\Users\rites\Anaconda3\lib\si
  ' Beautiful Soup.' % markup)
 96%|   | 84097/87773 [00:30<00:01, 2608.71it/s]C:\Users\rites\Anaconda3\lib\site-packages\bs4
  ' Beautiful Soup.' % markup)
100%|| 87773/87773 [00:32<00:00, 2719.69it/s]
```

5 [4] Featurization

5.1 [4.1] BAG OF WORDS

```
In [34]: #BoW
        count_vect = CountVectorizer() #in scikit-learn
        count_vect.fit(preprocessed_reviews)
        print("some feature names ", count_vect.get_feature_names()[:10])
        print('='*50)
```

```
         final_counts = count_vect.transform(preprocessed_reviews)
         print("the type of count vectorizer ",type(final_counts))
         print("the shape of out text BOW vectorizer ",final_counts.get_shape())
         print("the number of unique words ", final_counts.get_shape()[1])
```

```
some feature names  ['aa', 'aaa', 'aaaa', 'aaaaa', 'aaaaaaaaaaaa', 'aaaaaaaaaaaaaaa', 'aaaaaaal
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (87773, 54904)
the number of unique words  54904
```

5.2 [4.2] Bi-Grams and n-Grams.

```
In [35]: #bi-gram, tri-gram and n-gram

         #removing stop words like "not" should be avoided before building n-grams
         # count_vect = CountVectorizer(ngram_range=(1,2))
         # please do read the CountVectorizer documentation http://scikit-learn.org/stable/mod

         # you can choose these numebrs min_df=10, max_features=5000, of your choice
         count_vect = CountVectorizer(ngram_range=(1,2), min_df=10, max_features=5000)
         final_bigram_counts = count_vect.fit_transform(preprocessed_reviews)
         print("the type of count vectorizer ",type(final_bigram_counts))
         print("the shape of out text BOW vectorizer ",final_bigram_counts.get_shape())
         print("the number of unique words including both unigrams and bigrams ", final_bigram_
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (87773, 5000)
the number of unique words including both unigrams and bigrams  5000
```

5.3 [4.3] TF-IDF

```
In [36]: tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
         tf_idf_vect.fit(preprocessed_reviews)
         print("some sample features(unique words in the corpus)",tf_idf_vect.get_feature_names
         print('='*50)

         final_tf_idf = tf_idf_vect.transform(preprocessed_reviews)
         print("the type of count vectorizer ",type(final_tf_idf))
         print("the shape of out text TFIDF vectorizer ",final_tf_idf.get_shape())
         print("the number of unique words including both unigrams and bigrams ", final_tf_idf
```

```
some sample features(unique words in the corpus) ['aa', 'aafco', 'aback', 'abandon', 'abandoned
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (87773, 51709)
the number of unique words including both unigrams and bigrams  51709
```

5.4 [4.4] Word2Vec

```
In [26]: # Train your own Word2Vec model using your own text corpus
         list_of_sentance=[]
         for sentance in tqdm(preprocessed_reviews):
             list_of_sentance.append(sentance.split())
```

```
100%|| 87773/87773 [00:01<00:00, 67330.64it/s]
```

```
In [28]: # Using Google News Word2Vectors

         # in this project we are using a pretrained model by google
         # its 3.3G file, once you load this into your memory
         # it occupies ~9Gb, so please do this step only if you have >12G of ram
         # we will provide a pickle file wich contains a dict ,
         # and it contains all our courpus words as keys and  model[word] as values
         # To use this code-snippet, download "GoogleNews-vectors-negative300.bin"
         # from https://drive.google.com/file/d/0B7XkCwpI5KDYNlNUTTlSS21pQmM/edit
         # it's 1.9GB in size.


         # http://kavita-ganesan.com/gensim-word2vec-tutorial-starter-code/#.W17SRFAzZPY
         # you can comment this whole cell
         # or change these varible according to your need

         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(list_of_sentance,min_count=5,size=100, workers=4)
             print(w2v_model.wv.most_similar('great'))
             print('='*50)
             print(w2v_model.wv.most_similar('worst'))

         elif want_to_use_google_w2v and is_your_ram_gt_16g:
             if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                 w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.b
                 print(w2v_model.wv.most_similar('great'))
                 print(w2v_model.wv.most_similar('worst'))
             else:
                 print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, 
[('fantastic', 0.7899521589279175), ('awesome', 0.7837361097335815), ('excellent', 0.7781263589
==================================================
[('greatest', 0.7678017616271973), ('tastiest', 0.7277802228927612), ('best', 0.702406048774719
```

```
In [29]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  17386
sample words  ['deal', 'cuisinart', 'ding', 'shinier', 'das', 'toothbrushes', 'periodically',
```

5.5 [4.4.1] Converting text into vectors using Avg W2V, TFIDF-W2V

[4.4.1.1] Avg W2v

```
In [29]: # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_sentance): # for each review/sentence
             sent_vec = np.zeros(200) # as word vectors are of zero length 50, you might need
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             sent_vectors.append(sent_vec)
         print(len(sent_vectors))
         print(len(sent_vectors[0]))
```

```
100%|| 87773/87773 [22:15<00:00, 63.98it/s]

87773
200
```

[4.4.1.2] TFIDF weighted W2v

```
In [30]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
         model = TfidfVectorizer()
         tf_idf_matrix = model.fit_transform(preprocessed_reviews)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [42]: # TF-IDF weighted Word2Vec
         tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this l
         row=0;
         for sent in tqdm(list_of_sentance): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
         #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf valeus of word in this review
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += tf_idf
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidf_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 87773/87773 [52:51<00:00, 27.68it/s]
```

```
In [25]: # Function to plot confusion matrix
         def confusion_matrix_plot(test_y, predict_y):
             # C stores the confusion matrix
             C = confusion_matrix(test_y, predict_y)

             # Class labels
             labels_x = ["Predicted No","Predicted Yes"]
             labels_y = ["Original No","Original Yes"]

             cmap=sns.light_palette("orange")
             print("Confusion matrix")
             plt.figure(figsize=(4,4))
             sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels_x, yticklabels
             plt.show()
```

```
In [26]: # Function to plot roc curve

         def plot_roc_curve(Y_test,predict_y_test,Y_train,predict_y_train):
             fpr1,tpr1,threshold1 = roc_curve(Y_test,predict_y_test) # For test dataset
             fpr2,tpr2,threshold2 = roc_curve(Y_train,predict_y_train) # For train dataset
```

```
            plt.plot([0,1],[0,1])
            plt.plot(fpr1,tpr1,label="Validation AUC")
            plt.plot(fpr2,tpr2,label="Train AUC")
            plt.xlabel("False Positive Rate")
            plt.ylabel("True Positive Rate")
            plt.title("Reciever Operating Characteristics")
            plt.grid()
            plt.legend()
            plt.show()
```

```
In [27]: # Plotting graph of auc and parameter for training and cross validation error
         import math
         alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         alpha1 = [math.log10(i) for i in alpha]
         def plot_train_vs_auc(train_auc_list,cv_auc_list):
             plt.plot(alpha1,train_auc_list,label="Train AUC")
             plt.xlabel("Log of Hyper-parameter alpha for regularization")
             plt.ylabel("Area Under Curve")
             plt.plot(alpha1,cv_auc_list,label="Validation AUC")
             plt.title("Train and Validation Area Under Curve")
             plt.grid()
             plt.legend()
             plt.show()
```

6 [5] Assignment 7: SVM

```
<li><strong>Apply SVM on these feature sets</strong>
    <ul>
        <li><font color='red'>SET 1:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 2:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 3:</font>Review text, preprocessed one converted into vector
        <li><font color='red'>SET 4:</font>Review text, preprocessed one converted into vector
    </ul>
</li>
<br>
<li><strong>Procedure</strong>
    <ul>
<li>You need to work with 2 versions of SVM
    <ul><li>Linear kernel</li>
        <li>RBF kernel</li></ul>
<li>When you are working with linear kernel, use SGDClassifier with hinge loss because it is c
<li>When you are working with SGDClassifier with hinge loss and trying to find the AUC
    score, you would have to use <a href='https://scikit-learn.org/stable/modules/generated/sk
<li>Similarly, like kdtree of knn, when you are working with RBF kernel it's better to reduce
```

the number of dimensions. You can put min_df = 10, max_features = 500 and consider a sample size of 40k points.

```
    </ul>
</li>
<br>
<li><strong>Hyper paramter tuning (find best alpha in range [10^-4 to 10^4], and the best pena
    <ul>
<li>Find the best hyper parameter which will give the maximum <a href='https://www.appliedaico
<li>Find the best hyper paramter using k-fold cross validation or simple cross validation data
<li>Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this t
    </ul>
</li>
<br>
<li><strong>Feature importance</strong>
    <ul>
<li>When you are working on the linear kernel with BOW or TFIDF please print the top 10 best
```

features for each of the positive and negative classes.

```
    </ul>
</li>
<br>
<li><strong>Feature engineering</strong>
    <ul>
<li>To increase the performance of your model, you can also experiment with with feature engin
        <ul>
        <li>Taking length of reviews as another feature.</li>
        <li>Considering some features from review summary as well.</li>
    </ul>
    </ul>
</li>
<br>
<li><strong>Representation of results</strong>
    <ul>
<li>You need to plot the performance of model both on train data and cross validation data for
<img src='train_cv_auc.JPG' width=300px></li>
<li>Once after you found the best hyper parameter, you need to train your model with it, and f
<img src='train_test_auc.JPG' width=300px></li>
<li>Along with plotting ROC curve, you need to print the <a href='https://www.appliedaicourse.
<img src='confusion_matrix.png' width=300px></li>
    </ul>
</li>
<br>
<li><strong>Conclusion</strong>
    <ul>
<li>You need to summarize the results at the end of the notebook, summarize it in the table fo
    <img src='summary.JPG' width=400px>
</li>
    </ul>
```

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

7 Applying SVM

7.1 [5.1] Linear SVM

7.1.1 [5.1.1] Applying Linear SVM on BOW, SET 1

```
In [28]: from sklearn.cross_validation import train_test_split
         from sklearn.model_selection import TimeSeriesSplit

         # Splitting data into train and test dataset
         bow_vect = CountVectorizer()

         X = preprocessed_reviews
         Y = final['Score']

         X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)
         print(len(X_train))
         print(len(X_test))
```

```
C:\Users\rites\Anaconda3\lib\site-packages\sklearn\cross_validation.py:41: DeprecationWarning:
  "This module will be removed in 0.20.", DeprecationWarning)


61441
26332
```

```
In [33]: # Vectorizing train and test dataset seperately to prevent data lekage
         bow_train_vect = bow_vect.fit_transform(X_train)
         bow_test_vect = bow_vect.transform(X_test)
         bow_train_vect.shape

Out[33]: (61441, 46115)
```

```
In [34]: # Standarizing data
         from sklearn.preprocessing import StandardScaler
         std = StandardScaler(with_mean=False)
         bow_train_vect = std.fit_transform(bow_train_vect)
         bow_test_vect = std.transform(bow_test_vect)
```

L1 regularization

```
In [54]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
         from sklearn.calibration import CalibratedClassifierCV

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l1',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(bow_train_vect,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probabil
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

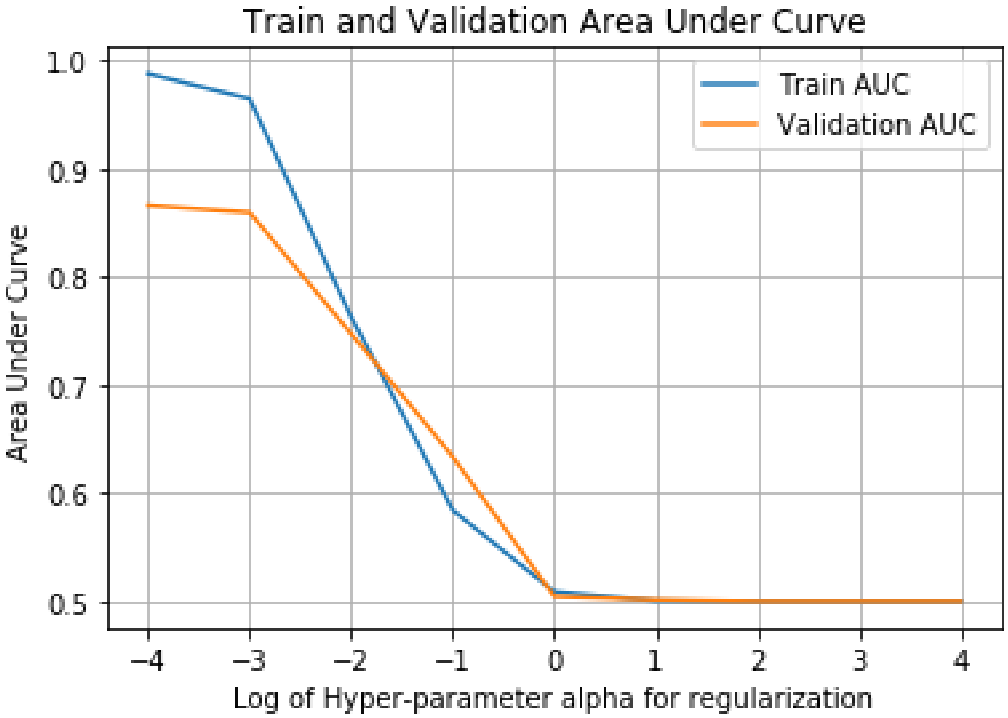
```
100%|| 9/9 [03:31<00:00,  9.28s/it]
```

```
In [55]: # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             # If data is imbalenced then giving weights to class improves AUC Score. Here cla
             clf = SGDClassifier(penalty='l1',alpha=k,tol=0.001,max_iter=400)#Giving weights f
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(bow_train_vect):
                 x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(excludi
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from train_i
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)
```

```
            cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [17:13<00:00, 45.87s/it]
```

```
In [57]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

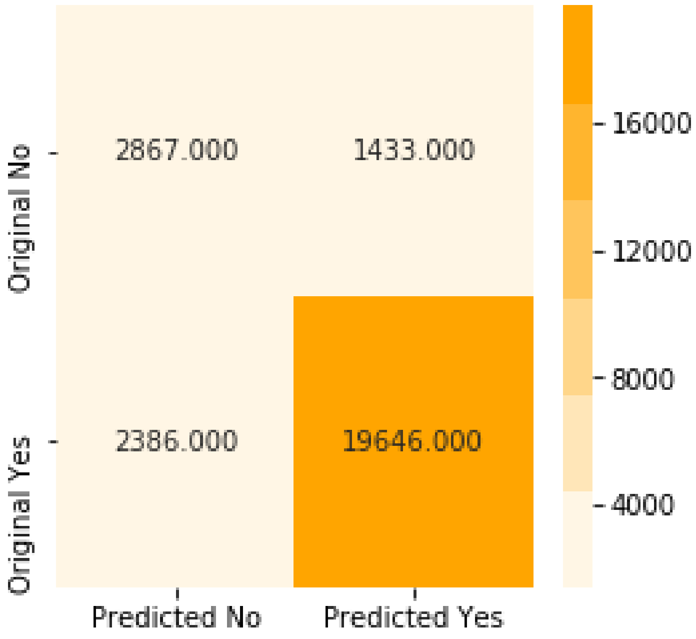


```
In [58]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400,class_weight={0:
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         calibrated_model.fit(bow_train_vect,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(bow_train_vect,Y_train)

         predict_y_test = clf.predict(bow_test_vect)# Getting labels predicted by SGDClassifie
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabil
         predict_y_train = clf.predict(bow_train_vect)
         probab_y_train = calibrated_model.predict_proba(bow_train_vect)[:,1]
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for BoW vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for BoW vectorized Linear SVM is 0.876
```

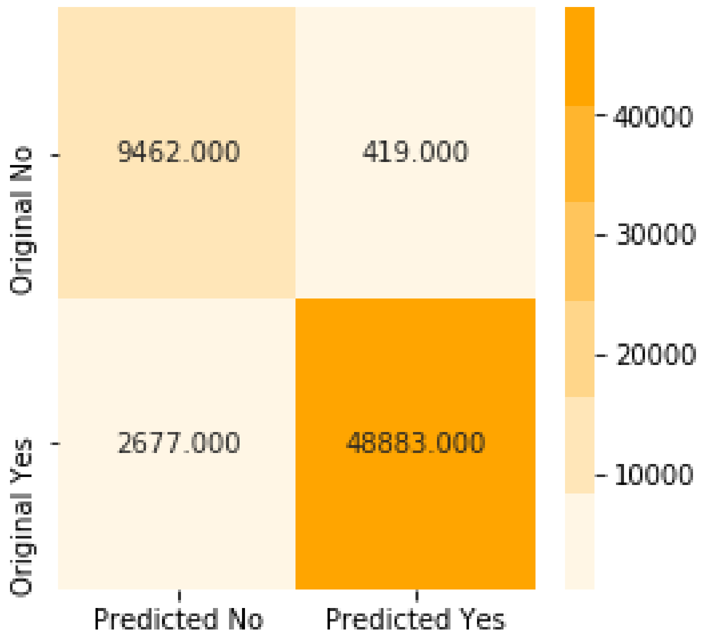
```
In [59]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

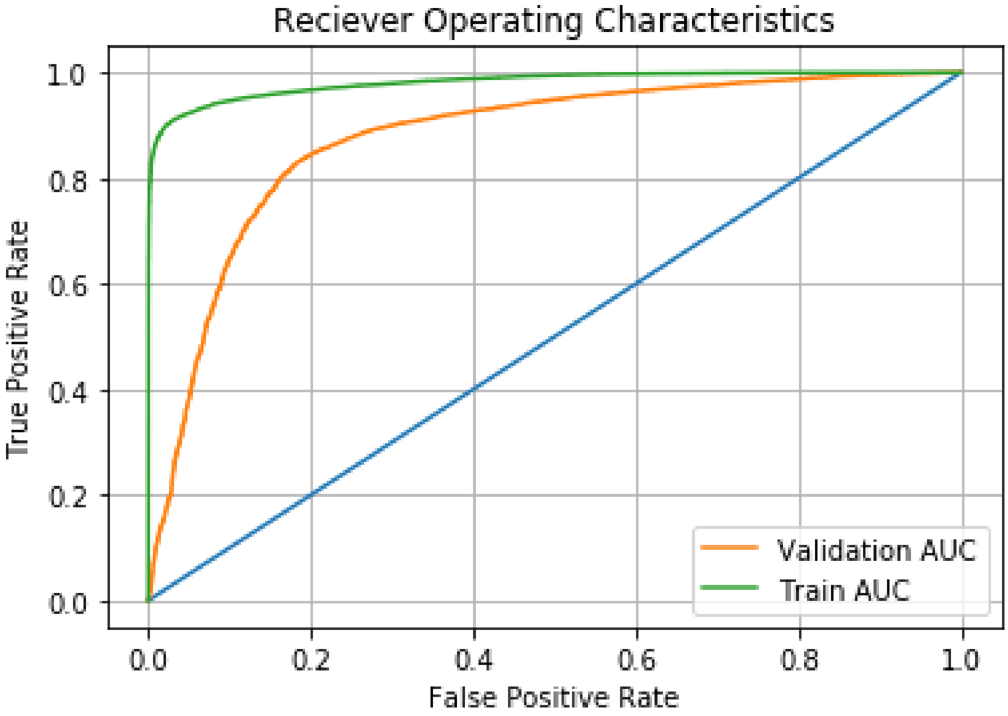


```
In [60]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [61]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using gridsearchcv for hyper parameter tunning

```
In [49]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l1',tol=0.001,max_iter=400)
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(bow_train_vect,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(bow_test_vect)
         predict_y_train = optimized_clf.predict(bow_train_vect)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(bow_test_vect,Y_test))
         print("The best alpha(1/C) is ",best_alpha)
```

```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l1', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.8713352574813915
The best alpha(1/C) is  0.0001
```

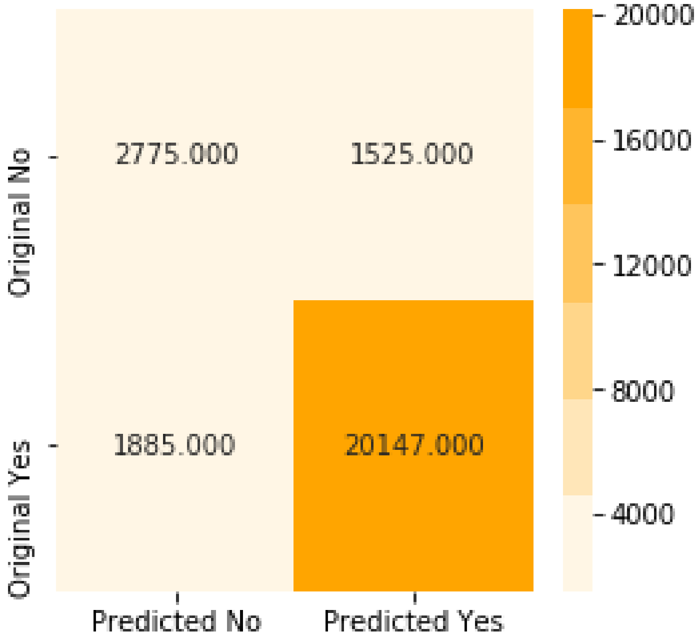
```
In [50]: # Training final model on alpha=0.0001
         # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         calibrated_model.fit(bow_train_vect,Y_train)
```

```
        #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
        clf.fit(bow_train_vect,Y_train)

        predict_y_test = clf.predict(bow_test_vect)# Getting labels predicted by SGDClassifie
        # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
        probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabil
        predict_y_train = clf.predict(bow_train_vect)
        probab_y_train = calibrated_model.predict_proba(bow_train_vect)[:,1]
        auc = roc_auc_score(Y_test,probab_y_test)
        print("Final AUC for BoW vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for BoW vectorized Linear SVM is 0.893
```

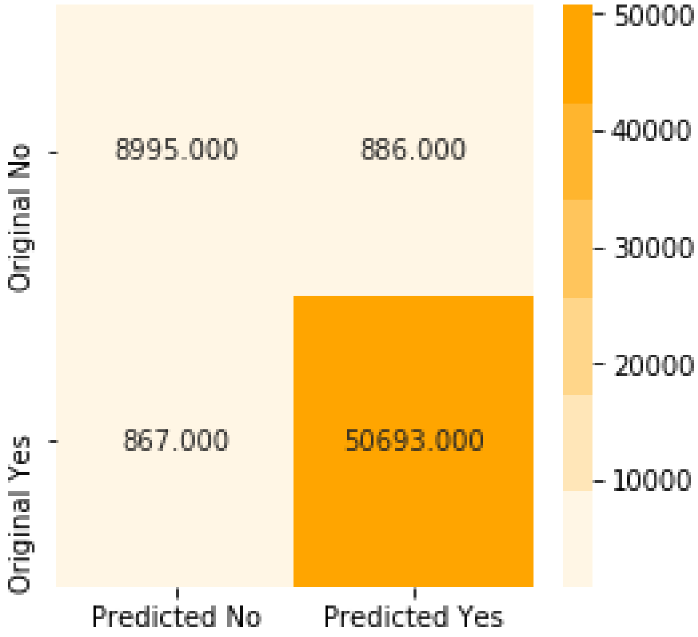
```
In [51]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

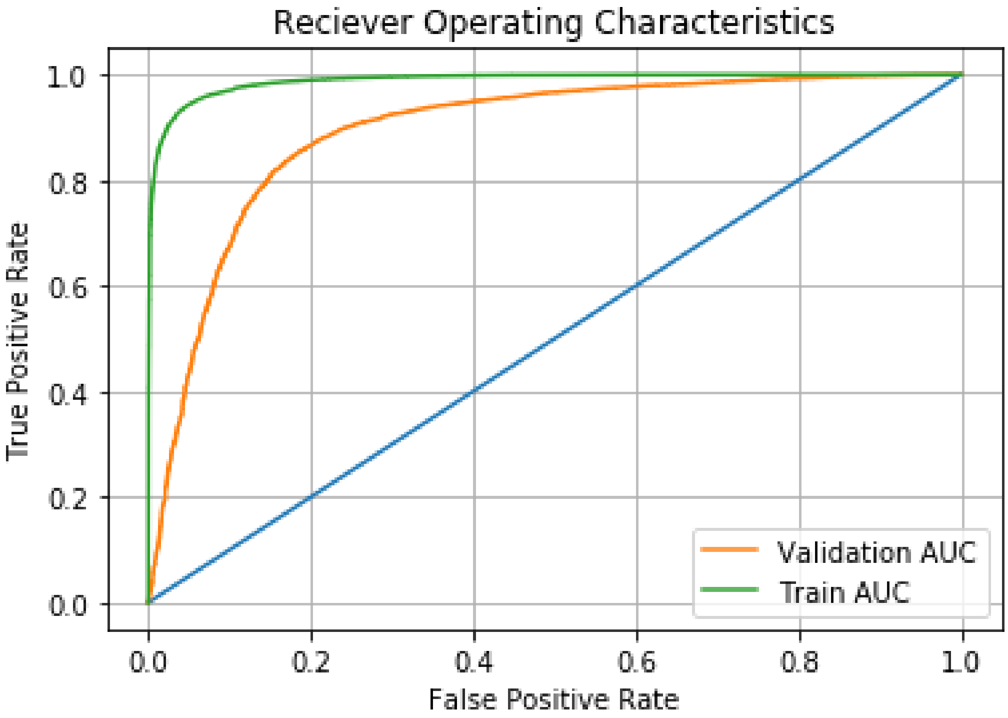


```
In [52]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [53]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



L2 regularization

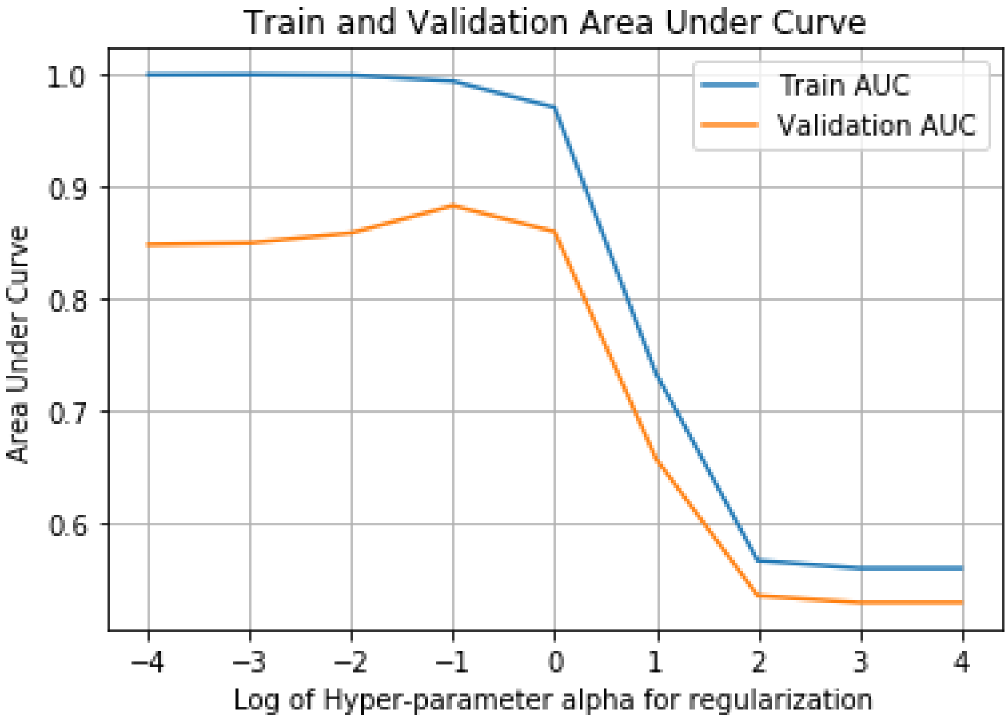
```
In [62]: param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l2',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(bow_train_vect,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probabil
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

```
100%|| 9/9 [00:07<00:00,  1.49it/s]
```

```
In [63]: # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k
         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l2',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(bow_train_vect):
                 x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(excludi
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from train_i
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [00:44<00:00,  3.79s/it]
```

```
In [64]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

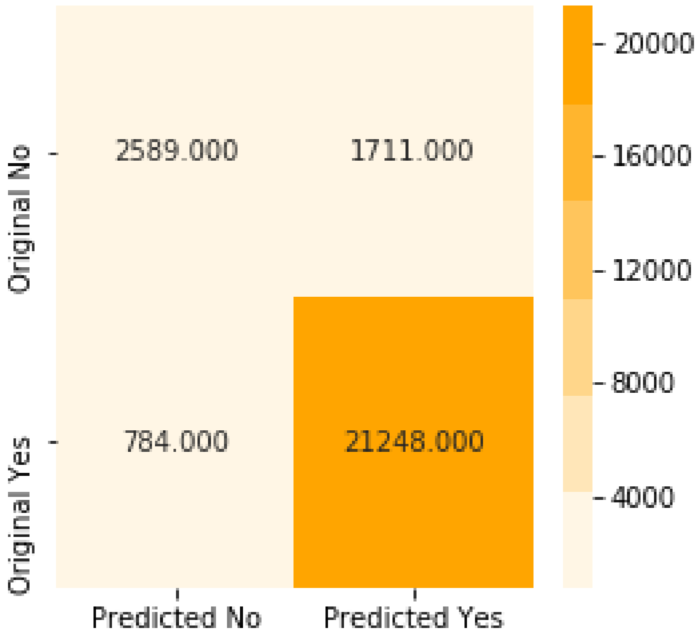


```
In [99]: # Taking best value of alpha = 0.1 an trainig final model
         # Initializing model
         clf2 = SGDClassifier(penalty='l2',alpha=0.1,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf2,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(bow_train_vect,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf2.fit(bow_train_vect,Y_train)

         predict_y = clf2.predict(bow_test_vect)# Getting labels predicted by SGDClassifier in
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabil
         predict_y_train = clf2.predict(bow_train_vect)
         probab_y_train = calibrated_model.predict_proba(bow_train_vect)[:,1]
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for BoW vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for BoW vectorized Linear SVM is 0.905
```

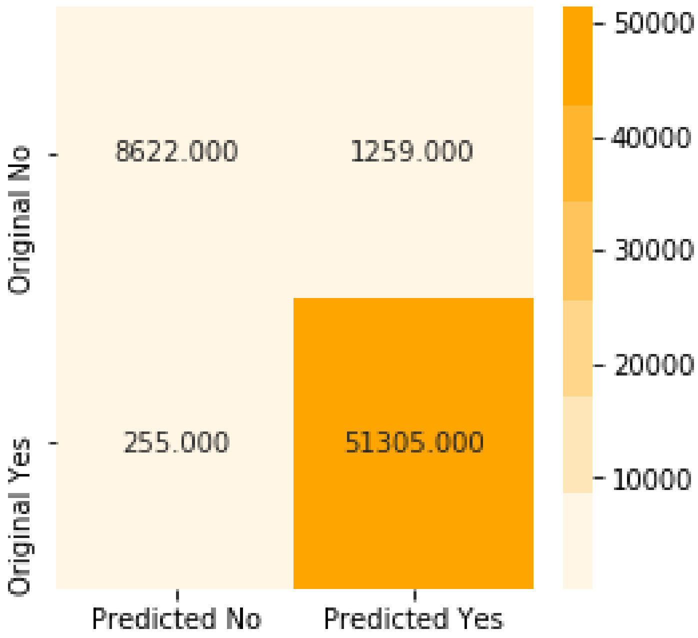
```
In [92]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion Matrix for test data
Confusion matrix
```

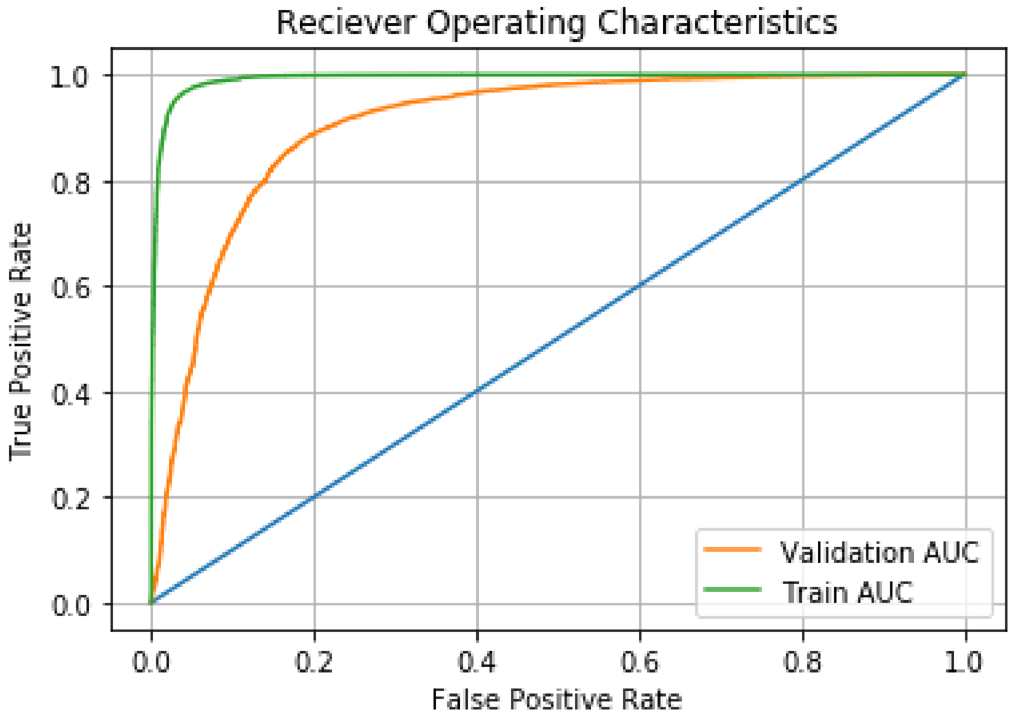


```
In [93]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [94]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using Grid Search Cv to tunr hyper parameters

```
In [96]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mod
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l2',tol=0.001,max_iter=400)
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(bow_train_vect,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(bow_test_vect)
         predict_y_train = optimized_clf.predict(bow_train_vect)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(bow_test_vect,Y_test))
         print("The best alpha(1/C) is ",best_alpha)
```

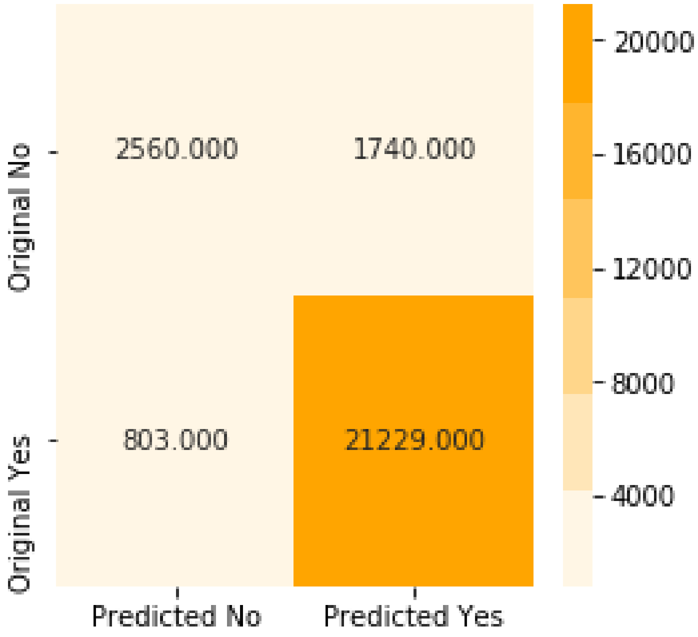
```
The optimized model is SGDClassifier(alpha=0.1, average=False, class_weight=None, epsilon=0.1,
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l2', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.9038812091751481
The best alpha(1/C) is  0.1
```

```
In [100]: # Taking best value of alpha = 0.1 an trainig final model
          # Initializing model
          clf2 = SGDClassifier(penalty='l2',alpha=0.1,tol=0.001,max_iter=400)
          calibrated_model = CalibratedClassifierCV(clf2,method='sigmoid',cv=5)
          # Training model on best value
          calibrated_model.fit(bow_train_vect,Y_train)

          #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the 
          clf2.fit(bow_train_vect,Y_train)

          predict_y = clf2.predict(bow_test_vect)# Getting labels predicted by SGDClassifier i
          # Getting probability values from CalibratedClassifier as SGDClassifier dont have me
          probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabi
          predict_y_train = clf2.predict(bow_train_vect)
          auc = roc_auc_score(Y_test,probab_y_test)
          print("Final AUC for BoW vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for BoW vectorized Linear SVM is 0.905
```

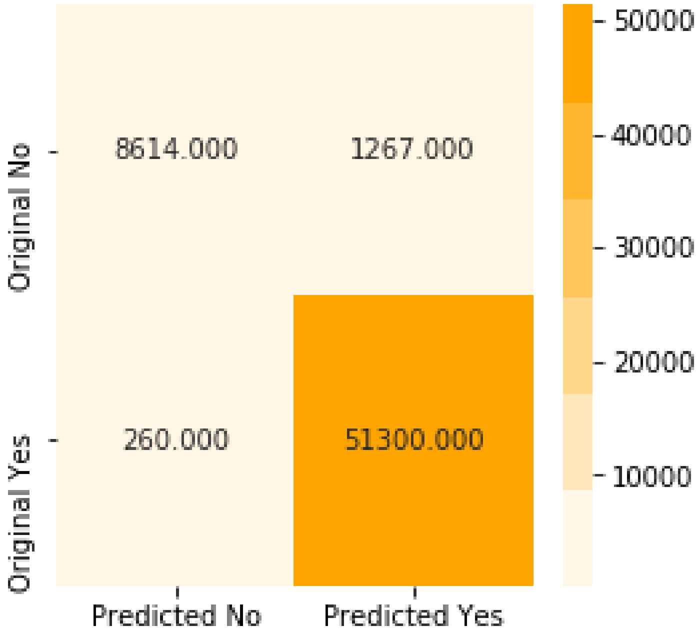
```
In [101]: # Plotting confusion matrix
          print("Confusion Matrix for test data")
          confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion Matrix for test data
Confusion matrix
```

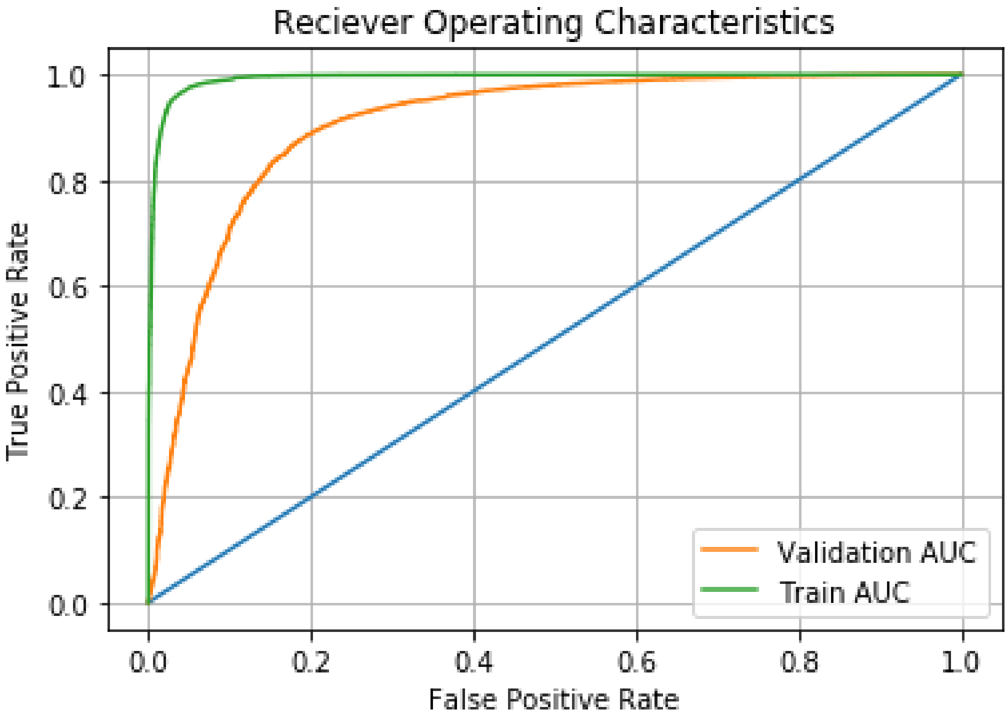


```
In [102]: # Plotting confusion matrix
          print("Confusion Matrix for train data")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [103]: # Plotting ROC AUC curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Top 10 positive features

```
In [77]: #To get most important features first sort the weight vectors in ascending order and
         # Corresponding to that index.

         # Getting all features from BoW model
         all_features = bow_vect.get_feature_names()

         # Getting weight vector of features.
         weight_vect = clf2.coef_

         #Contains the index of all weights in ascending order
         top10_pos_feat = weight_vect[0].argsort()

         # Top 10 features
         top10_pos_words = [all_features[i] for i in top10_pos_feat[-10:]]
         print(top10_pos_words)
```

```
['perfect', 'favorite', 'wonderful', 'excellent', 'loves', 'delicious', 'best', 'love', 'good'
```

Top 10 negative features

```
In [78]: #To get most important features first sort the weight vectors in ascending order and
         # Corresponding to that index.

         #Contains the index of all weights in ascending order
         top10_neg_feat = weight_vect[0].argsort()

         # Top 10 features
         top10_neg_words = [all_features[i] for i in top10_neg_feat[0:10]]
         print(top10_neg_words)
```

```
['not', 'disappointed', 'worst', 'awful', 'terrible', 'horrible', 'disappointing', 'threw', 'di
```

Observation

1. Linear SVM with l1 as penalty had AUC of 0.883 and False positive = 1437 and False Negative = 2406
2. Linear SVM with l2 as penalty had AUC of 0.909 and False positive=1718 and False Negative = 696
3. From these results it seems that Linear SVM model with l2 penalty is slightly biased towards positive points.

7.1.2 [5.1.2] Applying Linear SVM on TFIDF, SET 2

```
In [104]: # Initializing Tfidf vectorizer
          tfidf_vect = TfidfVectorizer()

          # Vectorizing train and test dataset seperately to prevent data lekage
          tfidf_train_vect = tfidf_vect.fit_transform(X_train)
          tfidf_test_vect = tfidf_vect.transform(X_test)
          tfidf_train_vect.shape
```

```
Out[104]: (61441, 46115)
```

```
In [105]: # Standarizing data
          from sklearn.preprocessing import StandardScaler
          std = StandardScaler(with_mean=False)
          tfidf_train_vect = std.fit_transform(tfidf_train_vect)
          tfidf_test_vect = std.transform(tfidf_test_vect)
```

L1 regularization

```
In [81]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
```

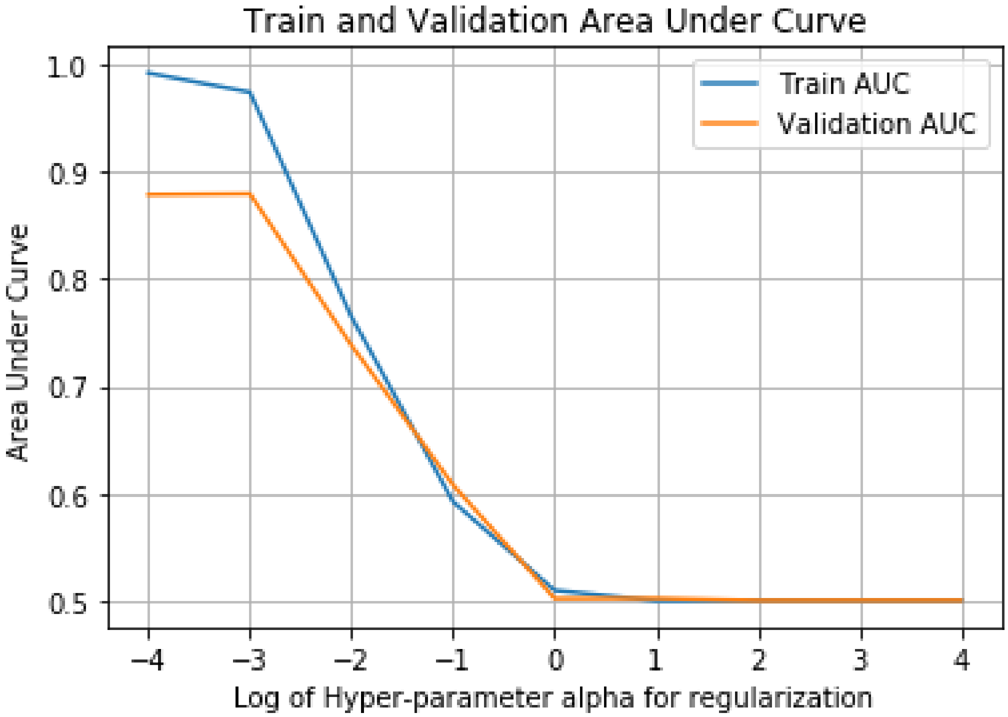
```
        from sklearn.calibration import CalibratedClassifierCV

        param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
        train_auc_list = [] # Will contain train auc score for various lambda

        # Calculating AUC on train dataset .
        for i in tqdm(param_alpha):
            clf = SGDClassifier(penalty='l1',alpha=i,tol=0.001,max_iter=400)
            calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
            calibrated_model.fit(tfidf_train_vect,Y_train)
            # evaluate the model
            probab_y = calibrated_model.predict_proba(tfidf_train_vect)[:,1] # Returns probab
            auc = roc_auc_score(Y_train,probab_y)
            train_auc_list.append(auc)
```

```
100%|| 9/9 [04:09<00:00, 10.88s/it]
```

```
In [82]: # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l1',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(tfidf_train_vect):
                 x_train = tfidf_train_vect[0:train_index[-1]][:] # row 0 to train_index(exclu
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = tfidf_train_vect[train_index[-1]:test_index[-1]][:] # row from train
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [17:51<00:00, 47.30s/it]
```

```
In [83]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

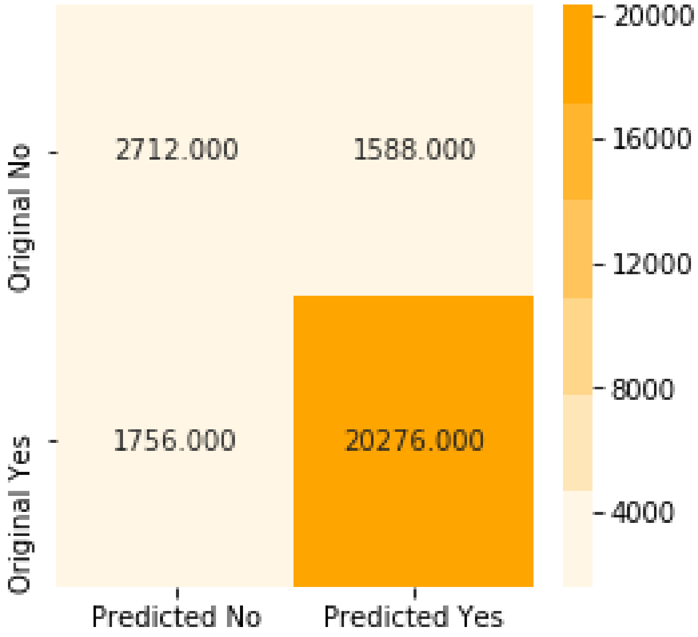


```
In [106]: # Taking best value of alpha = 0.001 an trainig final model
          # Initializing model
          clf = SGDClassifier(penalty='l1',alpha=0.001,tol=0.001,max_iter=400)
          calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
          # Training model on best value
          calibrated_model.fit(tfidf_train_vect,Y_train)

          #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the
          clf.fit(tfidf_train_vect,Y_train)

          predict_y = clf.predict(tfidf_test_vect)# Getting labels predicted by SGDClassifier
          # Getting probability values from CalibratedClassifier as SGDClassifier dont have me
          probab_y_test = calibrated_model.predict_proba(tfidf_test_vect)[:,1] # Returns proba
          predict_y_train = clf.predict(tfidf_train_vect)
          auc = roc_auc_score(Y_test,probab_y_test)
          print("Final AUC for Tfidf vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Tfidf vectorized Linear SVM is 0.896
```

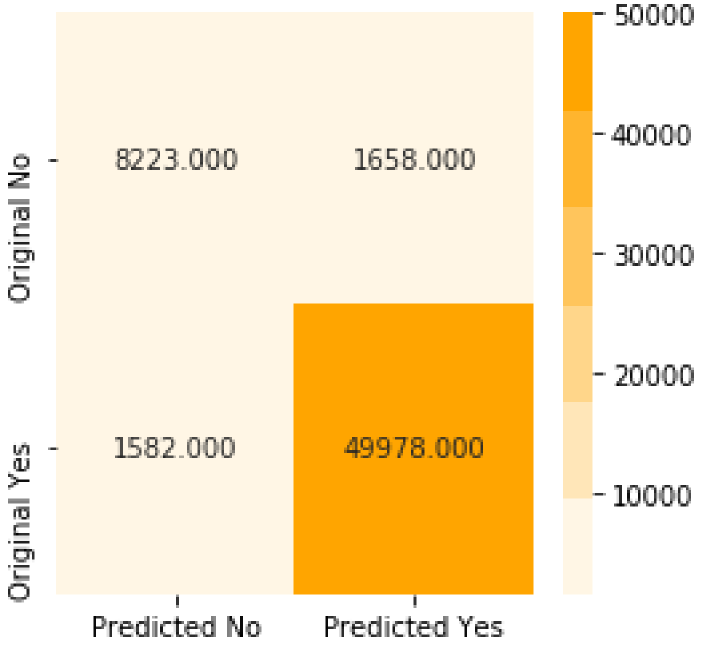
```
In [107]: # Plotting confusion matrix
          print("Confusion Matrix for test data")
          confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion Matrix for test data
Confusion matrix
```

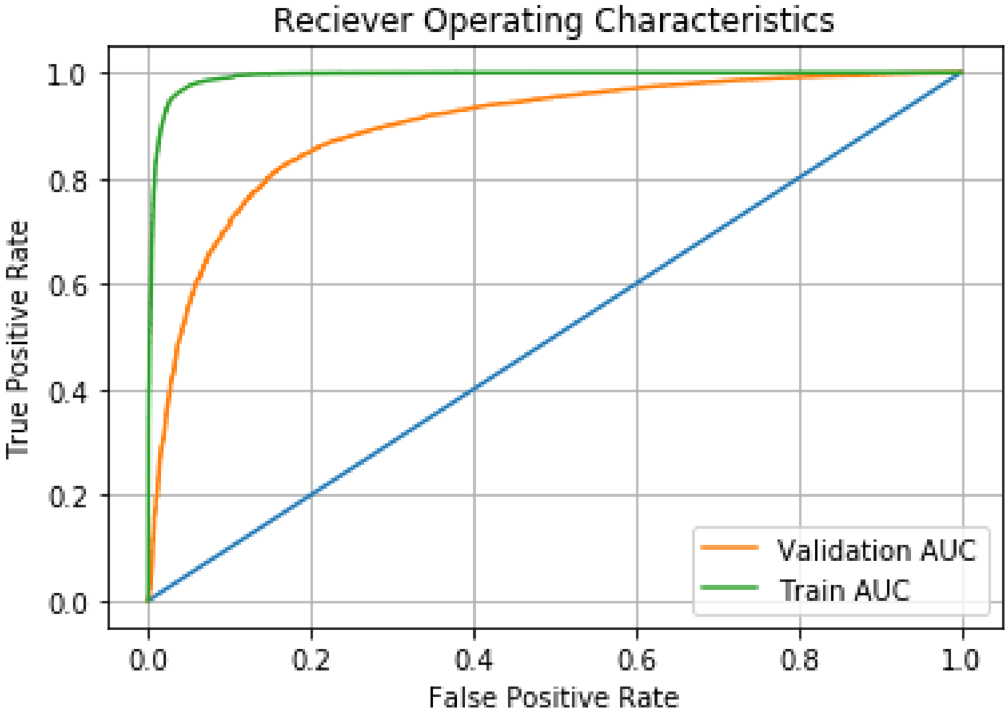


```
In [108]: # Plotting confusion matrix
          print("Confusion Matrix for train data")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [109]: # Plotting ROC AUC curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using Grid Search CV to tune hyperparameter

```
In [113]: from sklearn.model_selection import GridSearchCV
          from sklearn.metrics import make_scorer

          # Selecting the estimator . Estimator is the model that you will use to train your mo
          # We will pass this instance to GridSearchCV
          clf = SGDClassifier(penalty='l1',tol=0.001,max_iter=400)
          # Dictionary of parameters to be searched on
          parameters = {'alpha':param_alpha}

          # Value on which model will be evaluated
          auc_score = make_scorer(roc_auc_score)

          # Calling GridSearchCV .
          grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scori

          # Training the gridsearchcv instance
          grid_model.fit(tfidf_train_vect,Y_train)

          # this gives the best model with best hyper parameter
          optimized_clf = grid_model.best_estimator_
          best_alpha = grid_model.best_estimator_.alpha

          #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabil
          predict_y_test = optimized_clf.predict(tfidf_test_vect)
          predict_y_train = optimized_clf.predict(tfidf_train_vect)


          print("The optimized model is",optimized_clf)
          print("Accuracy of best model is",optimized_clf.score(tfidf_test_vect,Y_test))
          print("The best alpha(1/C) is ",best_alpha)
```

```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l1', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.8798799939237429
The best alpha(1/C) is  0.0001
```

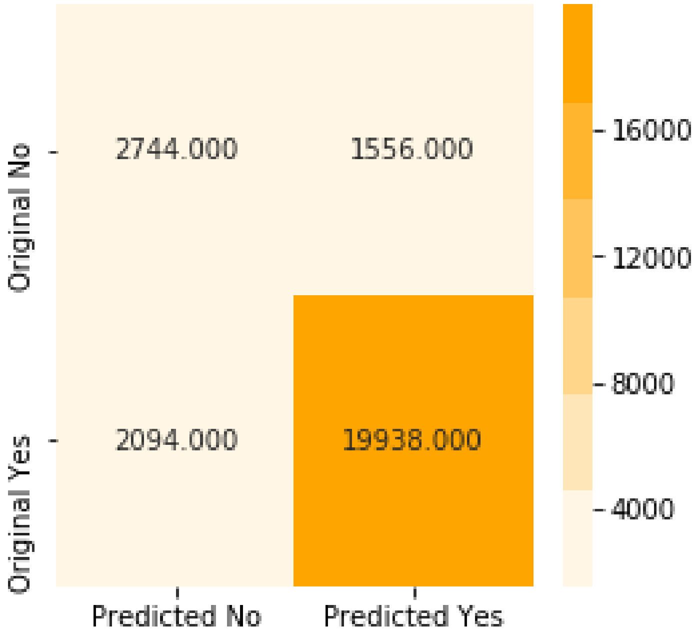
```
In [114]: # Taking best value of alpha = 0.001 an trainig final model
          # Initializing model
          clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
          calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
          # Training model on best value
          calibrated_model.fit(tfidf_train_vect,Y_train)
```

```
        #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the 
        clf.fit(tfidf_train_vect,Y_train)

        predict_y = clf.predict(tfidf_test_vect)# Getting labels predicted by SGDClassifier 
        # Getting probability values from CalibratedClassifier as SGDClassifier dont have me
        probab_y_test = calibrated_model.predict_proba(tfidf_test_vect)[:,1] # Returns proba
        predict_y_train = clf.predict(tfidf_train_vect)
        probab_y_train = calibrated_model.predict_proba(tfidf_train_vect)[:,1]
        auc = roc_auc_score(Y_test,probab_y_test)
        print("Final AUC for Tfidf vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Tfidf vectorized Linear SVM is 0.897
```

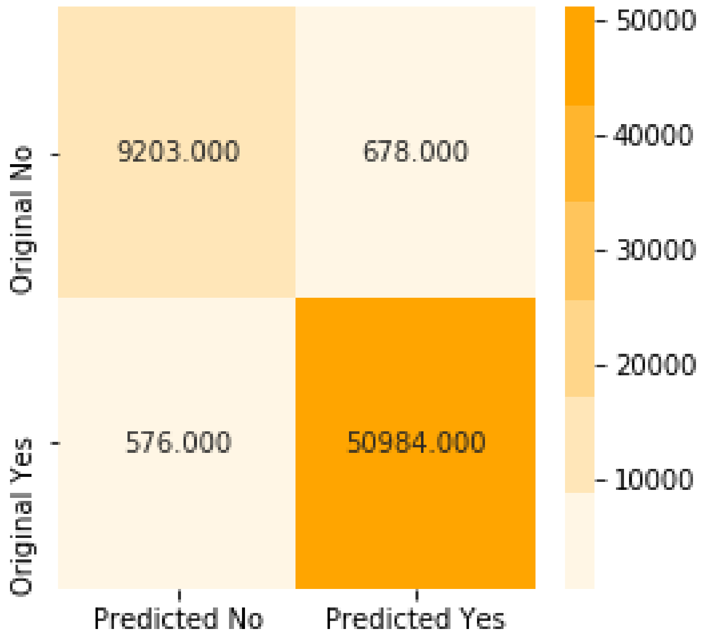
```
In [115]: # Plotting confusion matrix
          print("Confusion Matrix for test data")
          confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion Matrix for test data
Confusion matrix
```

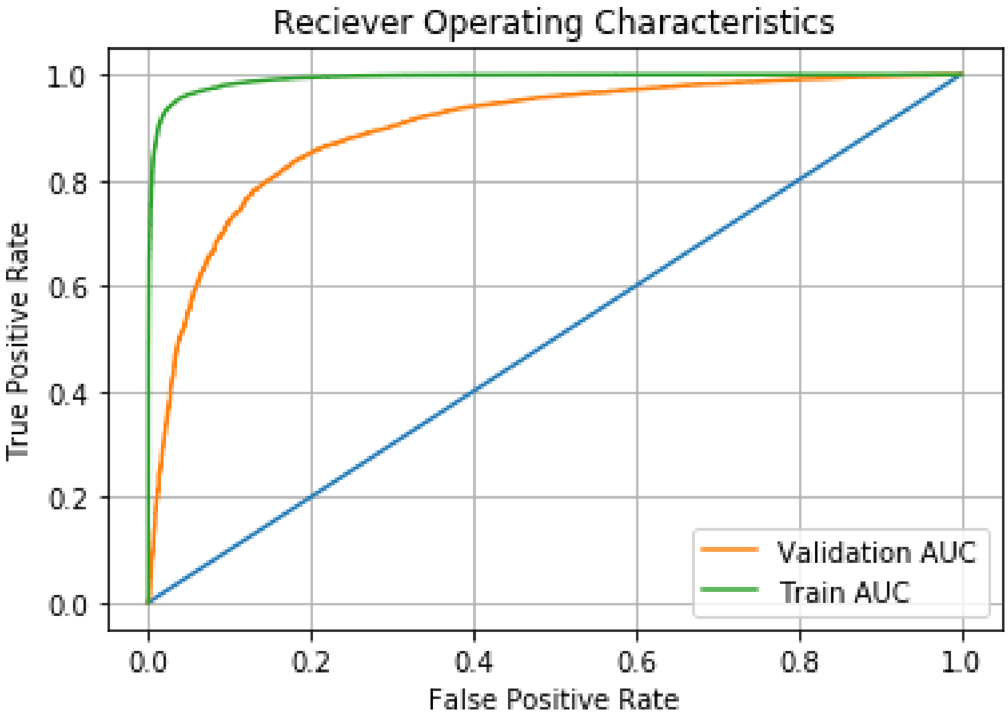


```
In [116]: # Plotting confusion matrix
          print("Confusion Matrix for train data")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [117]: # Plotting ROC AUC curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



L2 Regularization

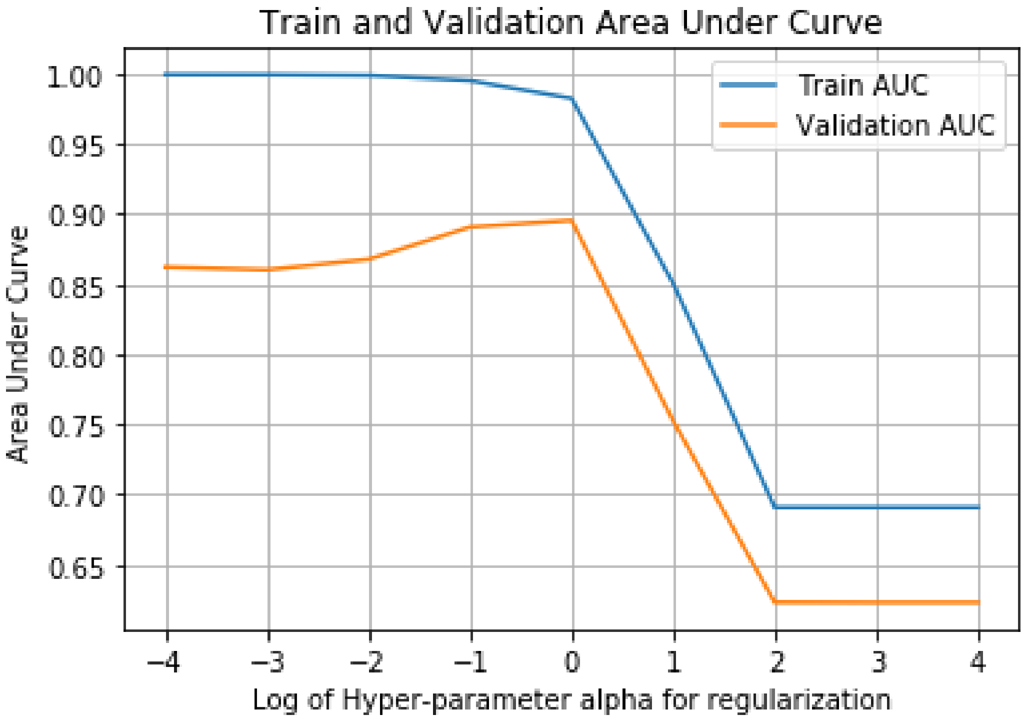
```
In [118]: # Initializing the linear SVM classifier
          from sklearn.linear_model import SGDClassifier
          from sklearn.metrics import roc_auc_score
          from tqdm import tqdm  # this module is used to check the progress of loops
          import numpy as np
          from sklearn.calibration import CalibratedClassifierCV

          param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
          train_auc_list = [] # Will contain train auc score for various lambda

          # Calculating AUC on train dataset .
          for i in tqdm(param_alpha):
              clf = SGDClassifier(penalty='l2',alpha=i,tol=0.001,max_iter=400)
              calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
              calibrated_model.fit(tfidf_train_vect,Y_train)
              # evaluate the model
              probab_y = calibrated_model.predict_proba(tfidf_train_vect)[:,1] # Returns proba
              auc = roc_auc_score(Y_train,probab_y)
              train_auc_list.append(auc)
```

```
100%|| 9/9 [00:07<00:00,  1.52it/s]
```

```
In [119]: # Time series object
          tscv = TimeSeriesSplit(n_splits=10)

          # In this section we will perform 10-fold Cross validation on timse series split dat

          cv_auc_list = [] # will contain cross validation AUC corresponding to each k

          for k in tqdm(param_alpha):
              # Linear SVM classifier
              clf = SGDClassifier(penalty='l2',alpha=k,tol=0.001,max_iter=400)
              calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
              i=0
              auc=0.0
              for train_index,test_index in tscv.split(tfidf_train_vect):
                  x_train = tfidf_train_vect[0:train_index[-1]][:] # row 0 to train_index(excl
                  y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                  x_test = tfidf_train_vect[train_index[-1]:test_index[-1]][:] # row from trai
                  y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index t

                  calibrated_model.fit(x_train,y_train)

                  probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                  i += 1
                  auc += roc_auc_score(y_test,probab_y)

              cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [00:38<00:00,  3.49s/it]
```

```
In [120]: # Plotting graph of auc and parameter for training and cross validation error
          plot_train_vs_auc(train_auc_list,cv_auc_list)
```

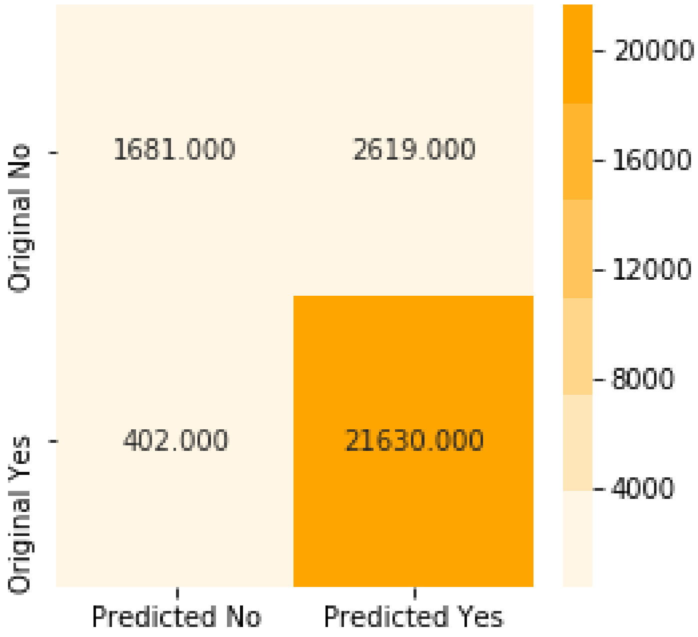


```
In [126]: # Taking best value of alpha = 0.1 an trainig final model
          # Initializing model
          clf2 = SGDClassifier(penalty='l2',alpha=1,tol=0.001,max_iter=400)
          calibrated_model = CalibratedClassifierCV(clf2,method='sigmoid',cv=5)
          # Training model on best value
          calibrated_model.fit(tfidf_train_vect,Y_train)

          #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the
          clf2.fit(tfidf_train_vect,Y_train)

          predict_y = clf2.predict(tfidf_test_vect)# Getting labels predicted by SGDClassifier
          # Getting probability values from CalibratedClassifier as SGDClassifier dont have me
          probab_y_test = calibrated_model.predict_proba(tfidf_test_vect)[:,1] # Returns proba
          predict_y_train = clf2.predict(tfidf_train_vect)
          probab_y_train = calibrated_model.predict_proba(tfidf_train_vect)[:,1]
          auc = roc_auc_score(Y_test,probab_y_test)
          print("Final AUC for Tfidf vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Tfidf vectorized Linear SVM is 0.911
```

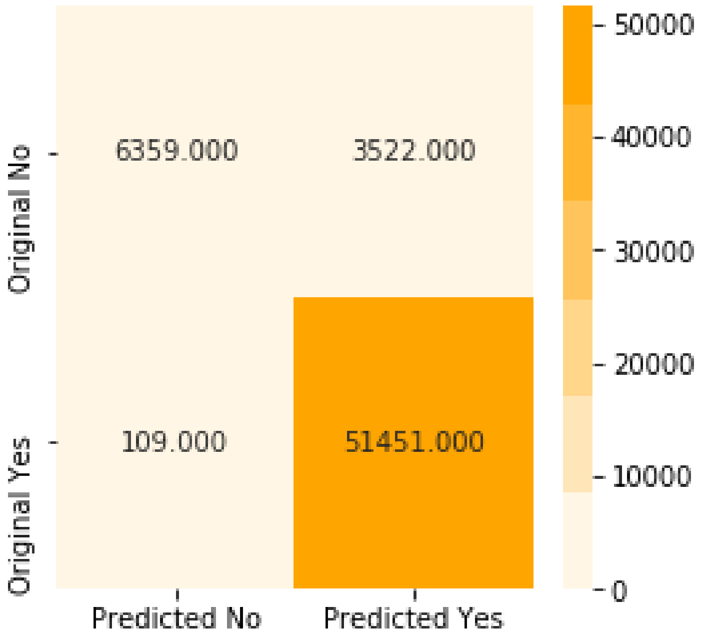
```
In [127]: # Plotting confusion matrix
          print("Confusion Matrix for test data")
          confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion Matrix for test data
Confusion matrix
```

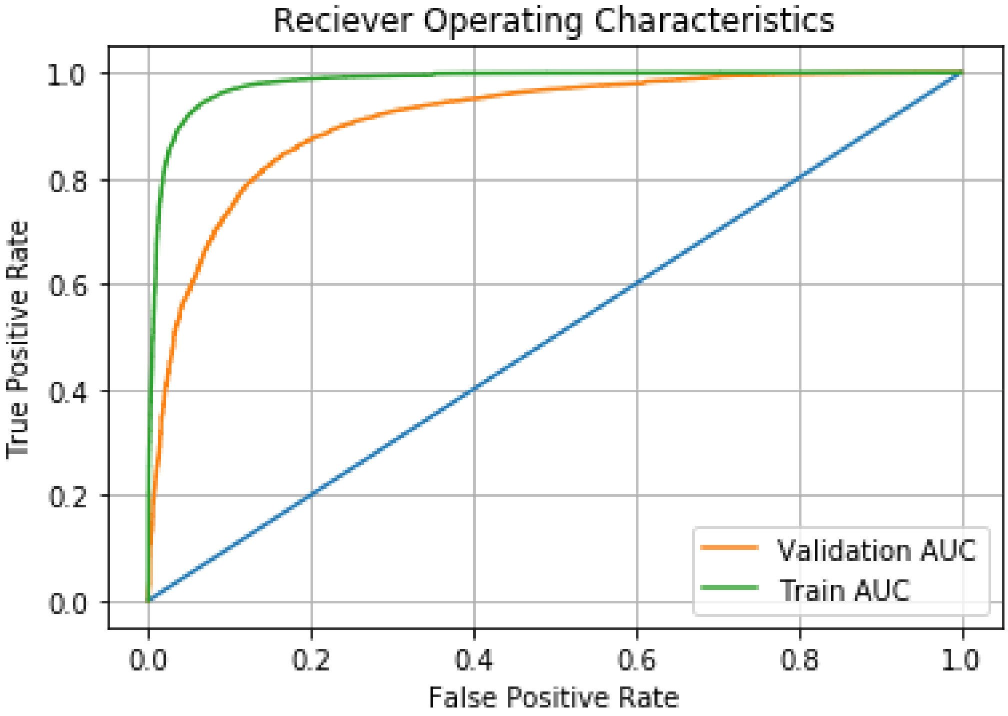


```
In [128]: # Plotting confusion matrix
          print("Confusion Matrix for train data")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [129]: # Plotting ROC AUC curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using grid search cv

```
In [124]: from sklearn.model_selection import GridSearchCV
          from sklearn.metrics import make_scorer

          # Selecting the estimator . Estimator is the model that you will use to train your m
          # We will pass this instance to GridSearchCV
          clf = SGDClassifier(penalty='l2',tol=0.001,max_iter=400)
          # Dictionary of parameters to be searched on
          parameters = {'alpha':param_alpha}

          # Value on which model will be evaluated
          auc_score = make_scorer(roc_auc_score)

          # Calling GridSearchCV .
          grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scori

          # Training the gridsearchcv instance
          grid_model.fit(tfidf_train_vect,Y_train)

          # this gives the best model with best hyper parameter
          optimized_clf = grid_model.best_estimator_
          best_alpha = grid_model.best_estimator_.alpha

          #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabil
          predict_y_test = optimized_clf.predict(tfidf_test_vect)
          predict_y_train = optimized_clf.predict(tfidf_train_vect)


          print("The optimized model is",optimized_clf)
          print("Accuracy of best model is",optimized_clf.score(tfidf_test_vect,Y_test))
          print("The best alpha(1/C) is ",best_alpha)
```

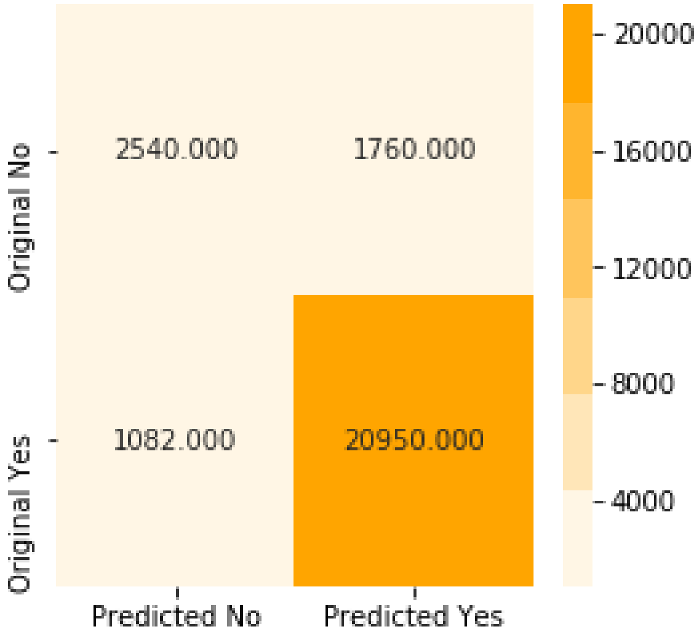
```
The optimized model is SGDClassifier(alpha=0.1, average=False, class_weight=None, epsilon=0.1,
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l2', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.8998556888956403
The best alpha(1/C) is  0.1
```

```
In [130]: # Taking best value of alpha = 0.1 an trainig final model
          # Initializing model
          clf2 = SGDClassifier(penalty='l2',alpha=0.1,tol=0.001,max_iter=400)
          calibrated_model = CalibratedClassifierCV(clf2,method='sigmoid',cv=5)
          # Training model on best value
          calibrated_model.fit(tfidf_train_vect,Y_train)
          #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the
          clf2.fit(tfidf_train_vect,Y_train)

          predict_y = clf2.predict(tfidf_test_vect)# Getting labels predicted by SGDClassifier
          # Getting probability values from CalibratedClassifier as SGDClassifier dont have me
          probab_y_test = calibrated_model.predict_proba(tfidf_test_vect)[:,1] # Returns proba
          predict_y_train = clf2.predict(tfidf_train_vect)
          probab_y_train = calibrated_model.predict_proba(tfidf_train_vect)[:,1]
          auc = roc_auc_score(Y_test,probab_y_test)
          print("Final AUC for Tfidf vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Tfidf vectorized Linear SVM is 0.912
```

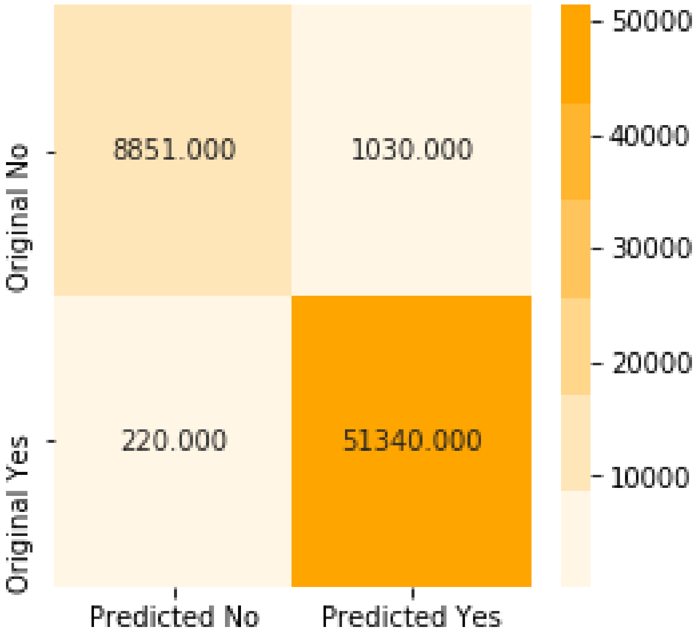
```
In [131]: # Plotting confusion matrix
          print("Confusion Matrix for test data")
          confusion_matrix_plot(Y_test,predict_y)
```

```
Confusion Matrix for test data
Confusion matrix
```

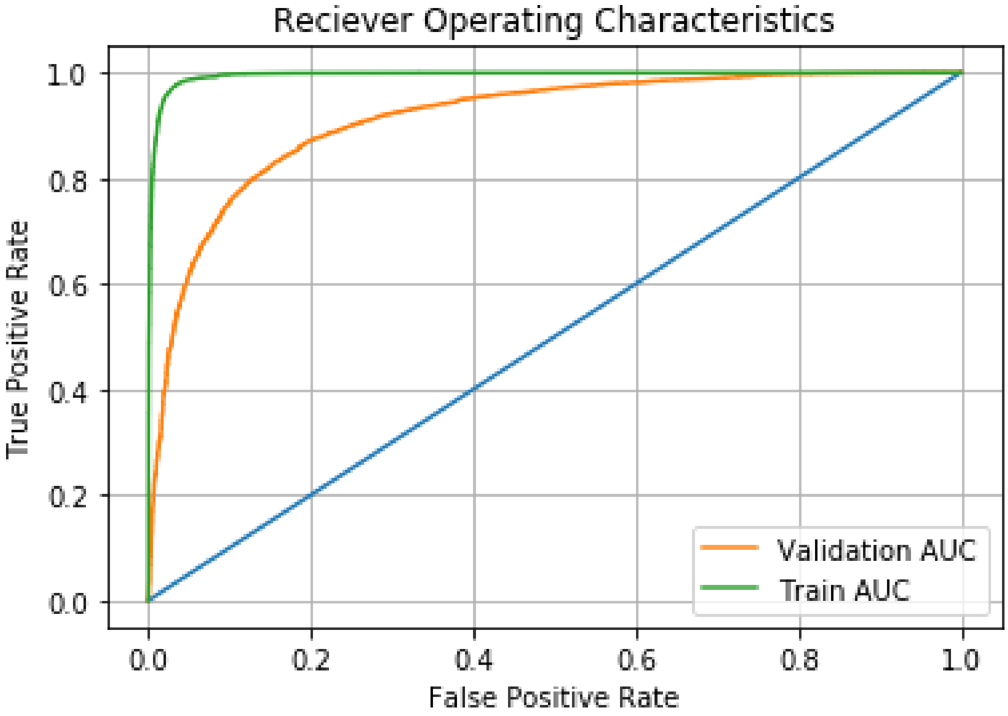


```
In [132]: # Plotting confusion matrix
          print("Confusion Matrix for train data")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



In [133]:
```
# Plotting ROC AUC curve
plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Top 10 positive words

```
In [134]: #To get most important features first sort the weight vectors in ascending order and
          # Corresponding to that index.

          # Getting all features from BoW model
          all_features = tfidf_vect.get_feature_names()

          # Getting weight vector of features
          weight_vect = clf2.coef_

          #Contains the index of all weights in ascending order
          top10_pos_feat = weight_vect[0].argsort()

          # Top 10 features
          top10_pos_words = [all_features[i] for i in top10_pos_feat[-10:]]
          print(top10_pos_words)
```

```
['wonderful', 'nice', 'perfect', 'loves', 'excellent', 'delicious', 'best', 'love', 'good', 'g
```

Top 10 negative words

```
In [135]: #To get most important features first sort the weight vectors in ascending order and
          # Corresponding to that index.
```

```
        #Contains the index of all weights in ascending order
        top10_neg_feat = weight_vect[0].argsort()

        # Top 10 features
        top10_neg_words = [all_features[i] for i in top10_neg_feat[0:10]]
        print(top10_neg_words)
```

```
['not', 'disappointed', 'worst', 'terrible', 'horrible', 'awful', 'disappointing', 'threw', 'di
```

7.1.3 [5.1.3] Applying Linear SVM on AVG W2V, SET 3

```
In [33]: # Splitting list_of_sentance into train and test dataset
         X_train,X_test,Y_train,Y_test = train_test_split(list_of_sentance,Y,test_size=0.3,ranc
         print(len(X_train))
```

```
61441
```

```
In [ ]: # Training word2Vec model on traain dataset and will use same for test dataset
        is_your_ram_gt_16g=False
        want_to_use_google_w2v = False
        want_to_train_w2v = True

        if want_to_train_w2v:
            # min_count = 5 considers only words that occured atleast 5 times
            w2v_model=Word2Vec(X_train,min_count=5,size=100, workers=4)
            print(w2v_model.wv.most_similar('great'))
            print('='*50)
            print(w2v_model.wv.most_similar('worst'))

        elif want_to_use_google_w2v and is_your_ram_gt_16g:
            if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bin
                print(w2v_model.wv.most_similar('great'))
                print(w2v_model.wv.most_similar('worst'))
            else:
                print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, to
```

```
In [ ]: w2v_words = list(w2v_model.wv.vocab)
        print("number of words that occured minimum 5 times ",len(w2v_words))
        print("sample words ", w2v_words[0:50])
```

```
In [34]: # Vectorizing train datset.
         # Train and test dataset are vectorized seperately to prevent d lekage
         # average Word2Vec
         # compute average word2vec for each review.
         train_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
```

```
for sent in tqdm(X_train): # for each review/sentence
    sent_vec = np.zeros(200) # as word vectors are of zero length 50, you might need
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    train_avg_w2v.append(sent_vec)
print(len(train_avg_w2v))
print(len(train_avg_w2v[0]))
```

```
100%|| 61441/61441 [14:14<00:00, 71.88it/s]

61441
200
```

```
In [35]: # Vectorizing test datset.
         # Train and test dataset are vectorized seperately to prevent d lekage
         # average Word2Vec
         # compute average word2vec for each review.
         test_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(200) # as word vectors are of zero length 50, you might need
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             test_avg_w2v.append(sent_vec)
         print(len(test_avg_w2v))
         print(len(test_avg_w2v[0]))
```

```
100%|| 26332/26332 [06:09<00:00, 71.22it/s]

26332
200
```

L1 Regularization

```
In [36]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
         from sklearn.calibration import CalibratedClassifierCV

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l1',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(train_avg_w2v,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(train_avg_w2v)[:,1] # Returns probabili
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

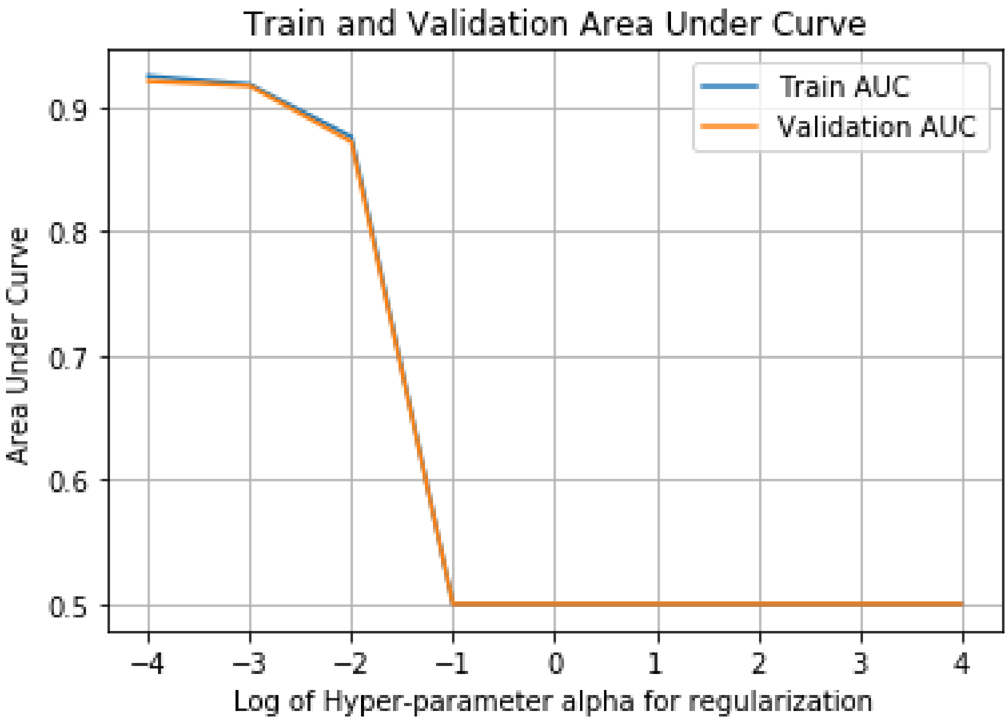
```
100%|| 9/9 [00:26<00:00,  2.86s/it]
```

```
In [37]: # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l1',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(train_avg_w2v):
                 x_train = train_avg_w2v[0:train_index[-1]][:] # row 0 to train_index(excludin
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = train_avg_w2v[train_index[-1]:test_index[-1]][:] # row from train_in
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
```

```
        auc += roc_auc_score(y_test,probab_y)

    cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [02:31<00:00, 15.79s/it]
```

```
In [38]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```



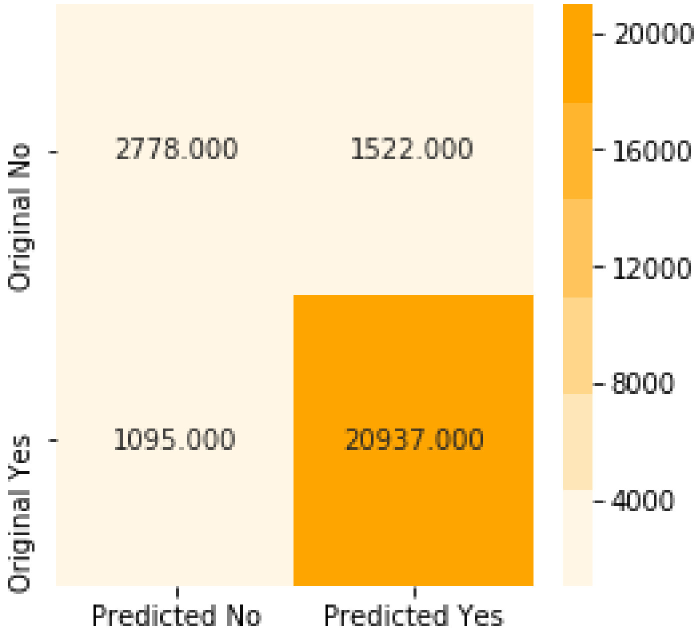
```
In [40]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(train_avg_w2v,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(train_avg_w2v,Y_train)

         predict_y_test = clf.predict(test_avg_w2v)# Getting labels predicted by SGDClassifier
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(test_avg_w2v)[:,1] # Returns probabili
```

```
predict_y_train = clf.predict(train_avg_w2v)
probab_y_train = calibrated_model.predict_proba(train_avg_w2v)[:,1] # Returns probabi
auc = roc_auc_score(Y_test,probab_y_test)
print("Final AUC for Avg W2V vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Avg W2V vectorized Linear SVM is 0.927
```

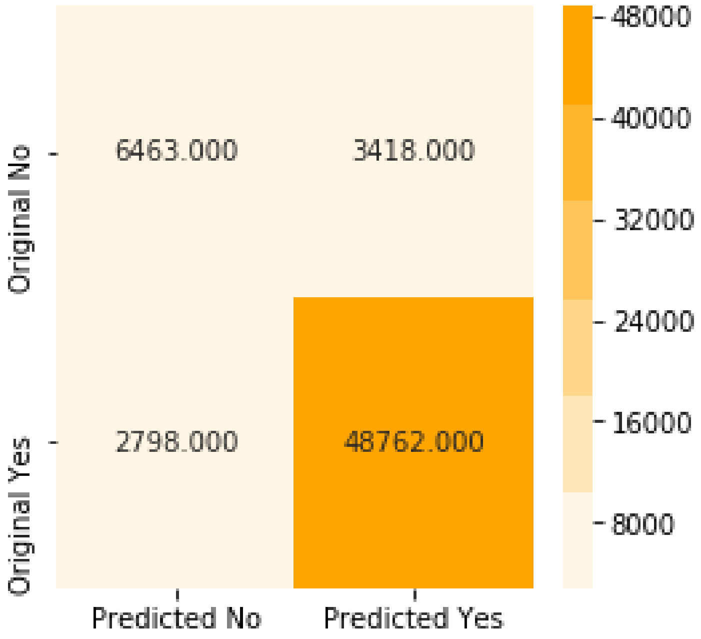
```
In [42]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

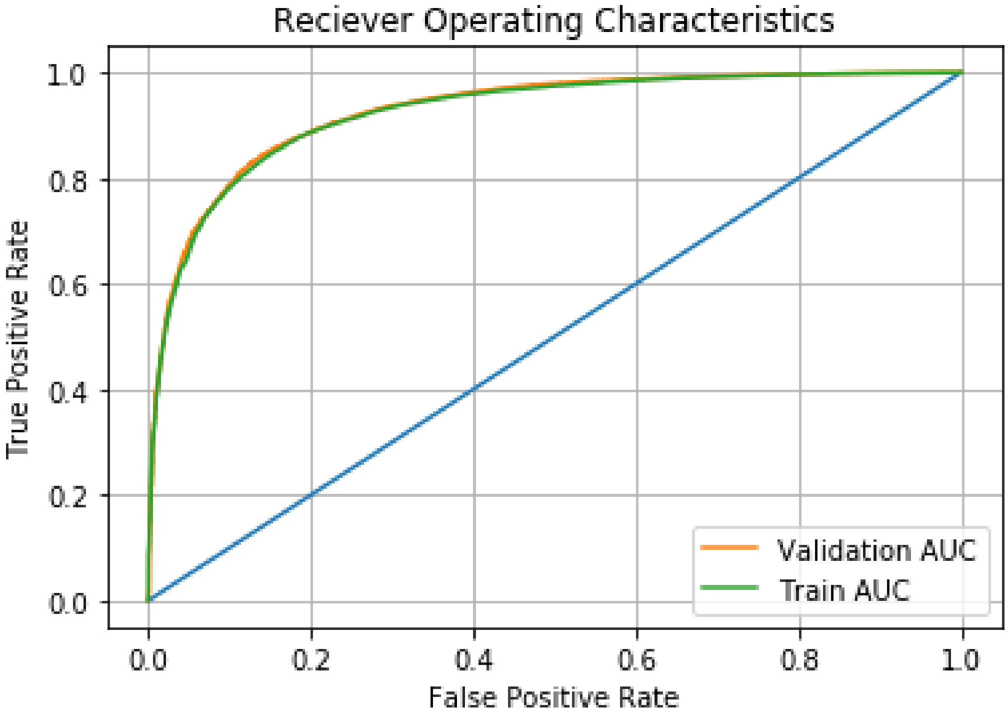


```
In [43]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [44]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using grid search cv

```
In [45]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l1',tol=0.001,max_iter=400)
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(train_avg_w2v,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(test_avg_w2v)
         predict_y_train = optimized_clf.predict(train_avg_w2v)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(test_avg_w2v,Y_test))
         print("The best alpha(1/C) is ",best_alpha)
```

```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l1', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.900919033875133
The best alpha(1/C) is  0.0001
```

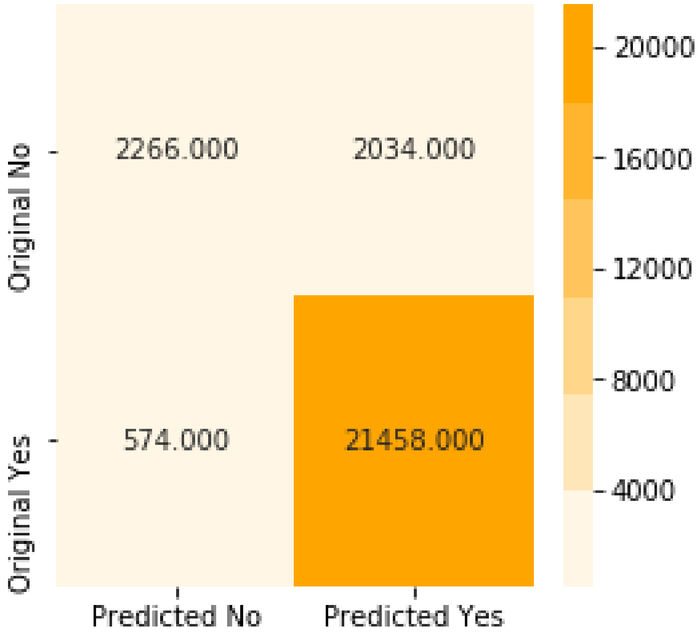
```
In [46]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(train_avg_w2v,Y_train)
```

```
        #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
        clf.fit(train_avg_w2v,Y_train)

        predict_y_test = clf.predict(test_avg_w2v)# Getting labels predicted by SGDClassifier
        # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
        probab_y_test = calibrated_model.predict_proba(test_avg_w2v)[:,1] # Returns probabili
        predict_y_train = clf.predict(train_avg_w2v)
        probab_y_train = calibrated_model.predict_proba(train_avg_w2v)[:,1] # Returns probabi
        auc = roc_auc_score(Y_test,probab_y_test)
        print("Final AUC for Avg W2V vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Avg W2V vectorized Linear SVM is 0.928
```

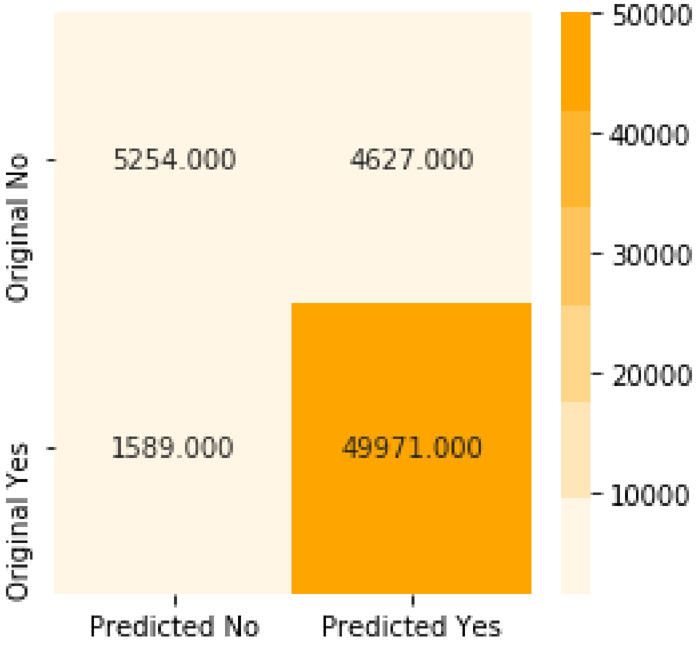
```
In [47]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

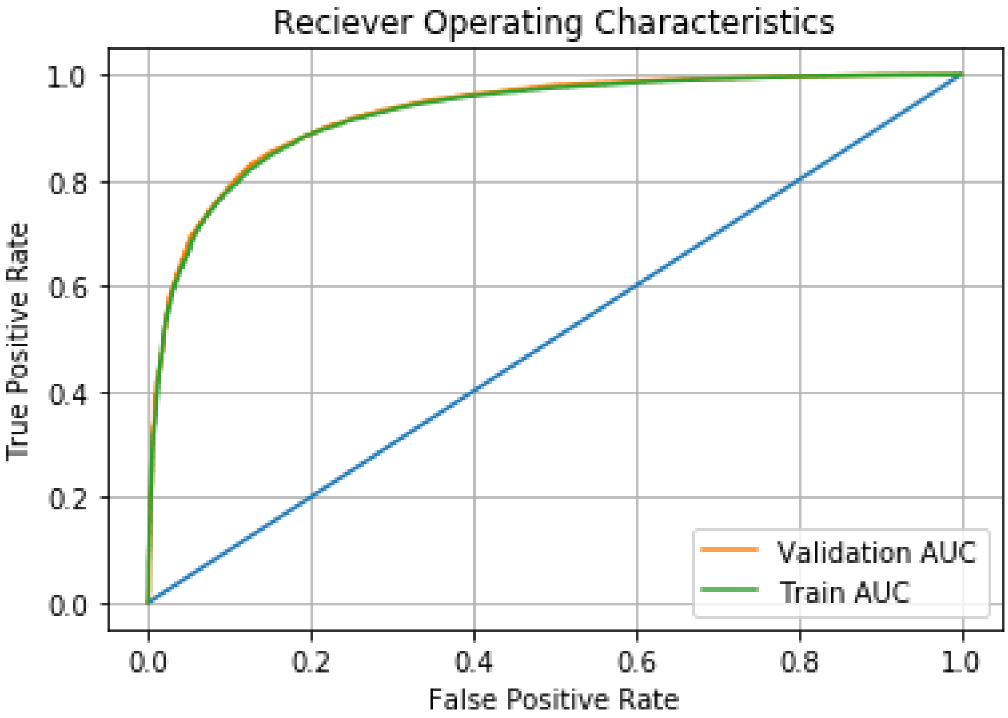


```
In [49]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [50]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



L2 Regularization

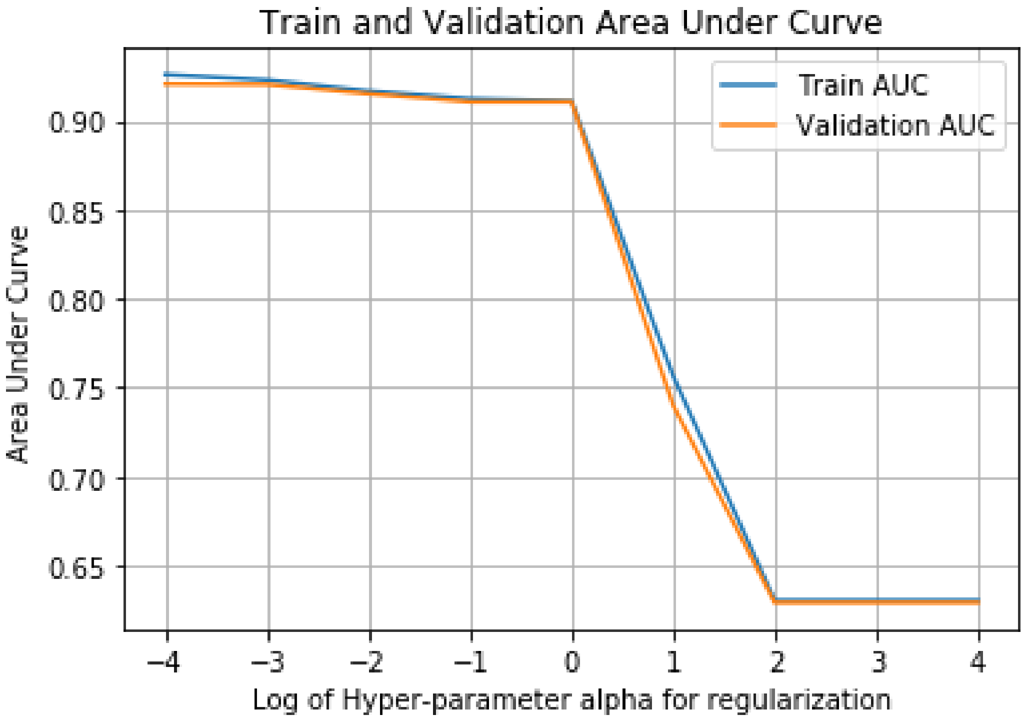
```
In [55]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
         from sklearn.calibration import CalibratedClassifierCV

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l2',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(train_avg_w2v,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(train_avg_w2v)[:,1] # Returns probabili
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

```
100%|| 9/9 [00:20<00:00,  2.05s/it]
```

```
In [56]: # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l2',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(train_avg_w2v):
                 x_train = train_avg_w2v[0:train_index[-1]][:] # row 0 to train_index(excludin
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = train_avg_w2v[train_index[-1]:test_index[-1]][:] # row from train_in
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [01:24<00:00,  8.47s/it]
```

```
In [57]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

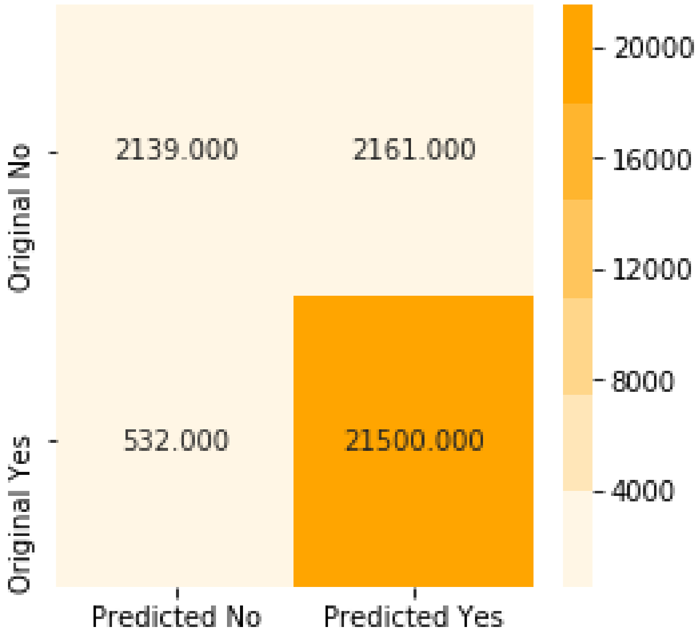


```
In [58]: # Taking best value of alpha = 0.001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(train_avg_w2v,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(train_avg_w2v,Y_train)

         predict_y_test = clf.predict(test_avg_w2v)# Getting labels predicted by SGDClassifier
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(test_avg_w2v)[:,1] # Returns probabili
         predict_y_train = clf.predict(train_avg_w2v)
         probab_y_train = calibrated_model.predict_proba(train_avg_w2v)[:,1] # Returns probabi
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for Avg W2V vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Avg W2V vectorized Linear SVM is 0.922
```

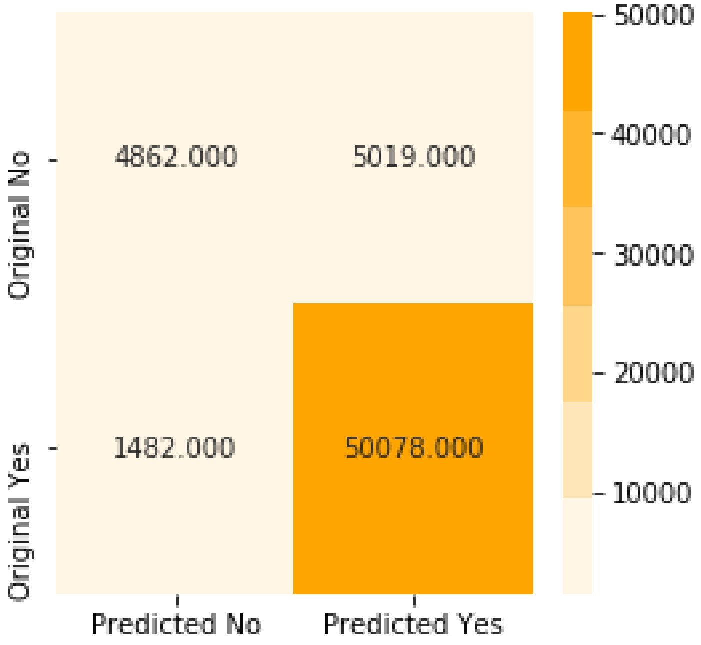
```
In [59]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

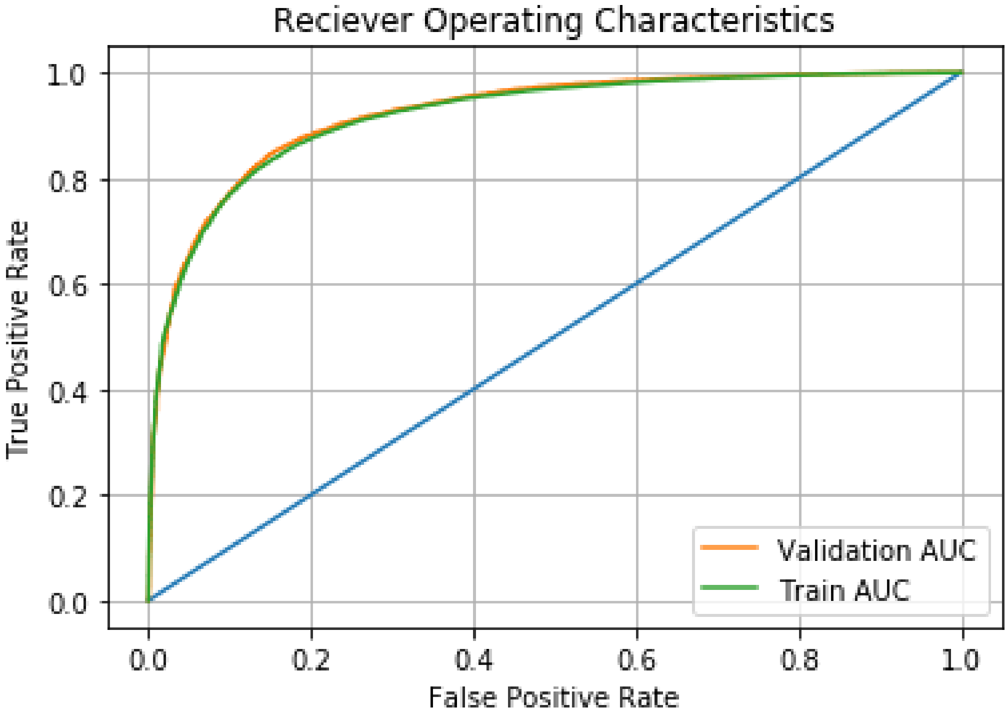


```
In [60]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [61]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using grid search cv

```
In [62]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l2',tol=0.001,max_iter=400)
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(train_avg_w2v,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(test_avg_w2v)
         predict_y_train = optimized_clf.predict(train_avg_w2v)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(test_avg_w2v,Y_test))
         print("The best alpha(1/C) is ",best_alpha)
```

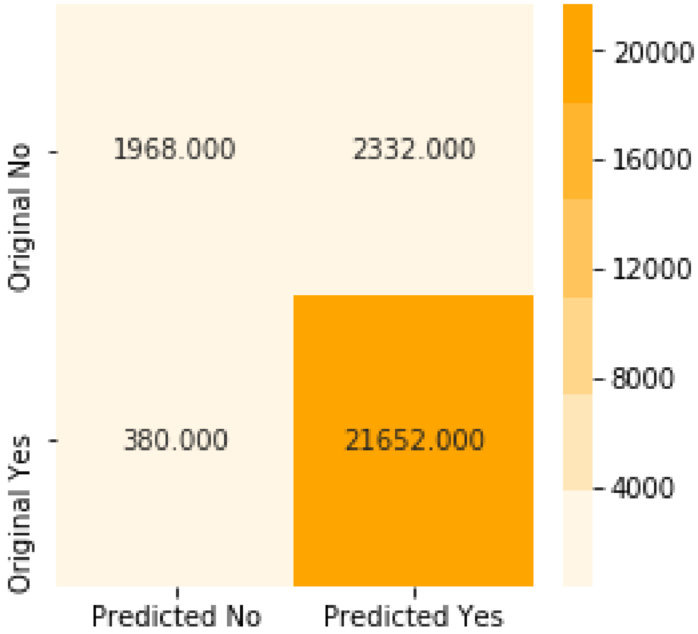
```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l2', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.9008051040559015
The best alpha(1/C) is  0.0001
```

```
In [63]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l2',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(train_avg_w2v,Y_train)
         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(train_avg_w2v,Y_train)

         predict_y_test = clf.predict(test_avg_w2v)# Getting labels predicted by SGDClassifier
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(test_avg_w2v)[:,1] # Returns probabili
         predict_y_train = clf.predict(train_avg_w2v)
         probab_y_train = calibrated_model.predict_proba(train_avg_w2v)[:,1] # Returns probabi
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for Avg W2V vectorized Linear SVM is {:.3f}".format(auc))
```

```
Final AUC for Avg W2V vectorized Linear SVM is 0.928
```

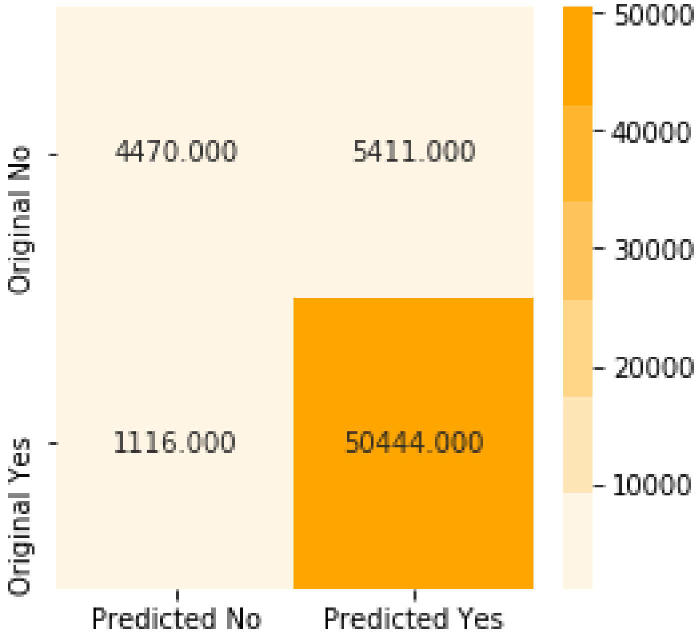
```
In [64]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

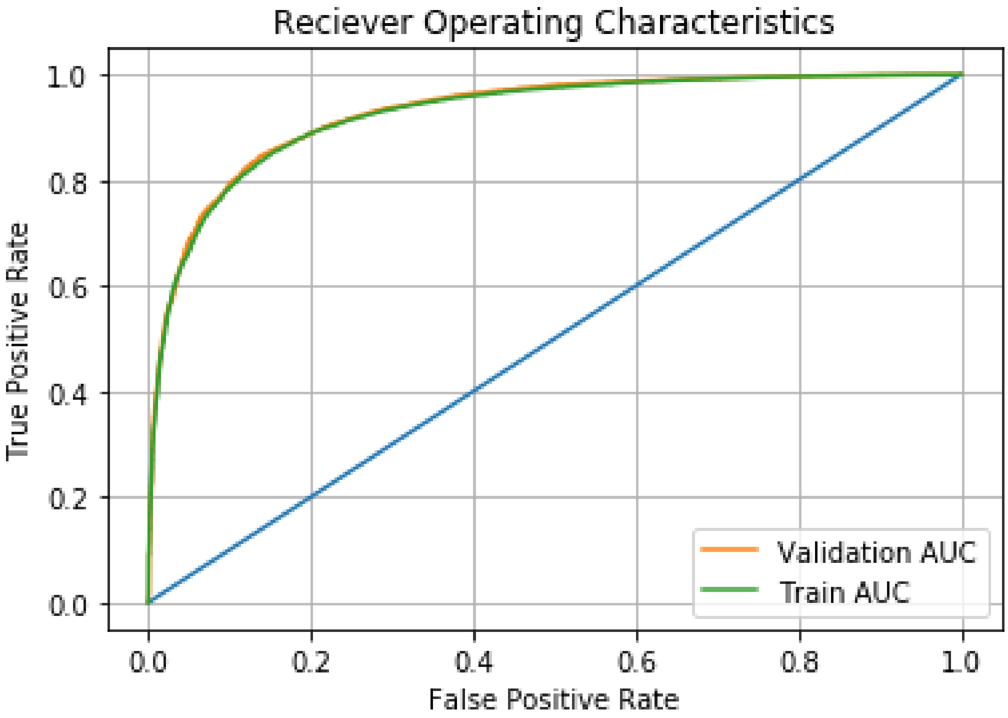


```
In [65]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [66]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



7.1.4 [5.1.4] Applying Linear SVM on TFIDF W2V, SET 4

```
In [30]: # Splitting list_of_sentance into train and test dataset
         from sklearn.cross_validation import train_test_split
         Y = final['Score'] # Labels of datapoints
         X_train,X_test,Y_train,Y_test = train_test_split(preprocessed_reviews,Y,test_size=0.3
         print(len(X_train))
```

```
61441
```

```
In [31]: # Training word2Vec model on traain dataset and will use same for test dataset
         w2v_train = []
         for sent in X_train:
             w2v_train.append(sent.split())

         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(w2v_train,min_count=5,size=100, workers=4)
             print(w2v_model.wv.most_similar('great'))
```

```
            print('='*50)
            print(w2v_model.wv.most_similar('worst'))

        elif want_to_use_google_w2v and is_your_ram_gt_16g:
            if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bi
                print(w2v_model.wv.most_similar('great'))
                print(w2v_model.wv.most_similar('worst'))
            else:
                print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, t
```

```
[('fantastic', 0.8098214268684387), ('awesome', 0.7502527236938477), ('terrific', 0.74155992269
==================================================
[('greatest', 0.7609308362007141), ('best', 0.683108389377594), ('closest', 0.649026095867157)
```

```
In [32]: w2v_words = list(w2v_model.wv.vocab)
         print("number of words that occured minimum 5 times ",len(w2v_words))
         print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  14819
sample words  ['shaped', 'spilled', 'stuffing', 'overnight', 'aspen', 'warehouse', 'tv', 'garre
```

```
In [33]: # Fitting on train and will use same for test to prevent data leakage
         model = TfidfVectorizer()
         tf_idf_matrix = model.fit_transform(X_train)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [72]: # TF-IDF weighted Word2Vec for test
         tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         tfidf_train_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in
         row=0;
         for sent in tqdm(X_train): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
         #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf valeus of word in this review
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += 1
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidf_train_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 61441/61441 [40:34<00:00, 25.23it/s]
```

```
In [73]: # TF-IDF weighted Word2Vec for test dataset
         tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         tfidf_test_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in t
         row=0;
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
         #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf valeus of word in this review
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += 1
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidf_test_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 26332/26332 [17:22<00:00, 25.26it/s]
```

L1 regularization

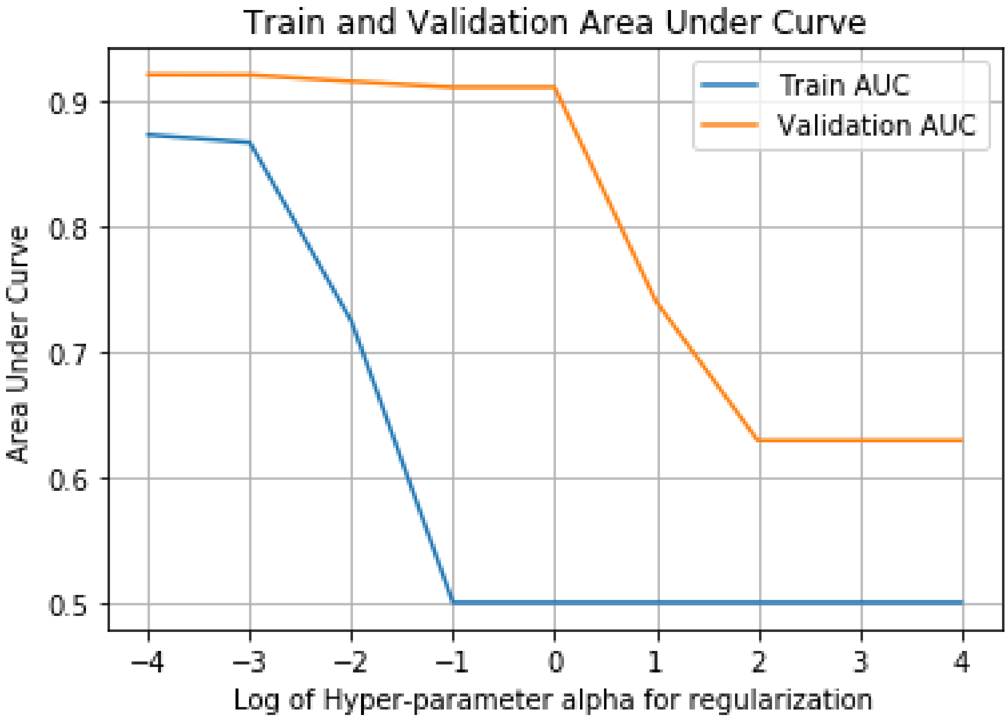
```
In [74]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
         from sklearn.calibration import CalibratedClassifierCV

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l1',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(tfidf_train_sent_vectors,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(tfidf_train_sent_vectors)[:,1] # Return
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

```
100%|| 9/9 [00:09<00:00,  1.00it/s]
```

```
In [37]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l1',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(tfidf_train_sent_vectors):
                 x_train = tfidf_train_sent_vectors[0:train_index[-1]][:] # row 0 to train_ind
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = tfidf_train_sent_vectors[train_index[-1]:test_index[-1]][:] # row fr
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [02:29<00:00, 16.18s/it]
```

```
In [75]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

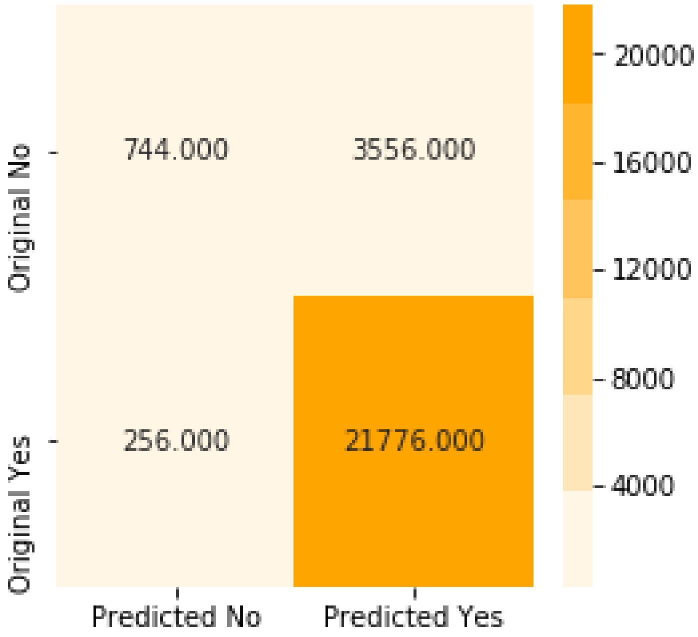


```
In [77]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(tfidf_train_sent_vectors,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(tfidf_train_sent_vectors,Y_train)

         predict_y_test = clf.predict(tfidf_test_sent_vectors)# Getting labels predicted by SG
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(tfidf_test_sent_vectors)[:,1] # Return
         predict_y_train = clf.predict(tfidf_train_sent_vectors)
         probab_y_train = calibrated_model.predict_proba(tfidf_train_sent_vectors)[:,1] # Retu
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is 0.877
```

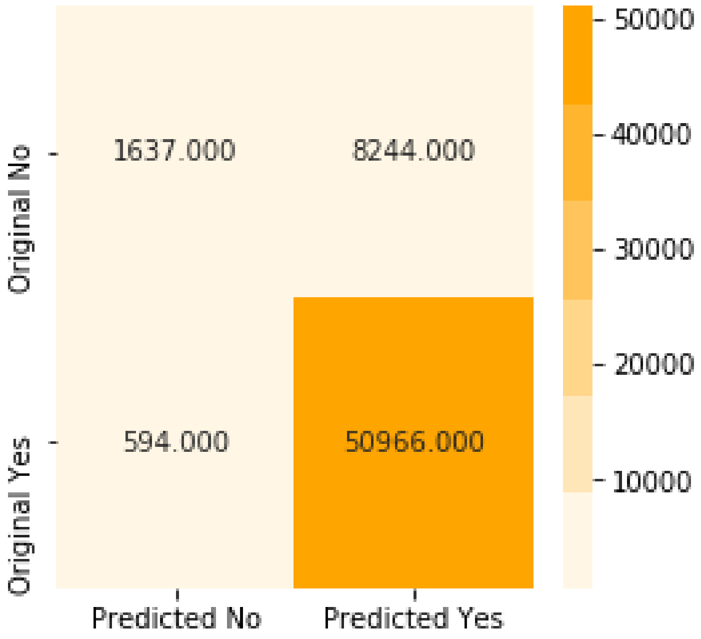
```
In [78]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for train data
Confusion matrix
```

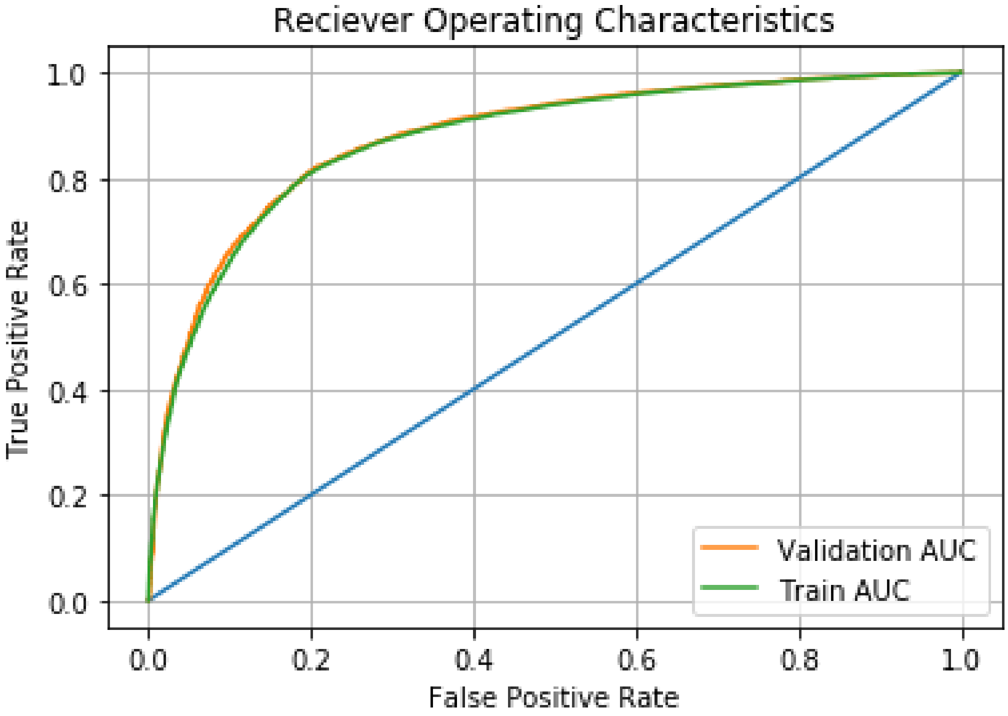


```
In [79]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [80]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using Grid Search CV

```
In [81]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l1',tol=0.001,max_iter=400)
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scori

         # Training the gridsearchcv instance
         grid_model.fit(tfidf_train_sent_vectors,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(tfidf_test_sent_vectors)
         predict_y_train = optimized_clf.predict(tfidf_train_sent_vectors)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(tfidf_test_sent_vectors,Y_test)
         print("The best alpha(1/C) is ",best_alpha)
```

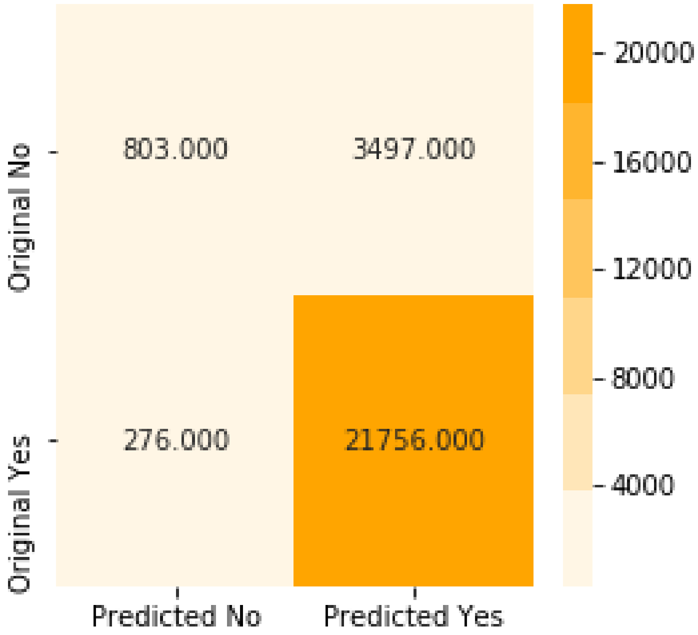
```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l1', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.8531444630107854
The best alpha(1/C) is  0.0001
```

```
In [87]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(tfidf_train_sent_vectors,Y_train)
         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(tfidf_train_sent_vectors,Y_train)

         predict_y_test = clf.predict(tfidf_test_sent_vectors)# Getting labels predicted by SG
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(tfidf_test_sent_vectors)[:,1] # Return
         predict_y_train = clf.predict(tfidf_train_sent_vectors)
         probab_y_train = calibrated_model.predict_proba(tfidf_train_sent_vectors)[:,1] # Retu
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is 0.878
```

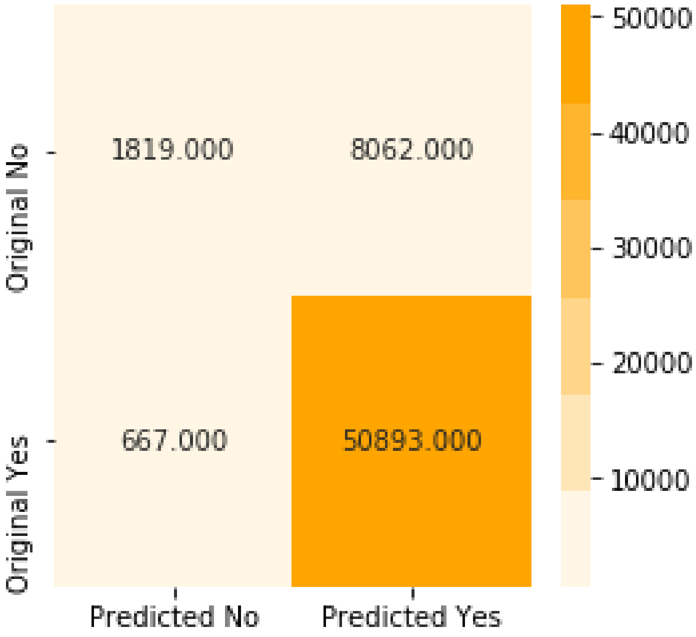
```
In [84]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for train data
Confusion matrix
```

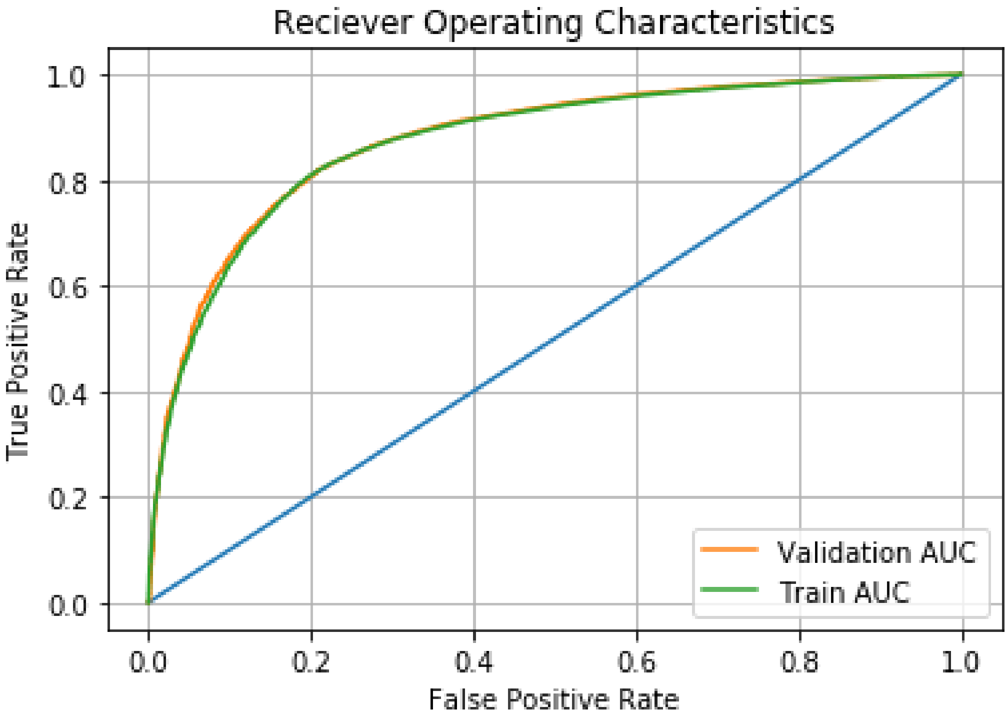


```
In [85]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [86]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



L2 Regularization

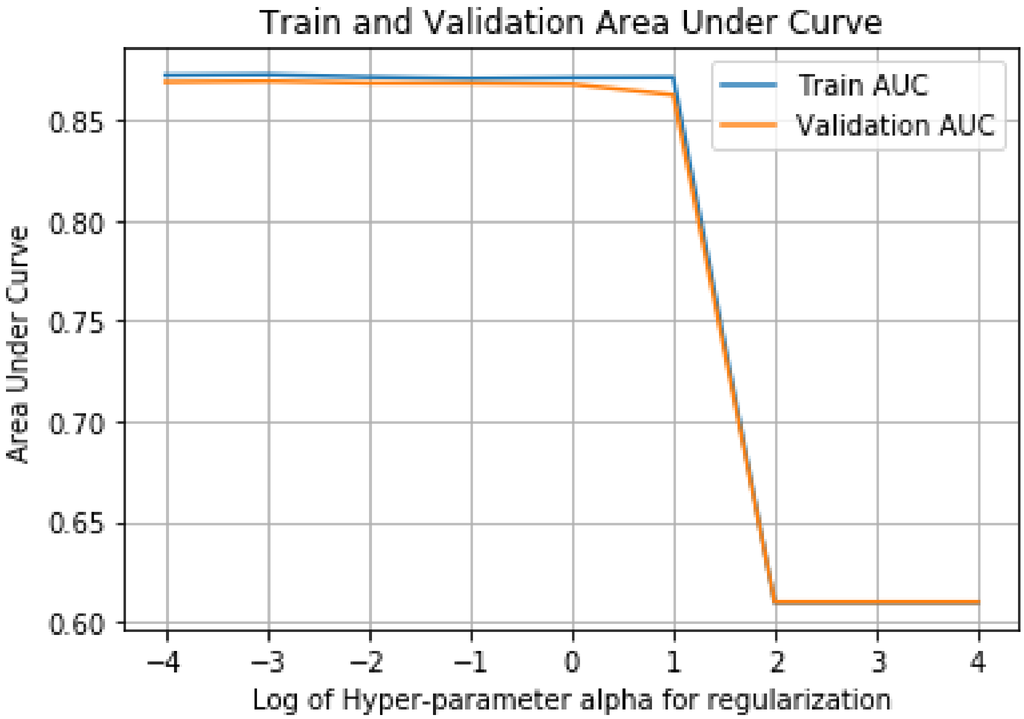
```
In [88]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
         from sklearn.calibration import CalibratedClassifierCV

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l2',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(tfidf_train_sent_vectors,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(tfidf_train_sent_vectors)[:,1] # Return
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

```
100%|| 9/9 [00:05<00:00,  1.66it/s]
```

```
In [89]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l2',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(tfidf_train_sent_vectors):
                 x_train = tfidf_train_sent_vectors[0:train_index[-1]][:] # row 0 to train_ind
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = tfidf_train_sent_vectors[train_index[-1]:test_index[-1]][:] # row fr
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [00:35<00:00,  3.53s/it]
```

```
In [90]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

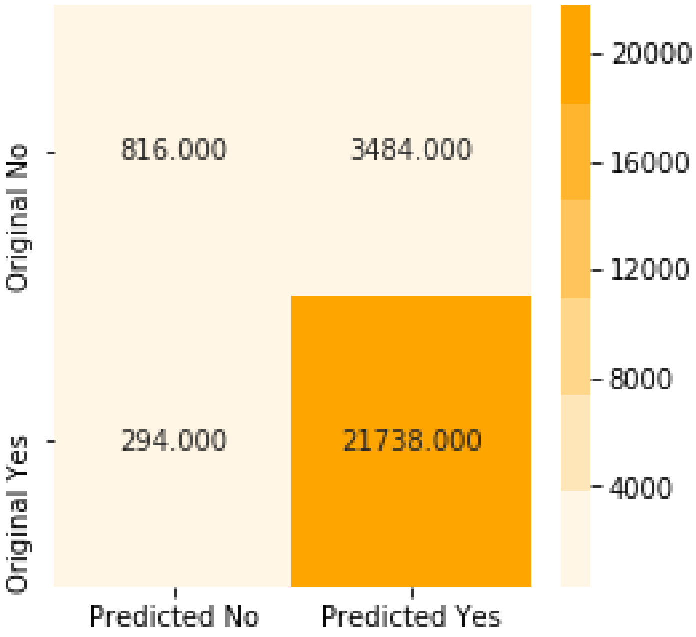


```
In [91]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l2',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(tfidf_train_sent_vectors,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(tfidf_train_sent_vectors,Y_train)

         predict_y_test = clf.predict(tfidf_test_sent_vectors)# Getting labels predicted by SG
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(tfidf_test_sent_vectors)[:,1] # Return
         predict_y_train = clf.predict(tfidf_train_sent_vectors)
         probab_y_train = calibrated_model.predict_proba(tfidf_train_sent_vectors)[:,1] # Retu
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is 0.875
```

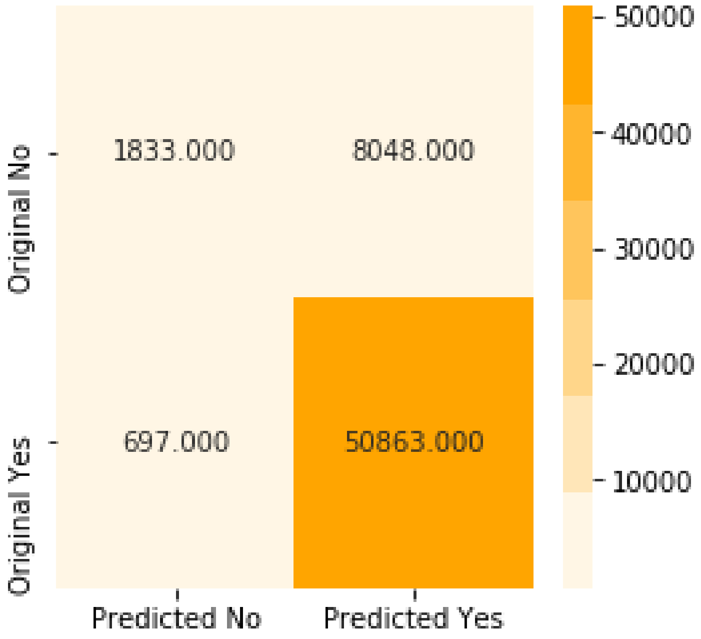
```
In [92]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

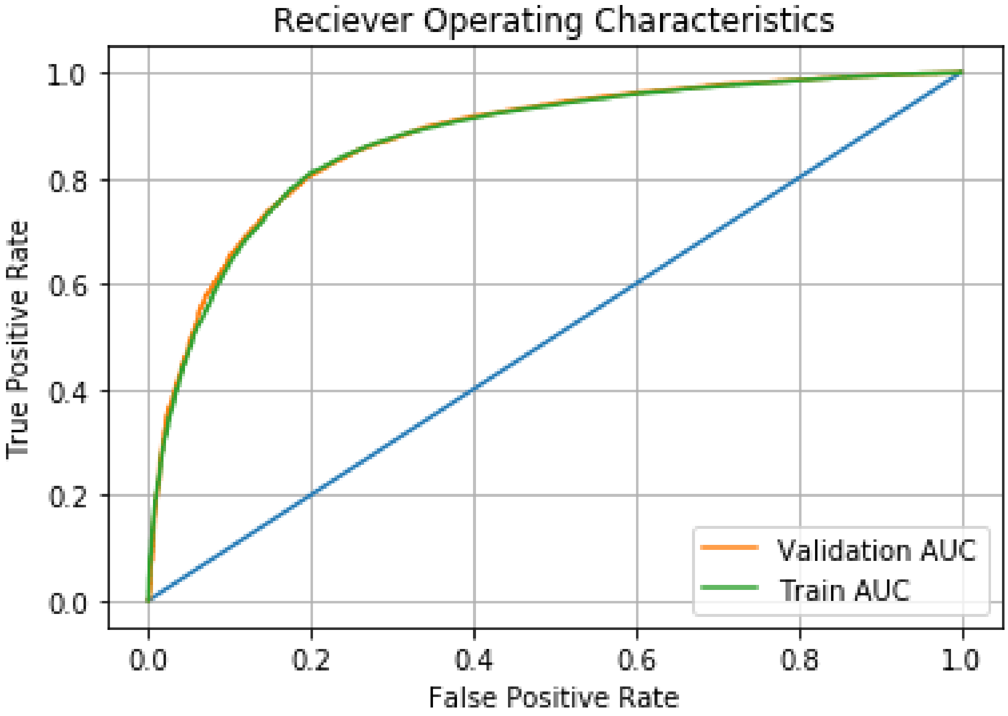


```
In [93]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [94]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using Grid Search CV

```
In [95]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l2',tol=0.001,max_iter=400)
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(tfidf_train_sent_vectors,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(tfidf_test_sent_vectors)
         predict_y_train = optimized_clf.predict(tfidf_train_sent_vectors)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(tfidf_test_sent_vectors,Y_test)
         print("The best alpha(1/C) is ",best_alpha)
```

```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l2', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.8556509190338751
The best alpha(1/C) is  0.0001
```

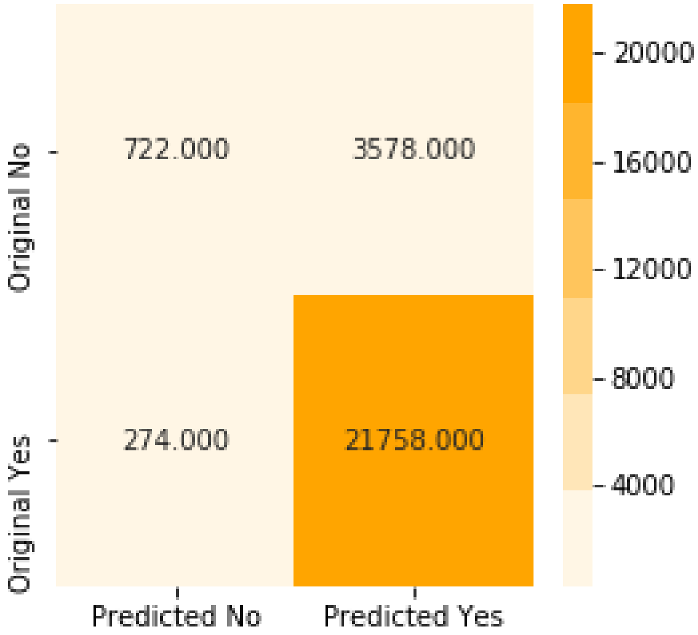
```
In [97]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l2',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(tfidf_train_sent_vectors,Y_train)
```

```
        #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
        clf.fit(tfidf_train_sent_vectors,Y_train)

        predict_y_test = clf.predict(tfidf_test_sent_vectors)# Getting labels predicted by SG
        # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
        probab_y_test = calibrated_model.predict_proba(tfidf_test_sent_vectors)[:,1] # Return
        predict_y_train = clf.predict(tfidf_train_sent_vectors)
        probab_y_train = calibrated_model.predict_proba(tfidf_train_sent_vectors)[:,1] # Retu
        auc = roc_auc_score(Y_test,probab_y_test)
        print("Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for Tfidf weighted avg w2v vectorized Linear SVM is 0.877
```

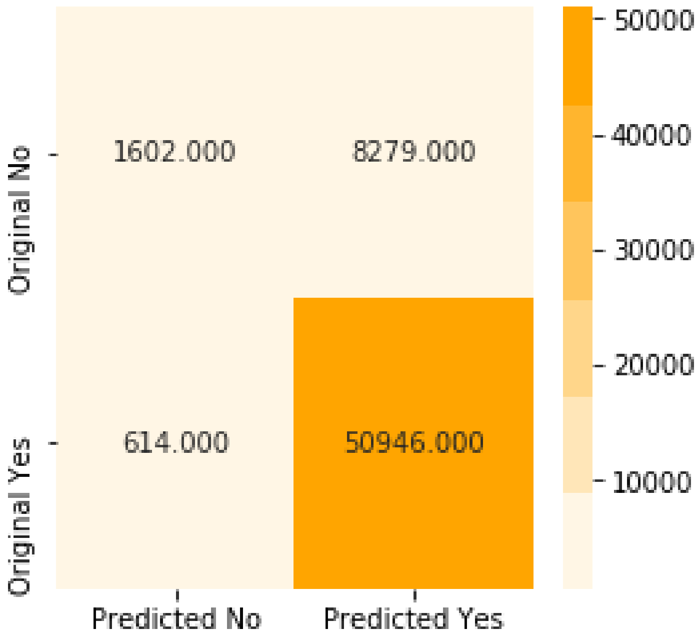
```
In [98]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

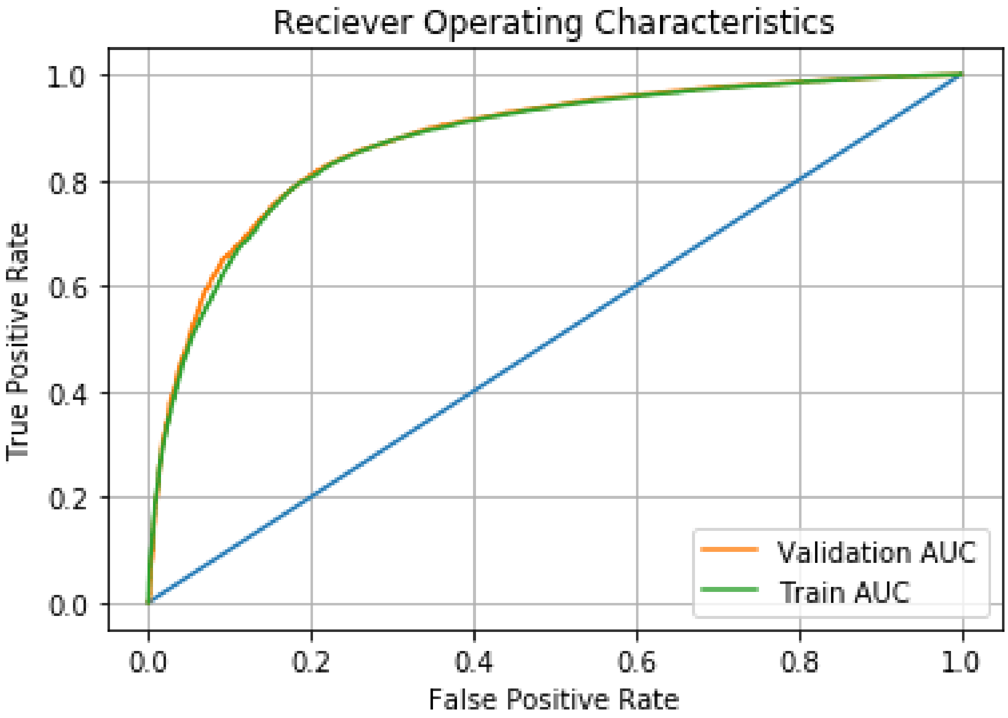


```
In [99]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [100]: # Plotting ROC AUC curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Feature Engineering for Linear SVM
BoW vectorization is used
Using review length as a feature

```
In [33]: # Calculating and storing length of each review in train data set, in an numpy array

         train_review_len = np.zeros(len(X_train))
         i=0
         for sent in X_train:
             train_review_len[i] = len(sent)
             i += 1

         print(train_review_len.shape)
```

```
(61441,)
```

```
In [34]: # Calculating and storing length of each review in train data set, in an numpy array

         test_review_len = np.zeros(len(X_test))
         i=0
         for sent in X_test:
             test_review_len[i] = len(sent)
             i += 1

         print(test_review_len.shape)
```

```
(26332,)
```

```
In [35]: # vectorizing train and test dataset using bow
         bow_train_vect = bow_vect.fit_transform(X_train)
         bow_test_vect = bow_vect.transform(X_test)
```

```
In [36]: print(bow_train_vect.shape)
```

```
(61441, 46115)
```

```
In [37]: from scipy.sparse import hstack
         from scipy.sparse import coo_matrix
         from scipy.sparse import csr_matrix

         # now we will add review length as a new feature to train  data set
         # The shape of train_review_len is 254919 and hstack takes compatible matrices only
         # Making the train_review_len to bow_train_vect
         A = coo_matrix([train_review_len]).T

         bow_train_vect = hstack([bow_train_vect,A])
         print(bow_train_vect.shape)
```

```
(61441, 46116)
```

```
In [38]: # now we will add review length as a new feature to train  data set
         # Since hstack takes compatible matrices only
         # Making the test_review_len to bow_test_vect
         B = coo_matrix([test_review_len]).T
         bow_test_vect = hstack([bow_test_vect,B])
         print(bow_test_vect.shape)
```

```
(26332, 46116)
```

```
In [39]: from scipy import sparse
         # Converting bow_train_vect from scipy.sparse.coo.coo_matrix to scipy.sparse.csr.csr_
         # scipy.sparse.coo.coo_matrix are not subscriptable

         bow_train_vect = sparse.csr_matrix(bow_train_vect)
         print(type(bow_train_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [40]: # Doing same as above for test dataset
         bow_test_vect = sparse.csr_matrix(bow_test_vect)
         print(type(bow_test_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [41]: from sklearn.preprocessing import StandardScaler
         # Initializing standard scaler
         std = StandardScaler(with_mean=False)
         bow_train_vect = std.fit_transform(bow_train_vect)
         bow_test_vect = std.transform(bow_test_vect)
```

```
In [42]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
         from sklearn.calibration import CalibratedClassifierCV

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l1',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(bow_train_vect,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probabil
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

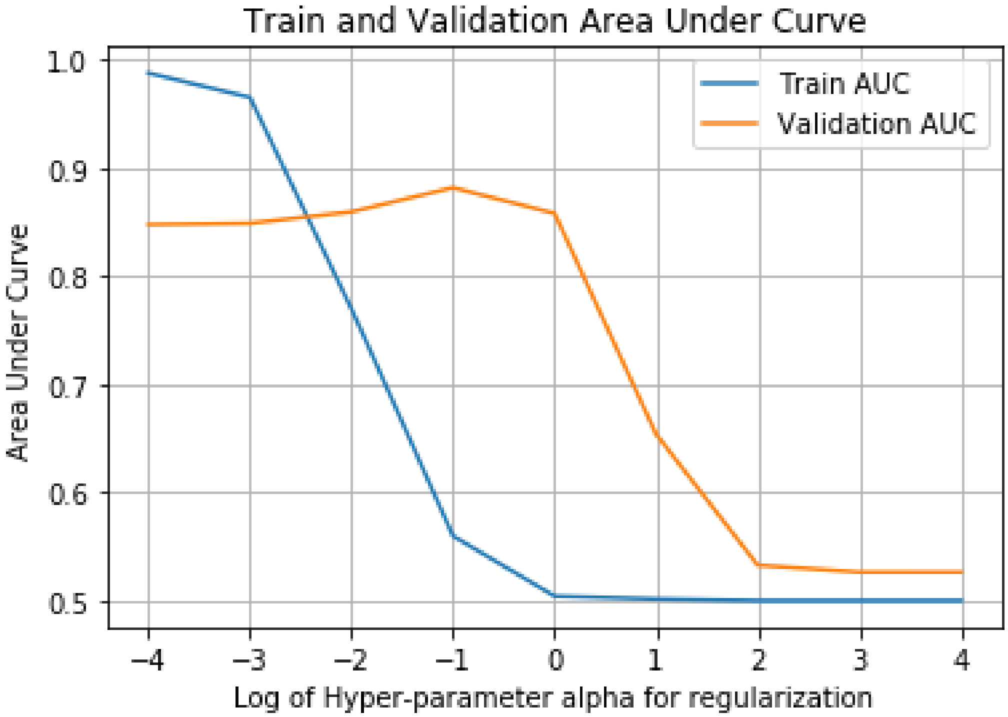
```
100%|| 9/9 [03:58<00:00, 10.45s/it]
```

```
In [43]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l2',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(bow_train_vect):
                 x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(excludi
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
```

```
        x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from train_i
        y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

        calibrated_model.fit(x_train,y_train)

        probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
        i += 1
        auc += roc_auc_score(y_test,probab_y)

    cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [00:45<00:00,  3.73s/it]
```

```
In [44]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

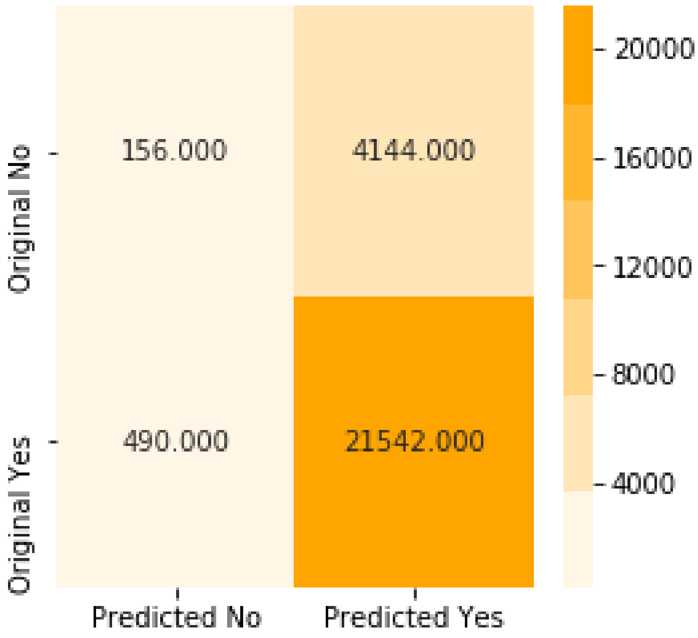


```
In [46]: # Taking best value of alpha = 0.1 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.1,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(bow_train_vect,Y_train)
         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(bow_train_vect,Y_train)

         predict_y_test = clf.predict(bow_test_vect)# Getting labels predicted by SGDClassifie
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabil
         predict_y_train = clf.predict(bow_train_vect)
         probab_y_train = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probab
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for feature engineered BoW vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for feature engineered BoW vectorized Linear SVM is 0.546
```

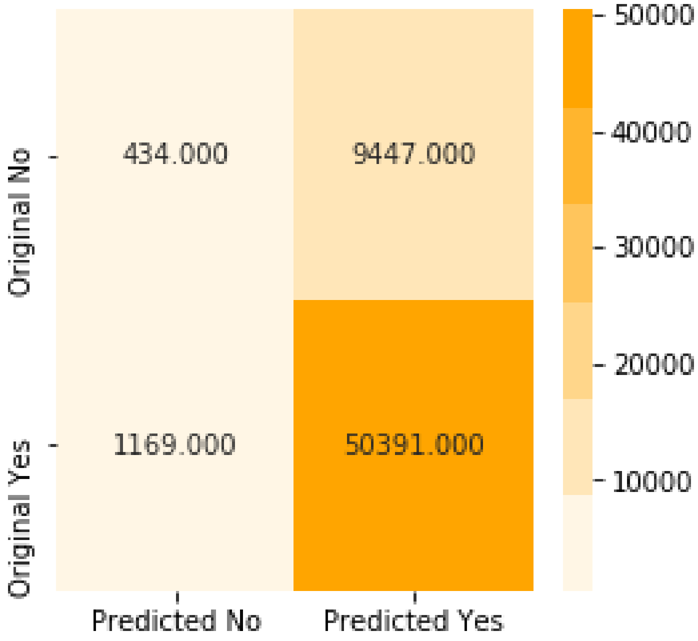
```
In [47]: # Plotting confusion matrix
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
Confusion matrix
```

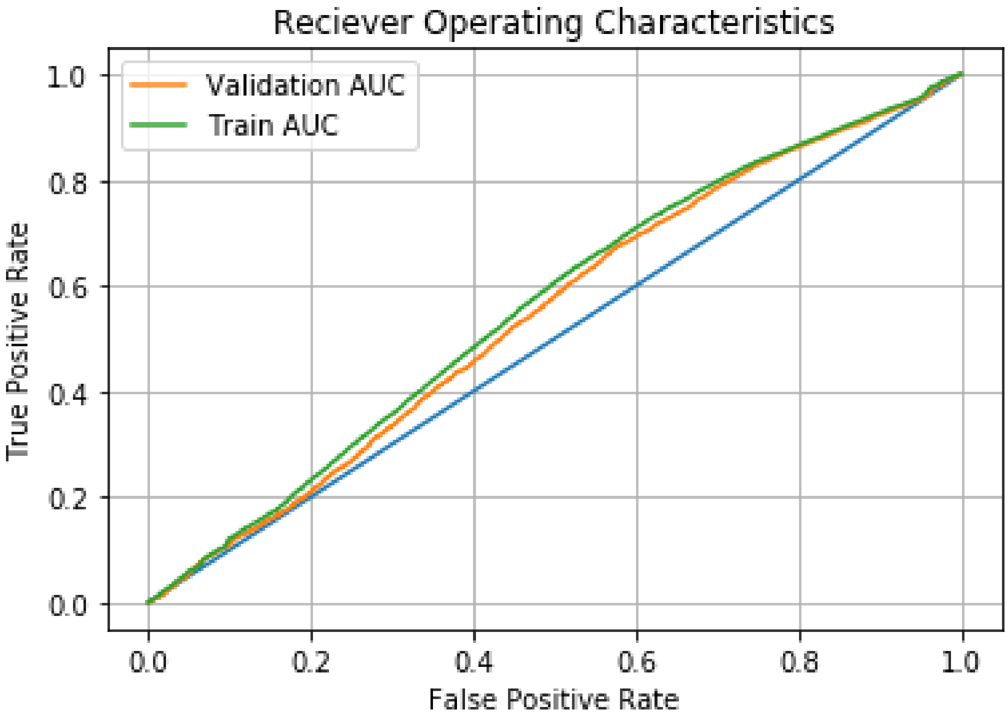


```
In [48]: # Plotting confusion matrix
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
Confusion matrix
```



```
In [49]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using grid search cv

```
In [50]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l1',tol=0.001,max_iter=400)
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(bow_train_vect,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(bow_test_vect)
         predict_y_train = optimized_clf.predict(bow_train_vect)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(bow_test_vect,Y_test))
         print("The best alpha(1/C) is ",best_alpha)
```

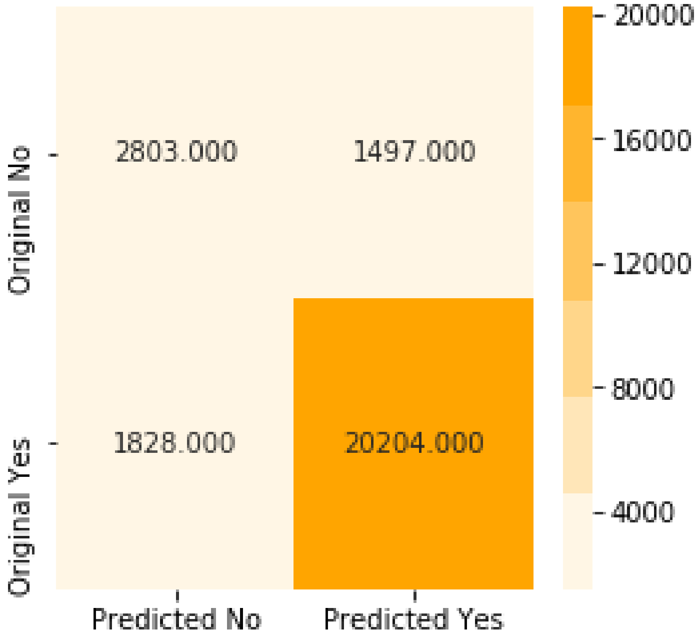
```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l1', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.8702339358954884
The best alpha(1/C) is  0.0001
```

```
In [51]: # Taking best value of alpha = 0.0001 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(bow_train_vect,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(bow_train_vect,Y_train)

         predict_y_test = clf.predict(bow_test_vect)# Getting labels predicted by SGDClassifie
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabil
         predict_y_train = clf.predict(bow_train_vect)
         probab_y_train = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probab
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for feature engineered BoW vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for feature engineered BoW vectorized Linear SVM is 0.892
```

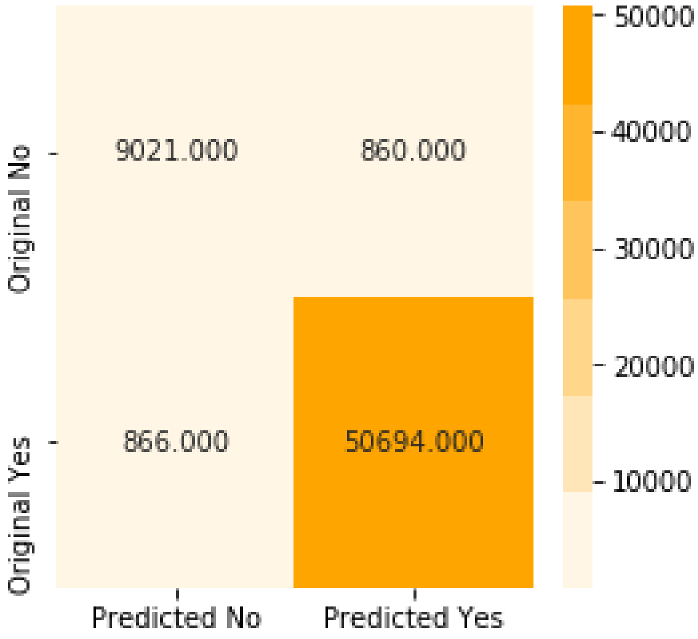
```
In [52]: # Plotting confusion matrix
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
Confusion matrix
```

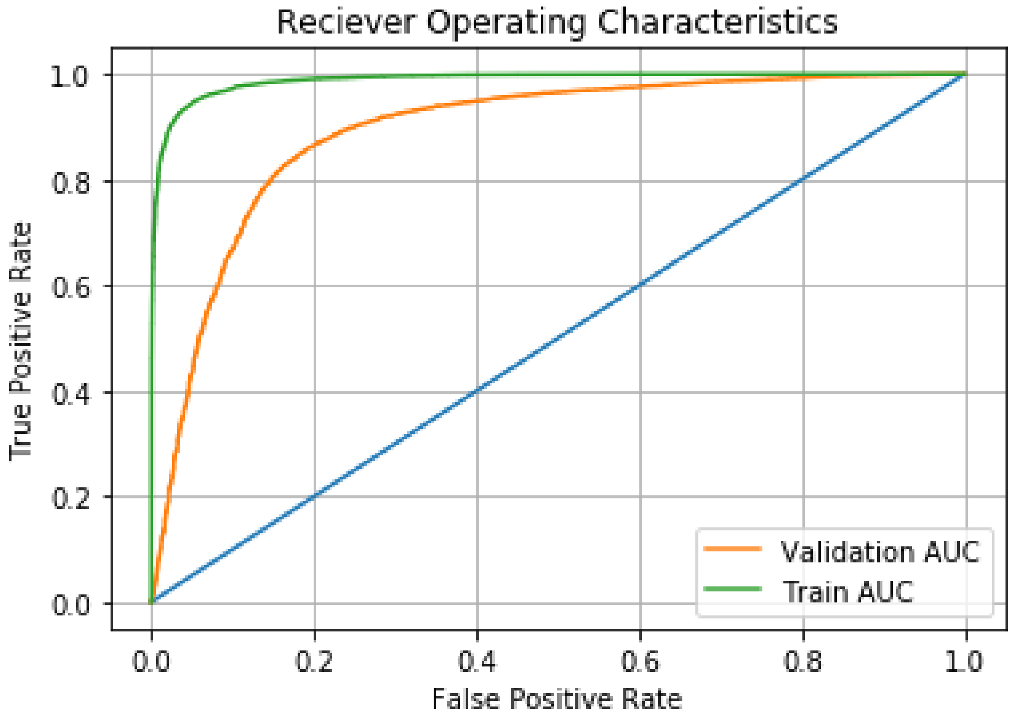


```
In [53]: # Plotting confusion matrix
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
Confusion matrix
```



```
In [54]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using summary as a feature

```
In [42]: # Splitting summary into train and test
         train_summ,test_summ,Y_train_summ,Y_test_summ = train_test_split(preprocessed_summary

In [43]: # Using bag of words to vectorize summary
         # For train dataset
         count_vect = CountVectorizer()
         train_vect = count_vect.fit_transform(train_summ)
         print(train_vect.shape)

         # for test dataset
         test_vect = count_vect.transform(test_summ)
         print(test_vect.shape)
```

```
(61441, 12239)
(26332, 12239)
```

```
In [44]: # now we will add vectorized review as a new feature to train  data set
         bow_train_vect = hstack([bow_train_vect,train_vect])
         print(bow_train_vect.shape)
```

```
(61441, 58355)
```

```
In [45]: # now we will add vectorized review as a new feature to train  data set
         bow_test_vect = hstack([bow_test_vect,test_vect])
         print(bow_test_vect.shape)
```

```
(26332, 58355)
```

```
In [46]: # Converting tfidf_train_vect and tfidf_test_vect from scipy.sparse.coo.coo_matrix to
         # scipy.sparse.coo.coo_matrix are not subscriptable

         bow_train_vect = sparse.csr_matrix(bow_train_vect)
         bow_test_vect = sparse.csr_matrix(bow_test_vect)
         print(type(bow_train_vect))
         print(type(bow_test_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [47]: from sklearn.preprocessing import StandardScaler
         # Initializing standard scaler
         std = StandardScaler(with_mean=False)
         bow_train_vect = std.fit_transform(bow_train_vect)
         bow_test_vect = std.transform(bow_test_vect)
```

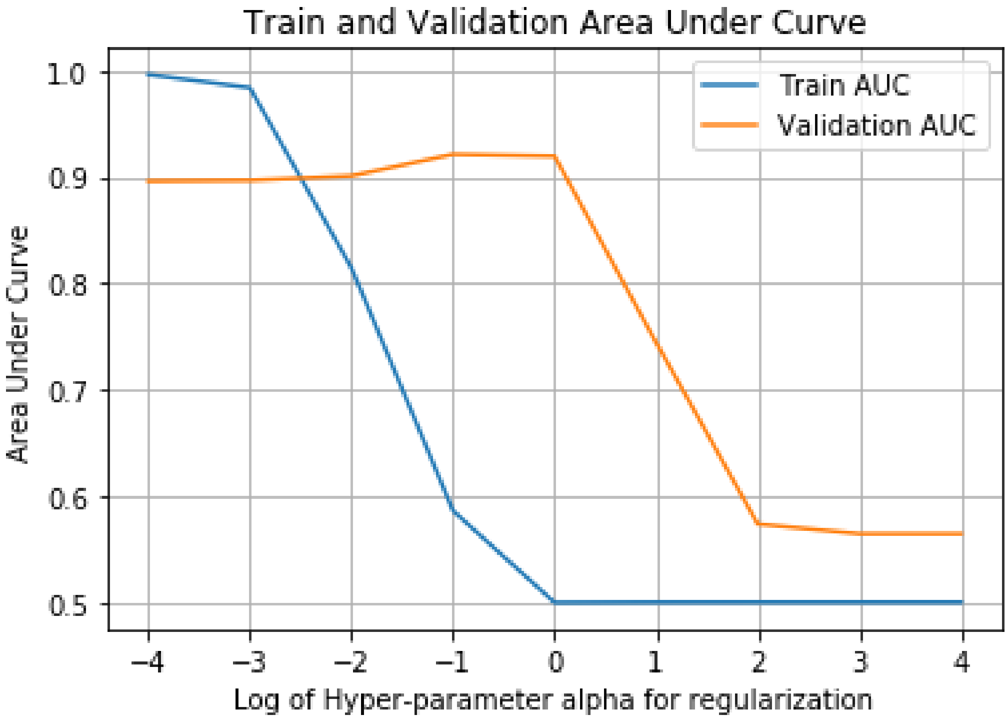
```
In [61]: # Initializing the linear SVM classifier
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
         from sklearn.calibration import CalibratedClassifierCV

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SGDClassifier(penalty='l1',alpha=i,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             calibrated_model.fit(bow_train_vect,Y_train)
             # evaluate the model
             probab_y = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probabil
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

```
100%|| 9/9 [04:58<00:00, 13.39s/it]
```

```
In [62]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SGDClassifier(penalty='l2',alpha=k,tol=0.001,max_iter=400)
             calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(bow_train_vect):
                 x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(excludi
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from train_i
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 calibrated_model.fit(x_train,y_train)

                 probab_y = calibrated_model.predict_proba(x_test)[:,1] # returns probability
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [00:52<00:00,  4.63s/it]
```

```
In [63]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```

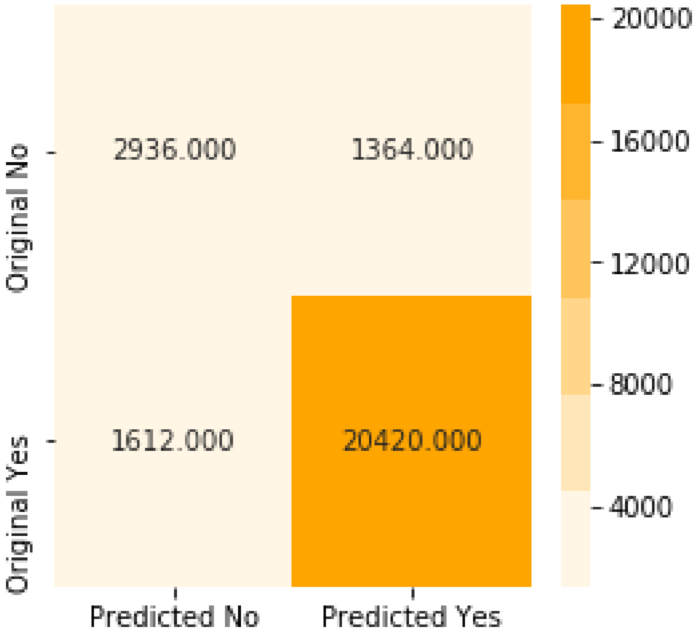


```
In [69]: # Taking best value of alpha = 0.01 an trainig final model
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(bow_train_vect,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(bow_train_vect,Y_train)

         predict_y_test = clf.predict(bow_test_vect)# Getting labels predicted by SGDClassifie
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabil
         predict_y_train = clf.predict(bow_train_vect)
         probab_y_train = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probab
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for feature engineered BoW vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for feature engineered BoW vectorized Linear SVM is 0.933
```

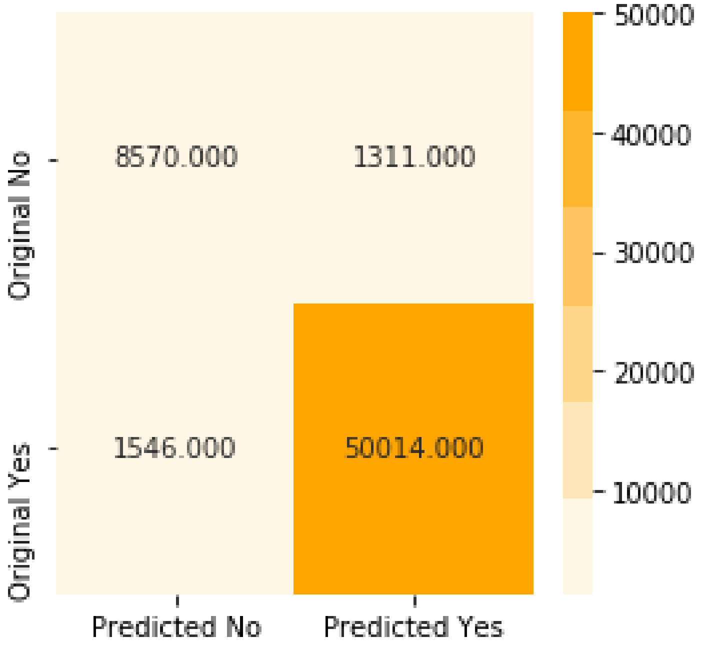
```
In [70]: # Plotting confusion matrix
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
Confusion matrix
```

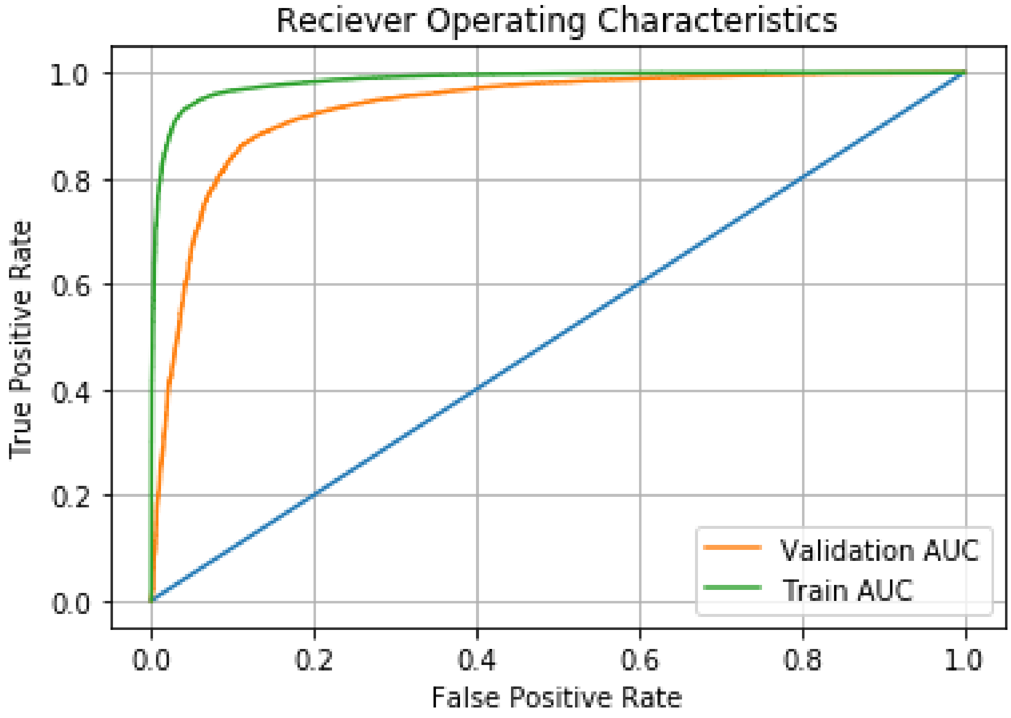


```
In [71]: # Plotting confusion matrix
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
Confusion matrix
```



```
In [72]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Using Grid Search CV

```
In [52]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer
         from sklearn.linear_model import SGDClassifier
         from sklearn.metrics import roc_auc_score
         from sklearn.calibration import CalibratedClassifierCV


         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SGDClassifier(penalty='l1',tol=0.001,max_iter=400)

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         # Dictionary of parameters to be searched on
         parameters = {'alpha':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(bow_train_vect,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_alpha = grid_model.best_estimator_.alpha

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(bow_test_vect)
         predict_y_train = optimized_clf.predict(bow_train_vect)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(bow_test_vect,Y_test))
         print("The best alpha(1/C) is ",best_alpha)
```

```
The optimized model is SGDClassifier(alpha=0.0001, average=False, class_weight=None, epsilon=0
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=400, n_iter=None,
       n_jobs=1, penalty='l1', power_t=0.5, random_state=None,
       shuffle=True, tol=0.001, verbose=0, warm_start=False)
Accuracy of best model is 0.8935135956250949
The best alpha(1/C) is  0.0001
```

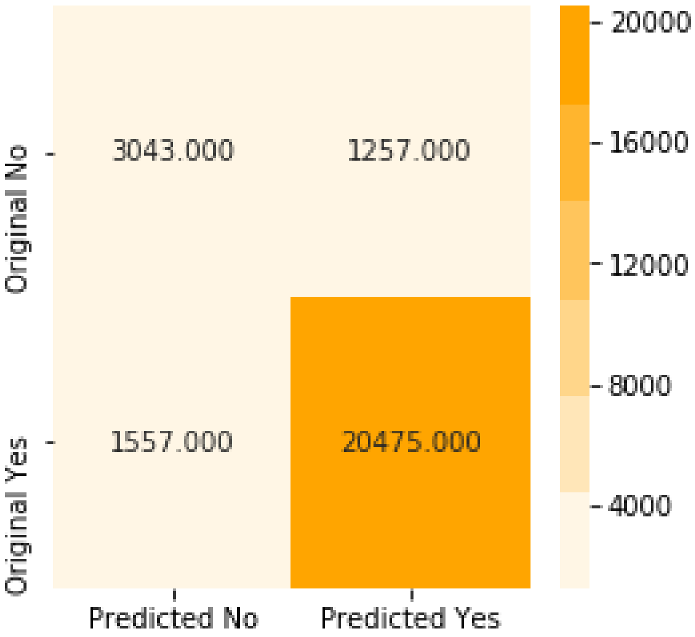
```
In [53]: # Taking best value of alpha = 0.01 an trainig final model
```

```
         # Initializing model
         clf = SGDClassifier(penalty='l1',alpha=0.0001,tol=0.001,max_iter=400)
         calibrated_model = CalibratedClassifierCV(clf,method='sigmoid',cv=5)
         # Training model on best value
         calibrated_model.fit(bow_train_vect,Y_train)

         #Training SGDClassifier to get weight vectors as CalibratedClassifier dont have the a
         clf.fit(bow_train_vect,Y_train)

         predict_y_test = clf.predict(bow_test_vect)# Getting labels predicted by SGDClassifie
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = calibrated_model.predict_proba(bow_test_vect)[:,1] # Returns probabil
         predict_y_train = clf.predict(bow_train_vect)
         probab_y_train = calibrated_model.predict_proba(bow_train_vect)[:,1] # Returns probab
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for feature engineered BoW vectorized Linear SVM is {:.3f}".format(au
```

```
Final AUC for feature engineered BoW vectorized Linear SVM is 0.930
```

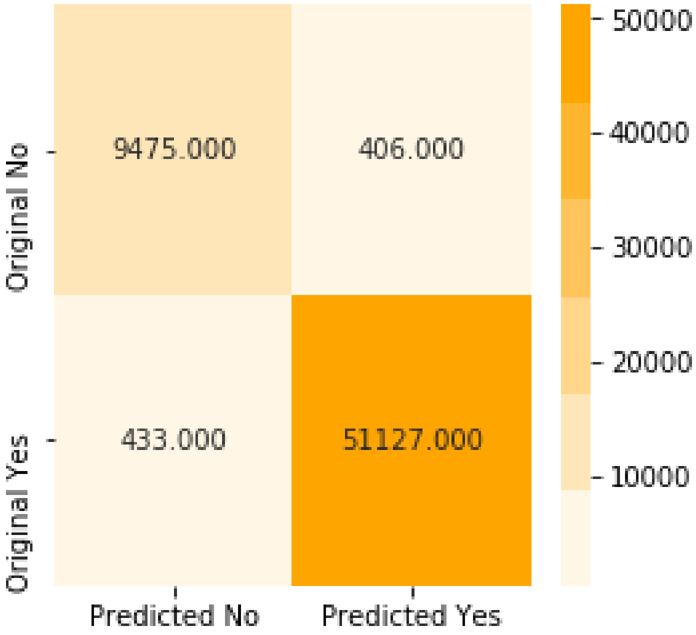
```
In [54]: # Plotting confusion matrix
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
Confusion matrix
```

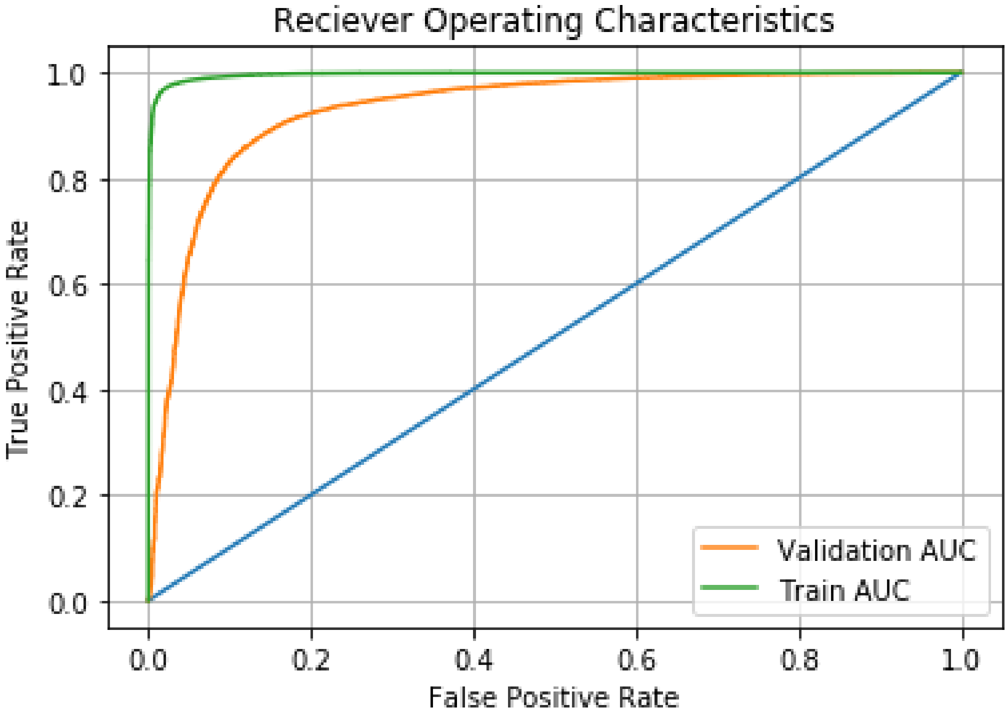


```
In [55]: # Plotting confusion matrix
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
Confusion matrix
```



```
In [56]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



7.2 [5.2] RBF SVM

7.2.1 [5.2.1] Applying RBF SVM on BOW, SET 1

```
In [48]: # Taking only 40k points for this section
         rbf_final = final.sample(40000)

         # Preprocessing reviews
         preprocessed_reviews = []
         # tqdm is for printing the status bar
         for sentance in tqdm(rbf_final['Text'].values):
             sentance = re.sub(r"http\S+", "", sentance)
             sentance = BeautifulSoup(sentance, 'lxml').get_text()
             sentance = decontracted(sentance)
             sentance = re.sub("\S*\d\S*", "", sentance).strip()
             sentance = re.sub('[^A-Za-z]+', ' ', sentance)
             # https://gist.github.com/sebleier/554280
             sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopwo
             preprocessed_reviews.append(sentance.strip())
```

```
100%|| 40000/40000 [00:21<00:00, 1818.49it/s]
```

```
In [49]: # Processing summary
         preprocessed_summary = []
```

```
        # tqdm is for printing the status bar
        for sentance in tqdm(rbf_final['Summary'].values):
            sentance = re.sub(r"http\S+", "", sentance)
            sentance = BeautifulSoup(sentance, 'lxml').get_text()
            sentance = decontracted(sentance)
            sentance = re.sub("\S*\d\S*", "", sentance).strip()
            sentance = re.sub('[^A-Za-z]+', ' ', sentance)
            # https://gist.github.com/sebleier/554280
            sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopwo
            preprocessed_summary.append(sentance.strip())
```

```
100%|| 40000/40000 [00:15<00:00, 2655.49it/s]
```

```
In [50]: from sklearn.cross_validation import train_test_split
         from sklearn.model_selection import TimeSeriesSplit

         # Splitting data into train and test dataset
         bow_vect = CountVectorizer(min_df=5,max_features=500)

         X = preprocessed_reviews
         Y = rbf_final['Score']

         X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)
         print(len(X_train))
         print(len(X_test))
```

```
28000
12000
```

```
In [36]: # Vectorizing train and test dataset seperately to prevent data lekage
         bow_train_vect = bow_vect.fit_transform(X_train)
         bow_test_vect = bow_vect.transform(X_test)
         bow_train_vect.shape
```

```
Out[36]: (28000, 500)
```

```
In [37]: # Standarizing data
         from sklearn.preprocessing import StandardScaler
         std = StandardScaler(with_mean=False)
         bow_train_vect = std.fit_transform(bow_train_vect)
         bow_test_vect = std.transform(bow_test_vect)
```

```
In [38]: # Initializing the linear SVM classifier
         from sklearn.svm import SVC
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np
```

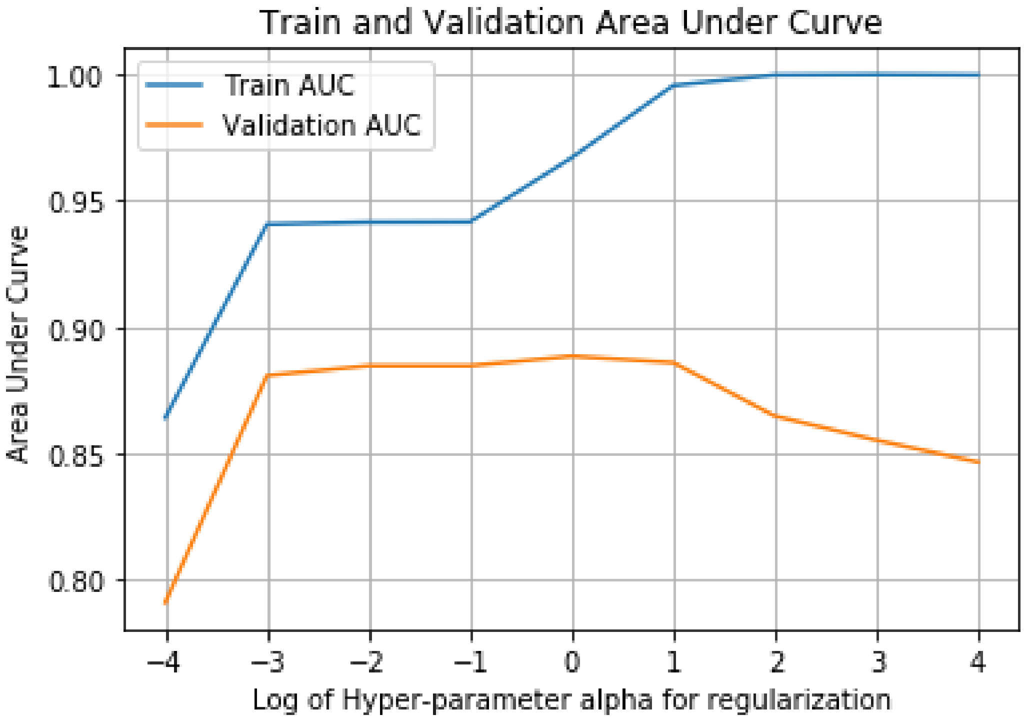
```
        param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
        train_auc_list = [] # Will contain train auc score for various lambda

        # Calculating AUC on train dataset .
        for i in tqdm(param_alpha):
            clf = SVC(C=i,tol=0.001,max_iter=-1,probability=True)
            clf.fit(bow_train_vect,Y_train)
            # evaluate the model
            probab_y = clf.predict_proba(bow_train_vect)[:,1] # Returns probability for posit
            auc = roc_auc_score(Y_train,probab_y)
            train_auc_list.append(auc)
```

```
100%|| 9/9 [3:50:02<00:00, 2074.69s/it]
```

```
In [39]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=3)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SVC(C=k,tol=0.001,max_iter=-1,probability=True)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(bow_train_vect):
                 x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(excludi
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from train_i
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 clf.fit(x_train,y_train)

                 probab_y = clf.predict_proba(x_test)[:,1] # returns probability for positive p
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [2:41:12<00:00, 1340.79s/it]
```

```
In [40]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```



Using Grid Search CV

```
In [41]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SVC(tol=0.001,max_iter=-1,probability=True)
         # Dictionary of parameters to be searched on
         parameters = {'C':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(bow_train_vect,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_c = grid_model.best_estimator_.C

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
```

```
        predict_y_test = optimized_clf.predict(bow_test_vect)
        predict_y_train = optimized_clf.predict(bow_train_vect)


        print("The optimized model is",optimized_clf)
        print("Accuracy of best model is",optimized_clf.score(bow_test_vect,Y_test))
        print("The best alpha(1/C) is ",best_c)
```

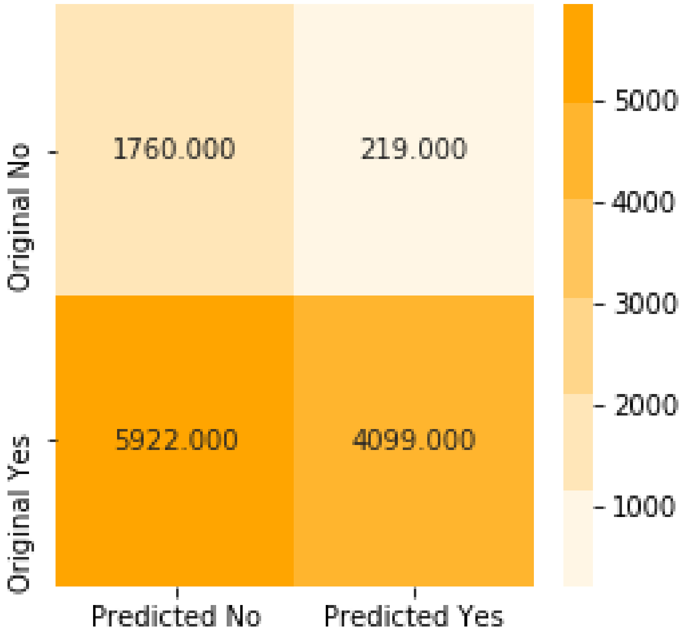
```
The optimized model is SVC(C=10, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
  max_iter=-1, probability=True, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
Accuracy of best model is 0.882
The best alpha(1/C) is  10
```

```
In [42]: # Taking best value of alpha = 10 an trainig final model
         # Initializing model
         clf = SVC(C=10,tol=0.001,max_iter=-1,probability=True)
         # Training model on best value
         clf.fit(bow_train_vect,Y_train)


         predict_y_test = clf.predict(bow_test_vect)
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # Returns probability for posit
         predict_y_train = clf.predict(bow_train_vect)
         probab_y_train = clf.predict_proba(bow_train_vect)[:,1]
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for  BoW vectorized RBF SVM is {:.3f}".format(auc))
```

```
Final AUC for  BoW vectorized RBF SVM is 0.895
```

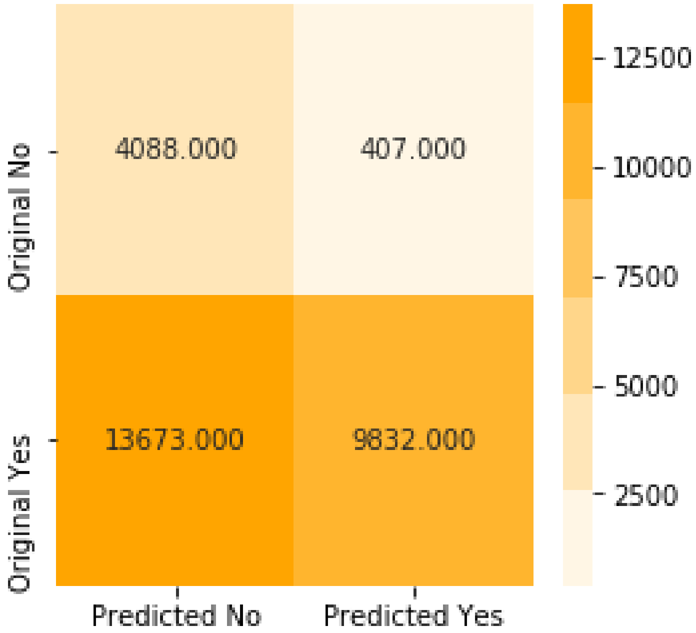
```
In [132]: # Plotting confusion matrix
          print("Confusion Matrix for test data")
          confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

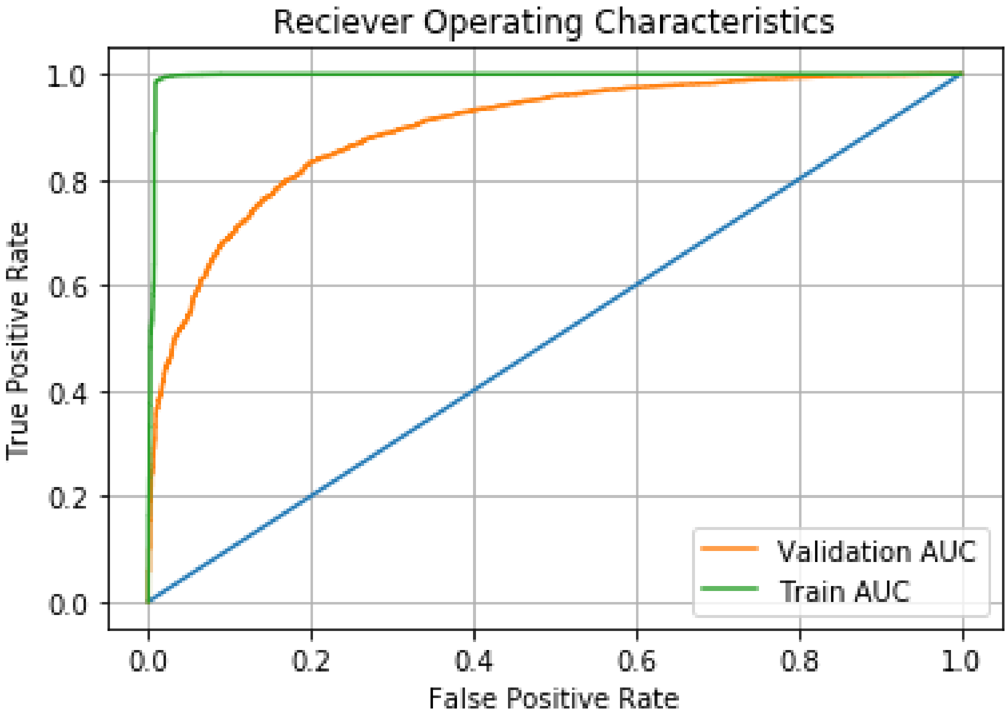


```
In [133]: # Plotting confusion matrix
          print("Confusion Matrix for train data")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [43]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



7.2.2 [5.2.2] Applying RBF SVM on TFIDF, SET 2

```
In [37]: # Initializing tfidf vect
         tfidf_vect = TfidfVectorizer(max_features=500)

         # Vectorizing train and test dataset seperately to prevent data lekage
         tfidf_train_vect = tfidf_vect.fit_transform(X_train)
         tfidf_test_vect = tfidf_vect.transform(X_test)
         tfidf_train_vect.shape

Out[37]: (28000, 500)
```

```
In [38]: from sklearn.preprocessing import StandardScaler
         std = StandardScaler(with_mean=False)
         tfidf_train_vect = std.fit_transform(tfidf_train_vect)
         tfidf_test_vect = std.transform(tfidf_test_vect)
```

```
In [39]: # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
         model = TfidfVectorizer(max_features=500)
```

```
        tf_idf_matrix = model.fit_transform(preprocessed_reviews)
        # we are converting a dictionary with word as a key, and the idf as a value
        dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [40]: # Initializing the linear SVM classifier
         from sklearn.svm import SVC
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SVC(C=i,tol=0.001,max_iter=-1,probability=True)
             clf.fit(tfidf_train_vect,Y_train)
             # evaluate the model
             probab_y = clf.predict_proba(tfidf_train_vect)[:,1] # Returns probability for pos
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

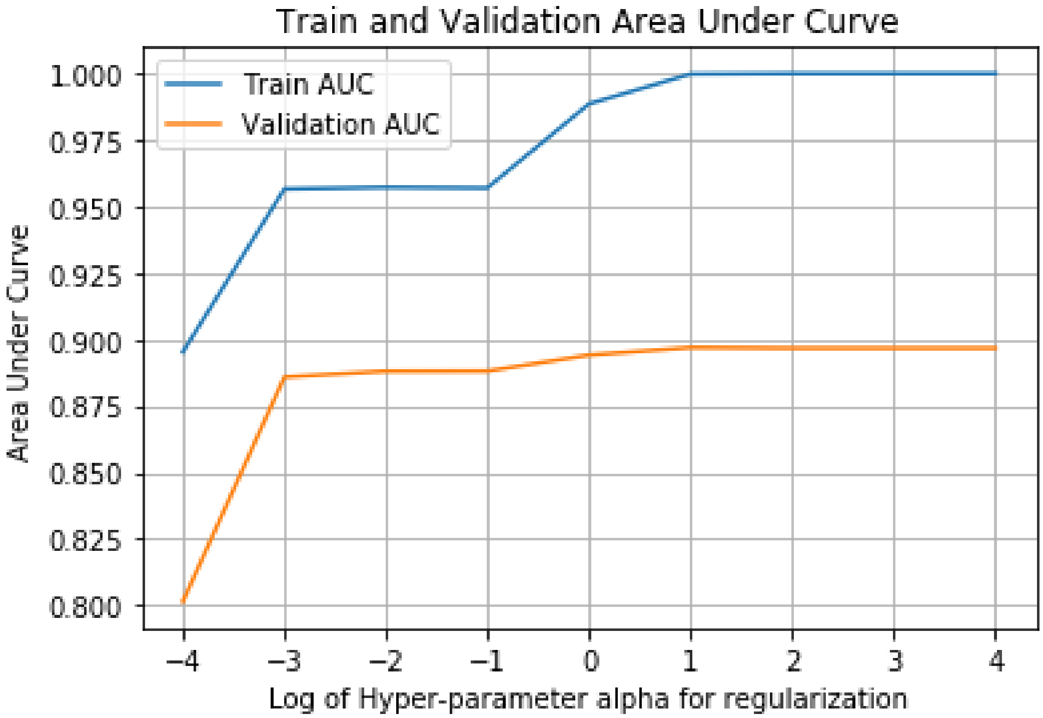
```
100%|| 9/9 [3:19:51<00:00, 1854.18s/it]
```

```
In [41]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=3)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SVC(C=k,tol=0.001,max_iter=-1,probability=True)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(tfidf_train_vect):
                 x_train = tfidf_train_vect[0:train_index[-1]][:] # row 0 to train_index(exclu
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = tfidf_train_vect[train_index[-1]:test_index[-1]][:] # row from train_
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 clf.fit(x_train,y_train)

                 probab_y = clf.predict_proba(x_test)[:,1] # returns probability for positive
                 i += 1
```

```
                    auc += roc_auc_score(y_test,probab_y)

                cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [2:21:49<00:00, 1297.17s/it]
```

```
In [42]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```



Using grid search cv

```
In [43]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SVC(tol=0.001,max_iter=-1,probability=True)
         # Dictionary of parameters to be searched on
         parameters = {'C':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(tfidf_train_vect,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_c = grid_model.best_estimator_.C

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(tfidf_test_vect)
         predict_y_train = optimized_clf.predict(tfidf_train_vect)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(tfidf_test_vect,Y_test))
         print("The best alpha(1/C) is ",best_c)
```

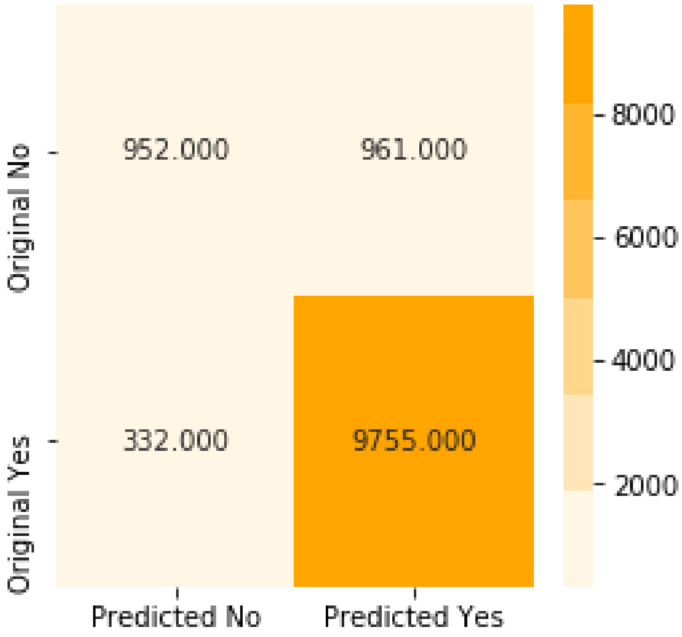
```
The optimized model is SVC(C=10, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
  max_iter=-1, probability=True, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
Accuracy of best model is 0.89225
The best alpha(1/C) is  10
```

```
In [44]: # Taking best value of alpha = 1 an trainig final model
         # Initializing model
         clf = SVC(C=10,tol=0.001,max_iter=-1,probability=True)
         # Training model on best value
         clf.fit(tfidf_train_vect,Y_train)


         predict_y_test = clf.predict(tfidf_test_vect)
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have meth
         probab_y_test = clf.predict_proba(tfidf_test_vect)[:,1] # Returns probability for pos
         predict_y_train = clf.predict(tfidf_train_vect)
         probab_y_train = clf.predict_proba(tfidf_train_vect)[:,1] # Returns probability for p
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for  Tfidf vectorized RBF SVM is {:.3f}".format(auc))
```

```
Final AUC for  Tfidf vectorized RBF SVM is 0.909
```

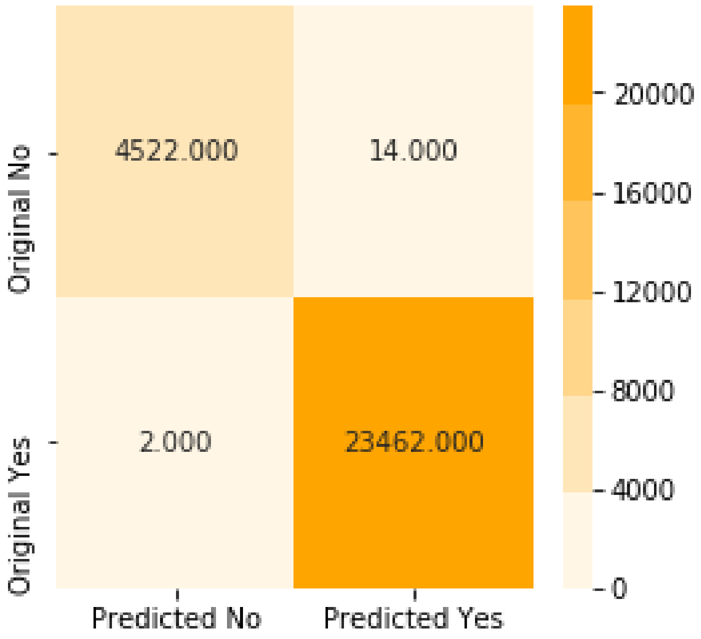
```
In [46]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

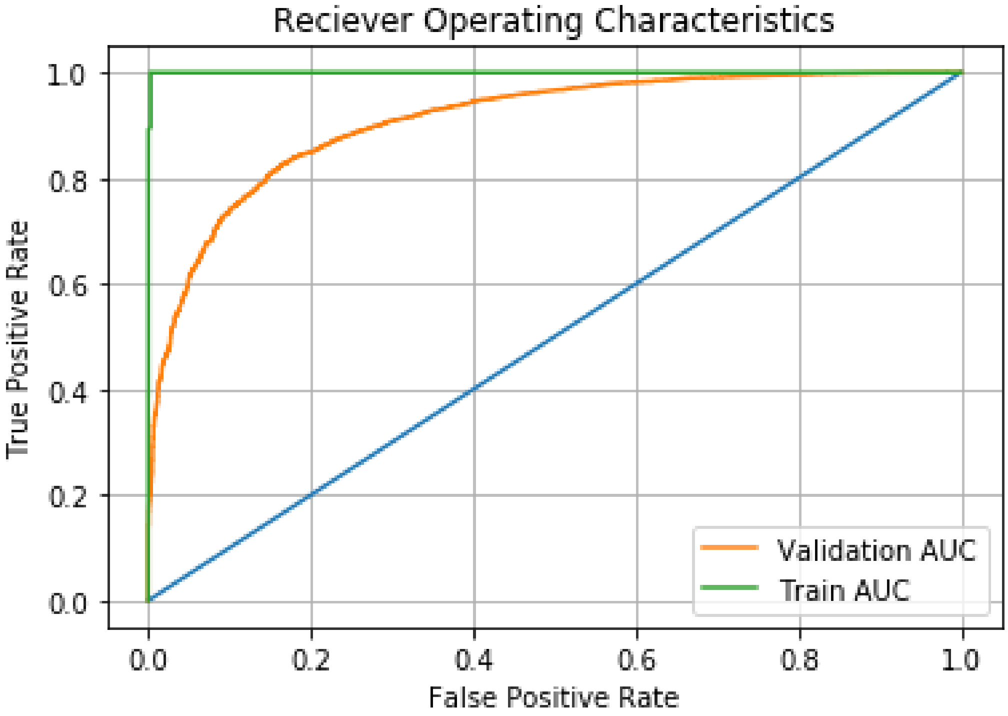


```
In [47]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [48]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



7.2.3 [5.2.3] Applying RBF SVM on AVG W2V, SET 3

```
In [31]: X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)
```

```
In [32]: # Train your own Word2Vec model using your own text corpus
         list_train=[]
         for sentance in tqdm(X_train):
             list_train.append(sentance.split())

         # Using Google News Word2Vectors

         # in this project we are using a pretrained model by google
         # its 3.3G file, once you load this into your memory
         # it occupies ~9Gb, so please do this step only if you have >12G of ram
         # we will provide a pickle file wich contains a dict ,
         # and it contains all our courpus words as keys and  model[word] as values
         # To use this code-snippet, download "GoogleNews-vectors-negative300.bin"
         # from https://drive.google.com/file/d/0B7XkCwpI5KDYNlNUTTlSS21pQmM/edit
         # it's 1.9GB in size.


         # http://kavita-ganesan.com/gensim-word2vec-tutorial-starter-code/#.W17SRFAzZPY
         # you can comment this whole cell
         # or change these varible according to your need

         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(list_train,min_count=5,size=50, workers=4)
             print(w2v_model.wv.most_similar('great'))
             print('='*50)
             print(w2v_model.wv.most_similar('worst'))

         elif want_to_use_google_w2v and is_your_ram_gt_16g:
             if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                 w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bi
                 print(w2v_model.wv.most_similar('great'))
                 print(w2v_model.wv.most_similar('worst'))
             else:
                 print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, 
```

```
100%|| 61441/61441 [00:00<00:00, 105075.31it/s]


[('awesome', 0.8333090543746948), ('fantastic', 0.8322309255599976), ('good', 0.81803232431411
==================================================
[('greatest', 0.8098580241203308), ('best', 0.7293096780776978), ('nastiest', 0.687490880489349
```

```
In [33]: w2v_words = list(w2v_model.wv.vocab)
```

```
In [34]: list_of_sentance=[]
         for sentance in tqdm(preprocessed_reviews):
             list_of_sentance.append(sentance.split())
```

```
100%|| 40000/40000 [00:00<00:00, 87391.85it/s]
```

```
In [35]: # Splitting list_of_sentance into train and test dataset
         Y = rbf_final['Score']
         X_train,X_test,Y_train,Y_test = train_test_split(list_of_sentance,Y,test_size=0.3,rand
         print(len(X_train))
```

```
28000
```

```
In [36]: # Vectorizing train datset.
         # Train and test dataset are vectorized seperately to prevent d lekage
         # average Word2Vec
         # compute average word2vec for each review.
         train_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(X_train): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need t
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     try:
                         vec = w2v_model.wv[word]
                         sent_vec += vec
                         cnt_words += 1
                     except:
                         pass
             if cnt_words != 0:
                 sent_vec /= cnt_words
             train_avg_w2v.append(sent_vec)
         print(len(train_avg_w2v))
         print(len(train_avg_w2v[0]))
```

```
100%|| 28000/28000 [01:19<00:00, 352.34it/s]
```

```
28000
50
```

```
In [37]: # Vectorizing test datset.
         # Train and test dataset are vectorized seperately to prevent d lekage
         # average Word2Vec
         # compute average word2vec for each review.
         test_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might need t
             cnt_words =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words:
                     try:
                         vec = w2v_model.wv[word]
                         sent_vec += vec
                         cnt_words += 1
                     except:
                         pass
             if cnt_words != 0:
                 sent_vec /= cnt_words
             test_avg_w2v.append(sent_vec)
         print(len(test_avg_w2v))
         print(len(test_avg_w2v[0]))
```

```
100%|| 12000/12000 [00:31<00:00, 381.71it/s]


12000
50
```

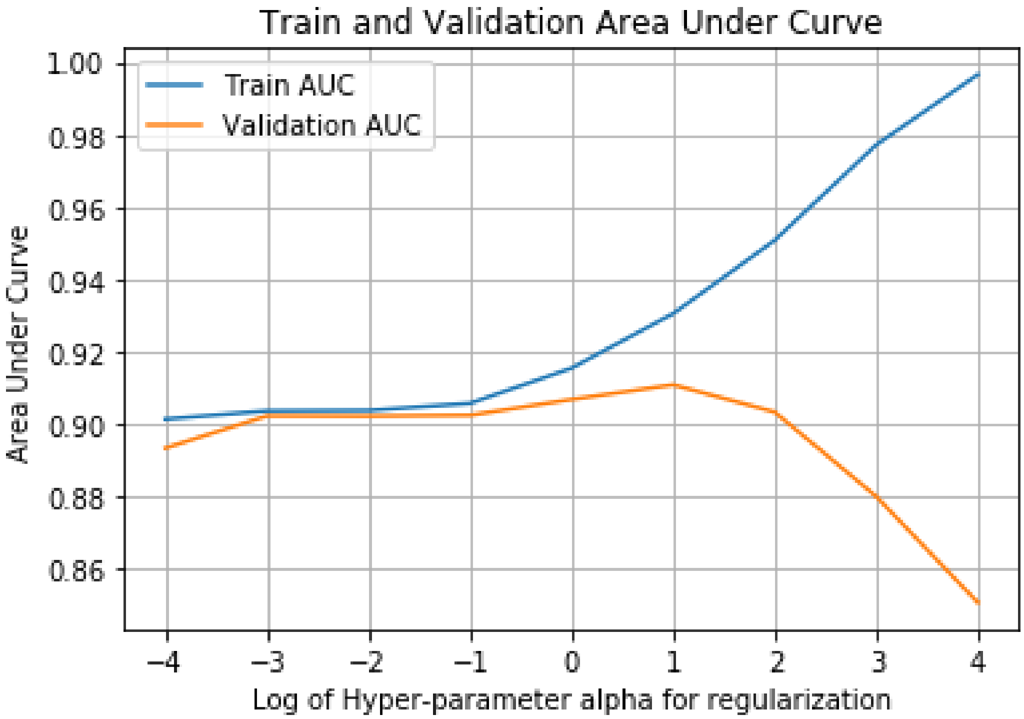
```
In [38]: # Initializing the linear SVM classifier
         from sklearn.svm import SVC
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SVC(C=i,tol=0.001,max_iter=-1,probability=True)
             clf.fit(train_avg_w2v,Y_train)
             # evaluate the model
             probab_y = clf.predict_proba(train_avg_w2v)[:,1] # Returns probability for positi
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

```
100%|| 9/9 [4:07:38<00:00, 3586.11s/it]
```

```
In [39]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=3)

         # In this section we will perform 3-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SVC(C=k,tol=0.001,max_iter=-1,probability=True)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(train_avg_w2v):
                 x_train = train_avg_w2v[0:train_index[-1]][:] # row 0 to train_index(excludin
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = train_avg_w2v[train_index[-1]:test_index[-1]][:] # row from train_in
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 clf.fit(x_train,y_train)

                 probab_y = clf.predict_proba(x_test)[:,1] # returns probability for positive
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)

             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [1:33:15<00:00, 1275.66s/it]
```

```
In [40]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```



Using grid search cv

```
In [41]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SVC(tol=0.001,max_iter=-1,probability=True)
         # Dictionary of parameters to be searched on
         parameters = {'C':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(train_avg_w2v,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_c = grid_model.best_estimator_.C

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(test_avg_w2v)
         predict_y_train = optimized_clf.predict(train_avg_w2v)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(test_avg_w2v,Y_test))
         print("The best alpha(1/C) is ",best_c)
```

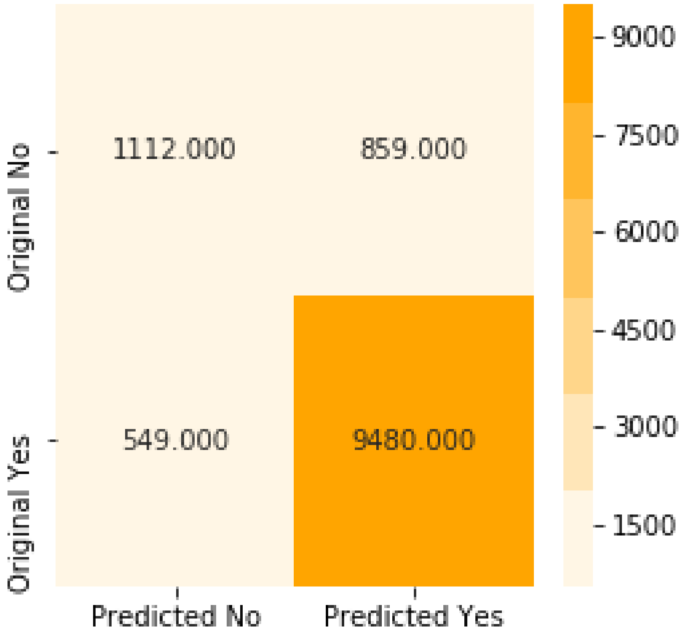
```
The optimized model is SVC(C=1000, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
  max_iter=-1, probability=True, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
Accuracy of best model is 0.8826666666666667
The best alpha(1/C) is  1000
```

```
In [44]: # Taking best value of alpha = 1000 an trainig final model
         # Initializing model
         from sklearn.svm import SVC
         from sklearn.metrics import roc_auc_score
         clf = SVC(C=1000,tol=0.001,max_iter=-1,probability=True)
         # Training model on best value
         clf.fit(train_avg_w2v,Y_train)


         predict_y_test = clf.predict(test_avg_w2v)
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = clf.predict_proba(test_avg_w2v)[:,1] # Returns probability for positi
         predict_y_train = clf.predict(train_avg_w2v)
         probab_y_rain = clf.predict_proba(train_avg_w2v)[:,1] # Returns probability for posit
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for avg W2v vectorized RBF SVM is {:.3f}".format(auc))
```

```
Final AUC for avg W2v vectorized RBF SVM is 0.892
```

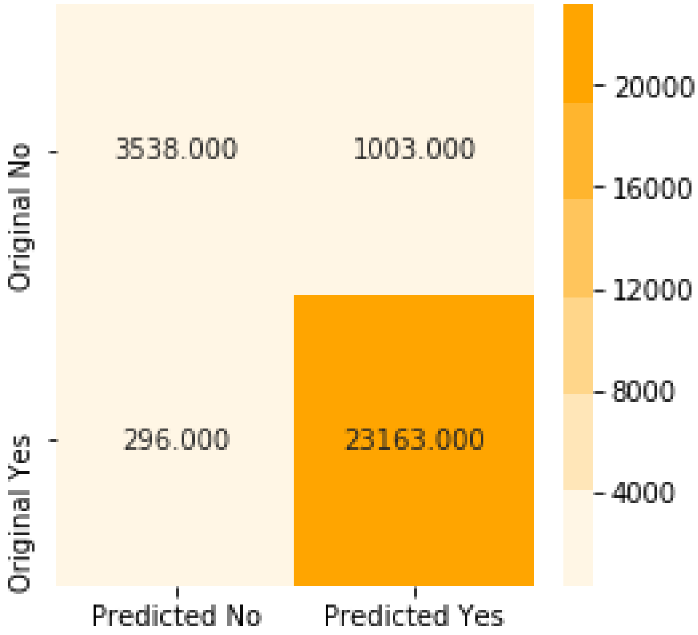
```
In [45]: # Plotting confusion matrix
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

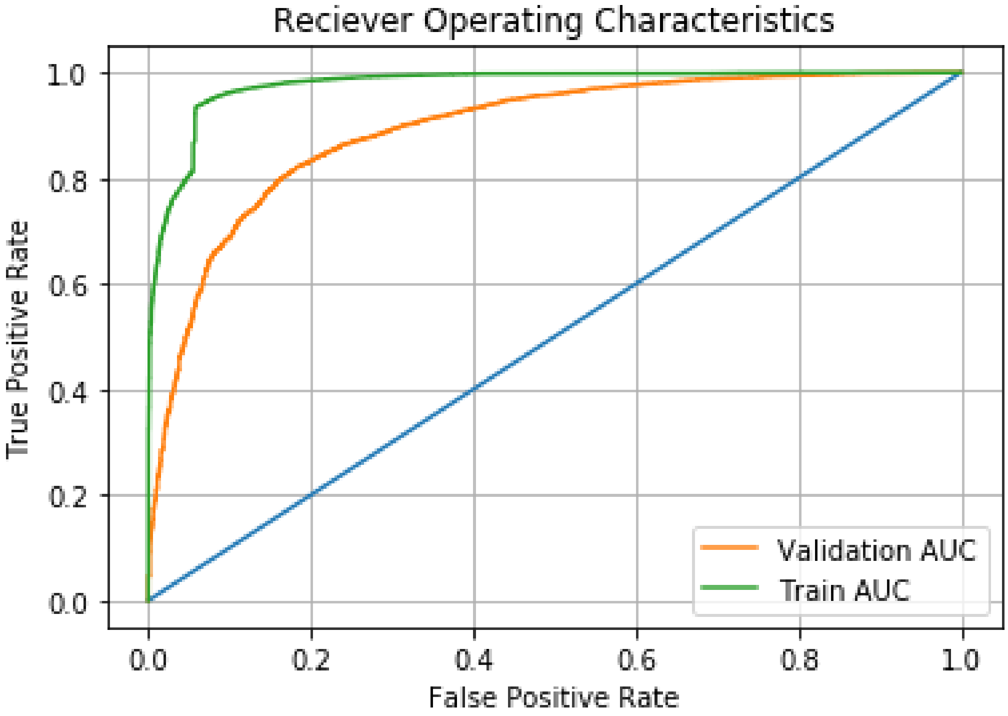


```
In [46]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [47]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_rain)
```



7.2.4 [5.2.4] Applying RBF SVM on TFIDF W2V, SET 4

```
In [51]: X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.3,random_state=42)
         # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
         model = TfidfVectorizer(max_features=500)
         tf_idf_matrix = model.fit_transform(X_train)
         # we are converting a dictionary with word as a key, and the idf as a value
         dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

```
In [52]: # Train your own Word2Vec model using your own text corpus
         list_train=[]
         for sentance in tqdm(X_train):
             list_train.append(sentance.split())

         # Using Google News Word2Vectors

         # in this project we are using a pretrained model by google
         # its 3.3G file, once you load this into your memory
         # it occupies ~9Gb, so please do this step only if you have >12G of ram
         # we will provide a pickle file wich contains a dict ,
         # and it contains all our courpus words as keys and  model[word] as values
         # To use this code-snippet, download "GoogleNews-vectors-negative300.bin"
         # from https://drive.google.com/file/d/0B7XkCwpI5KDYNlNUTTlSS21pQmM/edit
         # it's 1.9GB in size.


         # http://kavita-ganesan.com/gensim-word2vec-tutorial-starter-code/#.W17SRFAzZPY
         # you can comment this whole cell
         # or change these varible according to your need

         is_your_ram_gt_16g=False
         want_to_use_google_w2v = False
         want_to_train_w2v = True

         if want_to_train_w2v:
             # min_count = 5 considers only words that occured atleast 5 times
             w2v_model=Word2Vec(list_train,min_count=5,size=50, workers=4)
             print(w2v_model.wv.most_similar('great'))
             print('='*50)
             print(w2v_model.wv.most_similar('worst'))

         elif want_to_use_google_w2v and is_your_ram_gt_16g:
             if os.path.isfile('GoogleNews-vectors-negative300.bin'):
                 w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bi
                 print(w2v_model.wv.most_similar('great'))
                 print(w2v_model.wv.most_similar('worst'))
             else:
                 print("you don't have gogole's word2vec file, keep want_to_train_w2v = True, 
```

```
100%|| 28000/28000 [00:00<00:00, 142940.36it/s]


[('good', 0.7894672751426697), ('fantastic', 0.7849023938179016), ('awesome', 0.776270687580108
==================================================
[('nastiest', 0.7969458103179932), ('greatest', 0.767988383769989), ('best', 0.760701596736908
```

```
In [53]: w2v_words = list(w2v_model.wv.vocab)
```

```
In [54]: list_of_sentance=[]
         for sentance in tqdm(preprocessed_reviews):
             list_of_sentance.append(sentance.split())
```

```
100%|| 40000/40000 [00:00<00:00, 152759.14it/s]
```

```
In [55]: X_train,X_test,Y_train,Y_test = train_test_split(list_of_sentance,Y,test_size=0.3,rand
         print(len(X_train))
```

```
28000
```

```
In [56]: # TF-IDF weighted Word2Vec for test
         tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         tfidf_train_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in
         row=0;
         for sent in tqdm(X_train): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
                     #tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf valeus of word in this review
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += 1
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidf_train_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 28000/28000 [01:23<00:00, 336.87it/s]
```

```
In [57]: # TF-IDF weighted Word2Vec for test dataset
         tfidf_feat = model.get_feature_names() # tfidf words/col-names
         # final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf

         tfidf_test_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in t
         row=0;
         for sent in tqdm(X_test): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
                     #tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
                     # to reduce the computation we are
                     # dictionary[word] = idf value of word in whole courpus
                     # sent.count(word) = tf valeus of word in this review
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += 1
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidf_test_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 12000/12000 [00:36<00:00, 325.64it/s]
```

```
In [58]: # Initializing the linear SVM classifier
         from sklearn.svm import SVC
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SVC(C=i,tol=0.001,max_iter=-1,probability=True)
             clf.fit(tfidf_train_sent_vectors,Y_train)
             # evaluate the model
             probab_y = clf.predict_proba(tfidf_train_sent_vectors)[:,1] # Returns probability
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

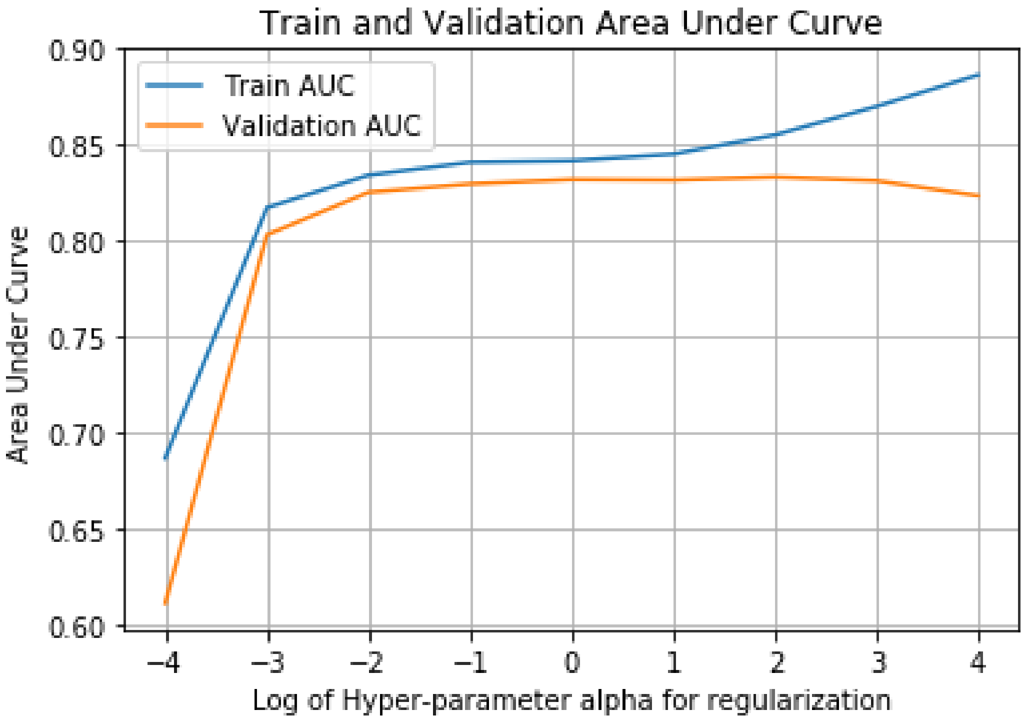
```
100%|| 9/9 [1:26:38<00:00, 1101.68s/it]
```

```
In [59]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=3)

         # In this section we will perform 3-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # RBF SVM classifier
             clf = SVC(C=k,tol=0.001,max_iter=-1,probability=True)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(tfidf_train_sent_vectors):
                 x_train = tfidf_train_sent_vectors[0:train_index[-1]][:] # row 0 to train_ind
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = tfidf_train_sent_vectors[train_index[-1]:test_index[-1]][:] # row fr
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to
```

```
        clf.fit(x_train,y_train)

        probab_y = clf.predict_proba(x_test)[:,1] # returns probability for positive 
        i += 1
        auc += roc_auc_score(y_test,probab_y)

    cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [1:03:05<00:00, 783.30s/it]
```

In [60]:
```
# Plotting graph of auc and parameter for training and cross validation error
plot_train_vs_auc(train_auc_list,cv_auc_list)
```



Using Grid Search CV

In [61]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import make_scorer

# Selecting the estimator . Estimator is the model that you will use to train your mo
# We will pass this instance to GridSearchCV
clf = SVC(tol=0.001,max_iter=-1,probability=True)
# Dictionary of parameters to be searched on
parameters = {'C':param_alpha}
```

```
         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scori

         # Training the gridsearchcv instance
         grid_model.fit(tfidf_train_sent_vectors,Y_train)

         # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_
         best_c = grid_model.best_estimator_.C

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(tfidf_test_sent_vectors)
         predict_y_train = optimized_clf.predict(tfidf_train_sent_vectors)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(tfidf_test_sent_vectors,Y_test))
         print("The best alpha(1/C) is ",best_c)
```

```
The optimized model is SVC(C=10000, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
  max_iter=-1, probability=True, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
Accuracy of best model is 0.8540833333333333
The best alpha(1/C) is  10000
```

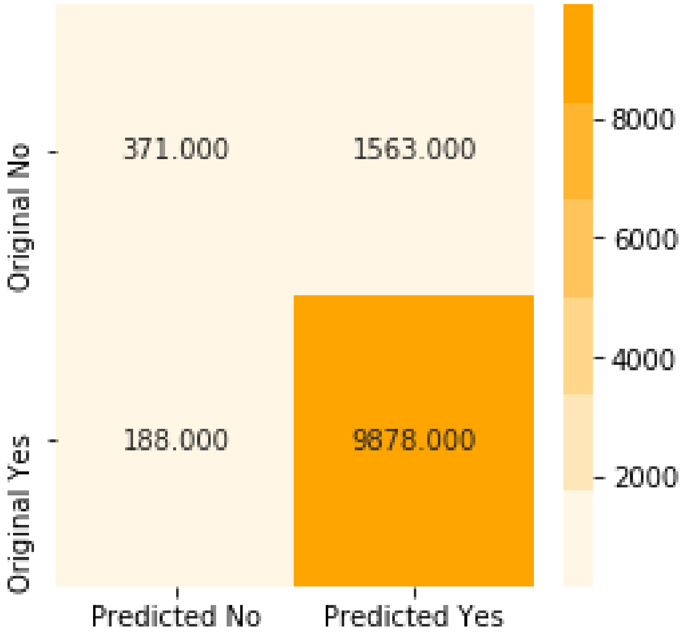
```
In [63]: # Taking best value of alpha = 1000 an trainig final model
         # Initializing model
         clf = SVC(C=10000,tol=0.001,max_iter=-1,probability=True)
         # Training model on best value
         clf.fit(tfidf_train_sent_vectors,Y_train)


         predict_y_test = clf.predict(tfidf_test_sent_vectors)
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = clf.predict_proba(tfidf_test_sent_vectors)[:,1] # Returns probability
         predict_y_train = clf.predict(tfidf_train_sent_vectors)
         probab_y_train = clf.predict_proba(tfidf_train_sent_vectors)[:,1]
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for  Tfidf weighted w2v vectorized RBF SVM is {:.3f}".format(auc))
```

```
Final AUC for  Tfidf weighted w2v vectorized RBF SVM is 0.840
```

```
In [64]: # Plotting confusion matrix
```

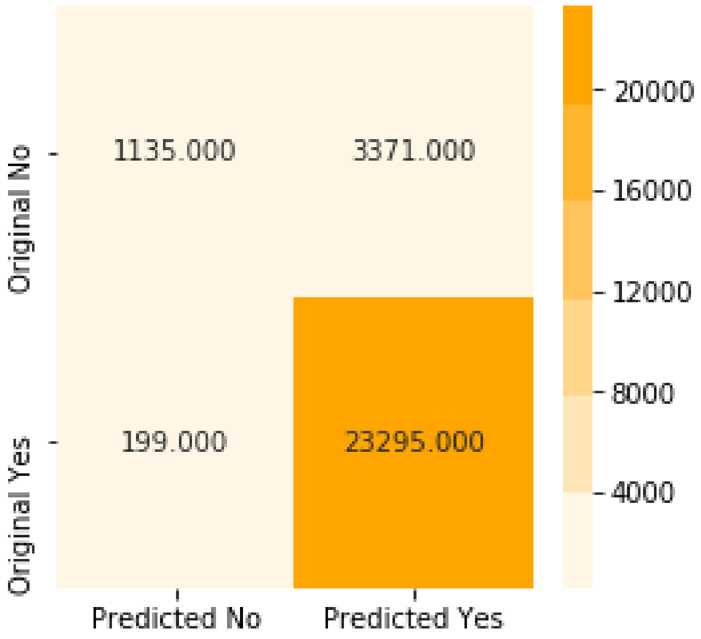
```
         print("Confusion Matrix for test data")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
Confusion Matrix for test data
Confusion matrix
```

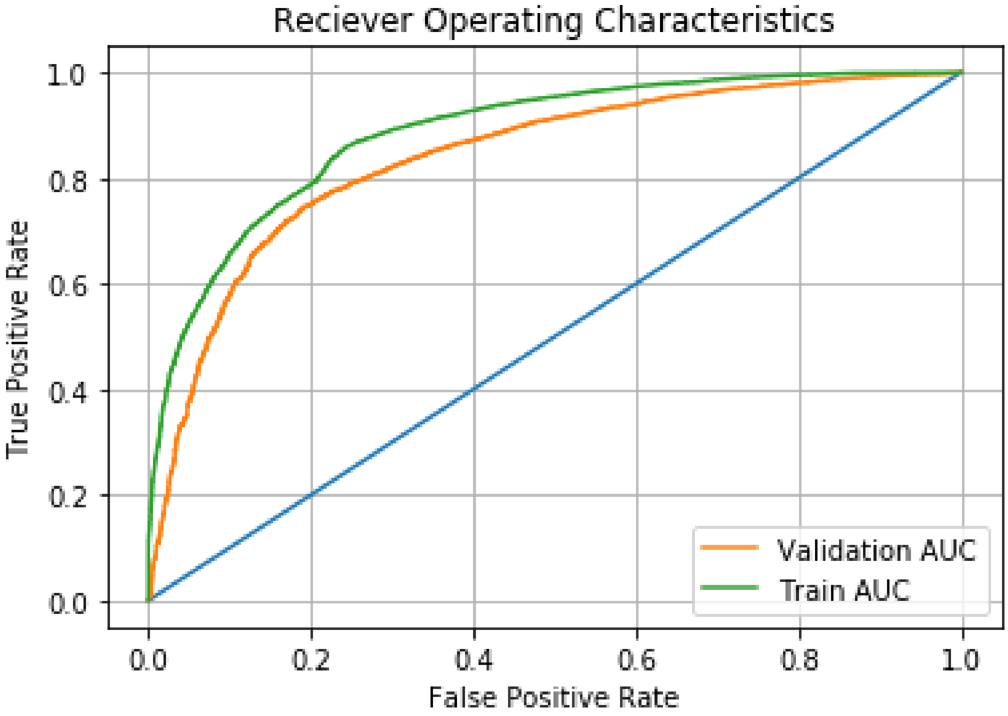


```
In [65]: # Plotting confusion matrix
         print("Confusion Matrix for train data")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
Confusion Matrix for train data
Confusion matrix
```



```
In [67]: # Plotting ROC AUC curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Feature Engineering on BoW Vectorizer
Using review length as a feature

```
In [68]: # Splitting summary into train and test
         Y = rbf_final['Score']
         X_train,X_test,Y_train,Y_test = train_test_split(preprocessed_reviews,Y,test_size=0.3
```

```
In [69]: # For reviews train and test dataset
         count_vect = CountVectorizer(max_features=500)
         # For train dataset
         bow_train_vect = count_vect.fit_transform(X_train)
         print(bow_train_vect.shape)

         # For test dataset
         bow_test_vect = count_vect.fit_transform(X_test)
         print(bow_test_vect.shape)
```

```
(28000, 500)
(12000, 500)
```

```
In [70]: # Calculating and storing length of each review in train data set, in an numpy array

         train_review_len = np.zeros(len(X_train))
         i=0
         for sent in X_train:
             train_review_len[i] = len(sent)
             i += 1

         print(train_review_len.shape)
```

```
(28000,)
```

```
In [71]: # Calculating and storing length of each review in train data set, in an numpy array

         test_review_len = np.zeros(len(X_test))
         i=0
         for sent in X_test:
             test_review_len[i] = len(sent)
             i += 1

         print(test_review_len.shape)
```

```
(12000,)
```

```
In [72]: print(bow_train_vect.shape)
         print(bow_test_vect.shape)
```

```
(28000, 500)
(12000, 500)
```

```
In [73]: from scipy.sparse import hstack
         from scipy.sparse import coo_matrix
         from scipy.sparse import csr_matrix

         # now we will add review length as a new feature to train  data set
         # The shape of train_review_len is 254919 and hstack takes compatible matrices only
         # Making the train_review_len to bow_train_vect
         A = coo_matrix([train_review_len]).T

         bow_train_vect = hstack([bow_train_vect,A])
         print(bow_train_vect.shape)
```

```
(28000, 501)
```

```
In [74]: # now we will add review length as a new feature to train  data set
         # Since hstack takes compatible matrices only
         # Making the test_review_len to bow_test_vect
         B = coo_matrix([test_review_len]).T
         bow_test_vect = hstack([bow_test_vect,B])
         print(bow_test_vect.shape)
```

```
(12000, 501)
```

```
In [75]: from scipy import sparse
         # Converting bow_train_vect from scipy.sparse.coo.coo_matrix to scipy.sparse.csr.csr_
         # scipy.sparse.coo.coo_matrix are not subscriptable

         bow_train_vect = sparse.csr_matrix(bow_train_vect)
         print(type(bow_train_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [76]: # Doing same as above for test dataset
         bow_test_vect = sparse.csr_matrix(bow_test_vect)
         print(type(bow_test_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [77]: # Standarizing data
         from sklearn.preprocessing import StandardScaler
         std = StandardScaler(with_mean=False)
         bow_train_vect = std.fit_transform(bow_train_vect)
         bow_test_vect = std.transform(bow_test_vect)
```

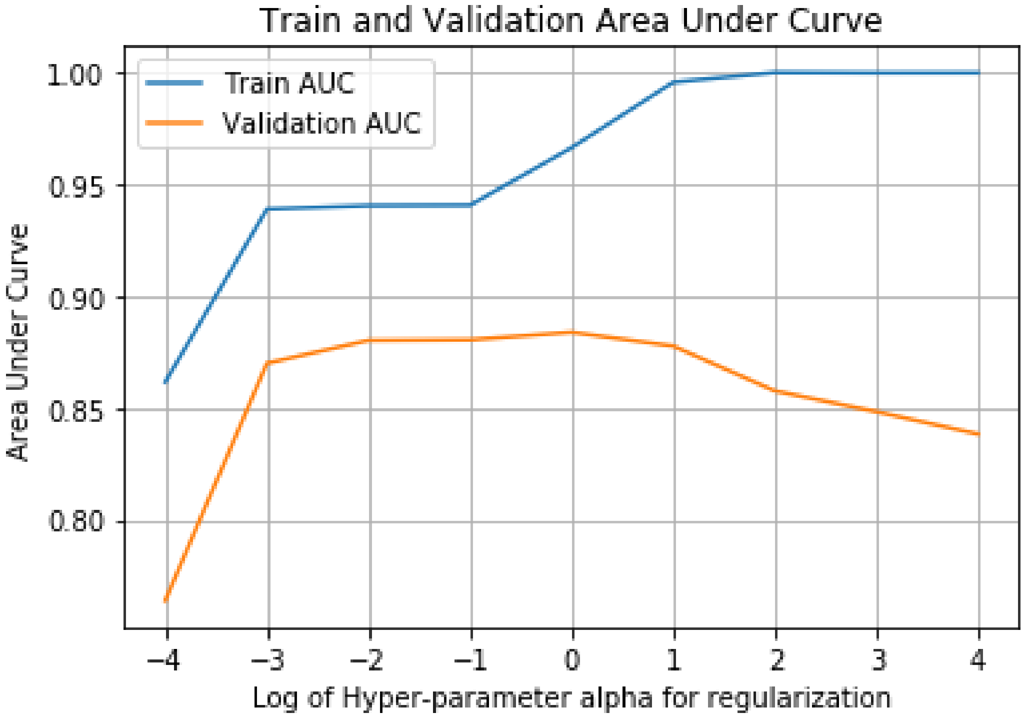
```
In [78]: # Initializing the linear SVM classifier
         from sklearn.svm import SVC
         from sklearn.metrics import roc_auc_score
         from tqdm import tqdm  # this module is used to check the progress of loops
         import numpy as np

         param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
         train_auc_list = [] # Will contain train auc score for various lambda

         # Calculating AUC on train dataset .
         for i in tqdm(param_alpha):
             clf = SVC(C=i,tol=0.001,max_iter=-1,probability=True)
             clf.fit(bow_train_vect,Y_train)
             # evaluate the model
             probab_y = clf.predict_proba(bow_train_vect)[:,1] # Returns probability for posit
             auc = roc_auc_score(Y_train,probab_y)
             train_auc_list.append(auc)
```

```
100%|| 9/9 [3:37:43<00:00, 1912.58s/it]
```

```
In [79]: from sklearn.model_selection import TimeSeriesSplit
         # Time series object
         tscv = TimeSeriesSplit(n_splits=10)

         # In this section we will perform 10-fold Cross validation on timse series split data

         cv_auc_list = [] # will contain cross validation AUC corresponding to each k

         for k in tqdm(param_alpha):
             # Linear SVM classifier
             clf = SVC(C=k,tol=0.001,max_iter=-1,probability=True)
             i=0
             auc=0.0
             for train_index,test_index in tscv.split(bow_train_vect):
                 x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(excludi
                 y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                 x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from train_i
                 y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index to

                 clf.fit(x_train,y_train)

                 probab_y = clf.predict_proba(x_test)[:,1] # returns probability for positive 
                 i += 1
                 auc += roc_auc_score(y_test,probab_y)
             cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [8:39:13<00:00, 4612.77s/it]
```

```
In [80]: # Plotting graph of auc and parameter for training and cross validation error
         plot_train_vs_auc(train_auc_list,cv_auc_list)
```



```
In [84]: from sklearn.model_selection import GridSearchCV
         from sklearn.metrics import make_scorer

         # Selecting the estimator . Estimator is the model that you will use to train your mo
         # We will pass this instance to GridSearchCV
         clf = SVC(tol=0.001,max_iter=-1,probability=True)
         # Dictionary of parameters to be searched on
         parameters = {'C':param_alpha}

         # Value on which model will be evaluated
         auc_score = make_scorer(roc_auc_score)

         # Calling GridSearchCV .
         grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scorin

         # Training the gridsearchcv instance
         grid_model.fit(bow_train_vect,Y_train)

Out[84]: GridSearchCV(cv=3, error_score='raise',
                estimator=SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
           decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
           max_iter=-1, probability=True, random_state=None, shrinking=True,
           tol=0.001, verbose=False),
                fit_params=None, iid=True, n_jobs=-1,
                param_grid={'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]},
                pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                scoring=make_scorer(roc_auc_score), verbose=0)
```

```
In [85]: # this gives the best model with best hyper parameter
         optimized_clf = grid_model.best_estimator_

         #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabili
         predict_y_test = optimized_clf.predict(bow_test_vect)
         predict_y_train = optimized_clf.predict(bow_train_vect)


         print("The optimized model is",optimized_clf)
         print("Accuracy of best model is",optimized_clf.score(bow_test_vect,Y_test))
```

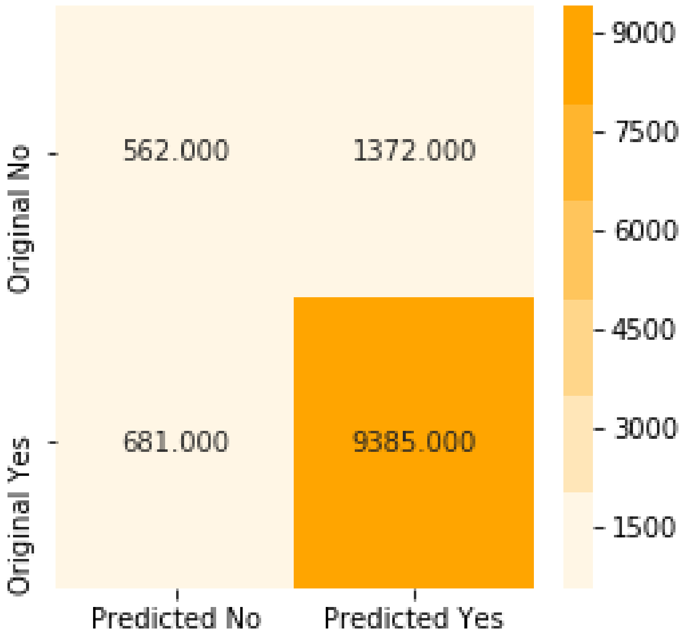
```
The optimized model is SVC(C=100, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
  max_iter=-1, probability=True, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
Accuracy of best model is 0.8289166666666666
```

```
In [92]: # Taking best value of alpha = 1 an trainig final model
         # Initializing model
         clf = SVC(C=100,tol=0.001,max_iter=-1,probability=True)
         # Training model on best value
         clf.fit(bow_train_vect,Y_train)


         predict_y_test = clf.predict(bow_test_vect)
         # Getting probability values from CalibratedClassifier as SGDClassifier dont have met
         probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # Returns probability for posit
         probab_y_train = clf.predict_proba(bow_train_vect)[:,1]
         predict_y_train = clf.predict(bow_train_vect)
         auc = roc_auc_score(Y_test,probab_y_test)
         print("Final AUC for feature engineered BoW vectorized RBF SVM is {:.3f}".format(auc)
```

```
Final AUC for feature engineered BoW vectorized RBF SVM is 0.756
```

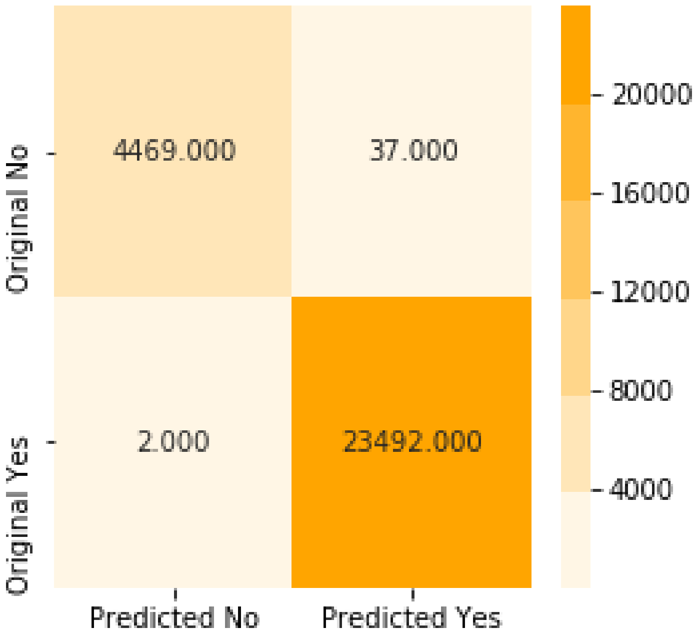
```
In [93]: # Plotting confusion matrix
         print("For test dataset")
         confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
Confusion matrix
```

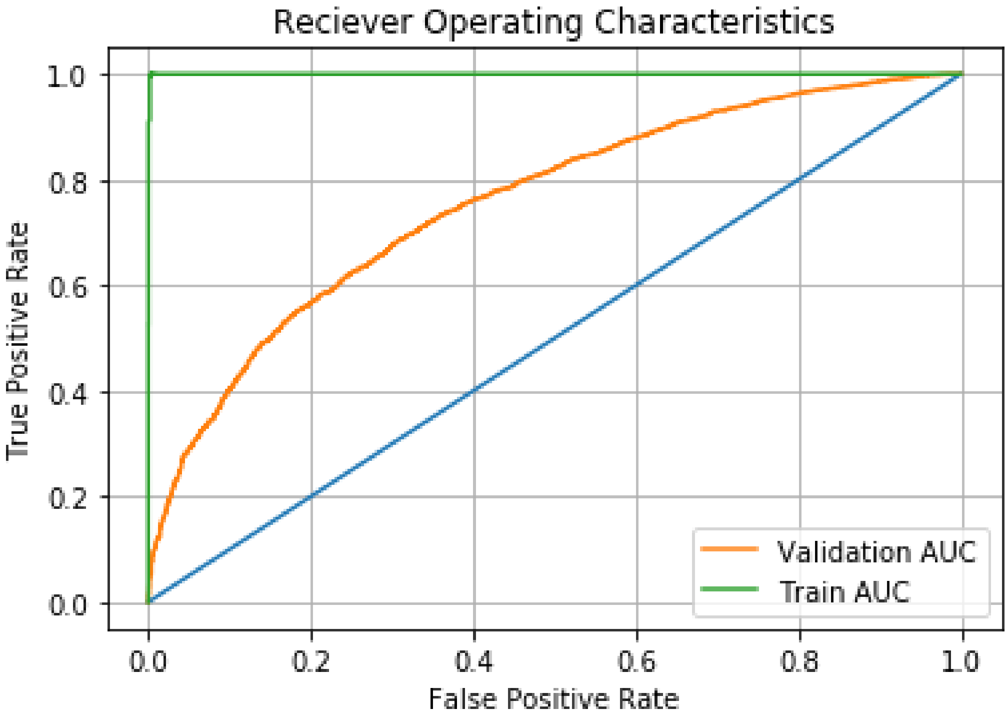


```
In [94]: # Plotting confusion matrix
         print("For train dataset")
         confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
Confusion matrix
```



```
In [95]: #Plotting ROC Curve
         plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



Bow Summary as a feature

```
In [96]: # Splitting summary into train and test
         Y = rbf_final['Score']
         X_train,X_test,Y_train,Y_test = train_test_split(preprocessed_reviews,Y,test_size=0.3
         train_summ,test_summ,Y_train_summ,Y_test_summ = train_test_split(preprocessed_summary

In [98]: # For reviews train and test dataset
         count_vect = CountVectorizer(max_features=500)
         # For train dataset
         bow_train_vect = count_vect.fit_transform(X_train)
         print(bow_train_vect.shape)

         # For test dataset
         bow_test_vect = count_vect.fit_transform(X_test)
         print(bow_test_vect.shape)

(28000, 500)
(12000, 500)
```

```
In [99]: # Using bag of words to vectorize summary
         # For train dataset
         count_vect = CountVectorizer(max_features=200)
         # For train dataset
         train_vect = count_vect.fit_transform(train_summ)
         print(train_vect.shape)

         # for test dataset
         test_vect = count_vect.transform(test_summ)
         print(test_vect.shape)
```

```
(28000, 200)
(12000, 200)
```

```
In [100]: # now we will add vectorized review as a new feature to train  data set
          bow_train_vect = hstack([bow_train_vect,train_vect])
          print(bow_train_vect.shape)
```

```
(28000, 700)
```

```
In [101]: # now we will add vectorized review as a new feature to train  data set
          bow_test_vect = hstack([bow_test_vect,test_vect])
          print(bow_test_vect.shape)
```

```
(12000, 700)
```

```
In [102]: # Converting bow_train_vect and bow_test_vect from scipy.sparse.coo.coo_matrix to sc
          # scipy.sparse.coo.coo_matrix are not subscriptable

          bow_train_vect = sparse.csr_matrix(bow_train_vect)
          bow_test_vect = sparse.csr_matrix(bow_test_vect)
          print(type(bow_train_vect))
          print(type(bow_test_vect))
```

```
<class 'scipy.sparse.csr.csr_matrix'>
<class 'scipy.sparse.csr.csr_matrix'>
```

```
In [103]: # Standarizing data
          from sklearn.preprocessing import StandardScaler
          std = StandardScaler(with_mean=False)
          bow_train_vect = std.fit_transform(bow_train_vect)
          bow_test_vect = std.transform(bow_test_vect)
```

```
C:\Users\rites\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475: DataConversionWarni
  warnings.warn(msg, DataConversionWarning)
```

```
C:\Users\rites\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475: DataConversionWarn
  warnings.warn(msg, DataConversionWarning)
C:\Users\rites\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475: DataConversionWarn
  warnings.warn(msg, DataConversionWarning)
```

```
In [104]: # Initializing the linear SVM classifier
          from sklearn.svm import SVC
          from sklearn.metrics import roc_auc_score
          from tqdm import tqdm  # this module is used to check the progress of loops
          import numpy as np

          param_alpha = [0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
          train_auc_list = [] # Will contain train auc score for various lambda

          # Calculating AUC on train dataset .
          for i in tqdm(param_alpha):
              clf = SVC(C=i,tol=0.001,max_iter=-1,probability=True)
              clf.fit(bow_train_vect,Y_train)
              # evaluate the model
              probab_y = clf.predict_proba(bow_train_vect)[:,1] # Returns probability for posi
              auc = roc_auc_score(Y_train,probab_y)
              train_auc_list.append(auc)
```

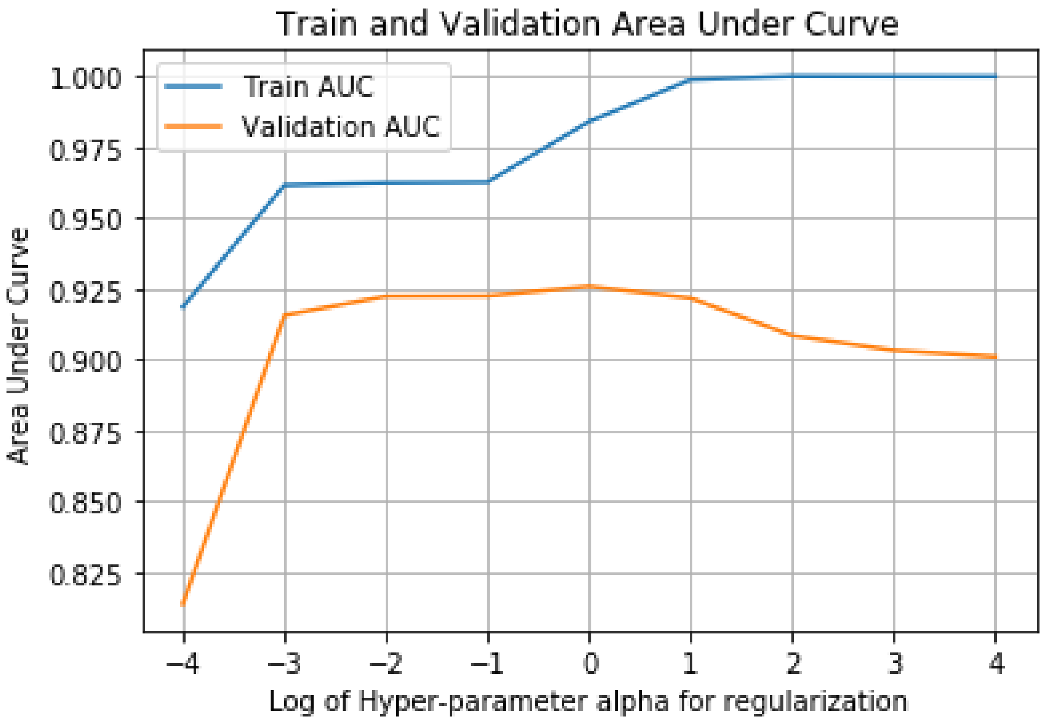
```
100%|| 9/9 [3:07:10<00:00, 1602.65s/it]
```

```
In [105]: from sklearn.model_selection import TimeSeriesSplit
          # Time series object
          tscv = TimeSeriesSplit(n_splits=10)

          # In this section we will perform 10-fold Cross validation on timse series split dat

          cv_auc_list = [] # will contain cross validation AUC corresponding to each k

          for k in tqdm(param_alpha):
              # Linear SVM classifier
              clf = SVC(C=k,tol=0.001,max_iter=-1,probability=True)
              i=0
              auc=0.0
              for train_index,test_index in tscv.split(bow_train_vect):
                  x_train = bow_train_vect[0:train_index[-1]][:] # row 0 to train_index(exclud
                  y_train = Y_train[0:train_index[-1]][:] # row 0 to train_index(excluding)
                  x_test = bow_train_vect[train_index[-1]:test_index[-1]][:] # row from train_
                  y_test = Y_train[train_index[-1]:test_index[-1]][:] # row from train_index t

                  clf.fit(x_train,y_train)
```

```
        probab_y = clf.predict_proba(x_test)[:,1] # returns probability for positive
        i += 1
        auc += roc_auc_score(y_test,probab_y)
    cv_auc_list.append(auc/i) # Storing AUC value
```

```
100%|| 9/9 [7:10:57<00:00, 3455.47s/it]
```

```
In [106]: # Plotting graph of auc and parameter for training and cross validation error
          plot_train_vs_auc(train_auc_list,cv_auc_list)
```



Using Grid Search CV

```
In [107]: from sklearn.model_selection import GridSearchCV
          from sklearn.metrics import make_scorer

          # Selecting the estimator . Estimator is the model that you will use to train your m
          # We will pass this instance to GridSearchCV
          clf = SVC(tol=0.001,max_iter=-1,probability=True)
          # Dictionary of parameters to be searched on
          parameters = {'C':param_alpha}

          # Value on which model will be evaluated
          auc_score = make_scorer(roc_auc_score)
          # Calling GridSearchCV .
          grid_model = GridSearchCV(estimator = clf,param_grid=parameters,cv=3,refit=True,scor

          # Training the gridsearchcv instance
          grid_model.fit(bow_train_vect,Y_train)
```

```
Out[107]: GridSearchCV(cv=3, error_score='raise',
                 estimator=SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
            decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
            max_iter=-1, probability=True, random_state=None, shrinking=True,
            tol=0.001, verbose=False),
                 fit_params=None, iid=True, n_jobs=-1,
                 param_grid={'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]},
                 pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
                 scoring=make_scorer(roc_auc_score), verbose=0)
```

```
In [110]: # this gives the best model with best hyper parameter
          optimized_clf = grid_model.best_estimator_

          #predict_probab = optimized_clf.predict_proba(bow_test_vect)[:,1] # returns probabil
          predict_y_test = optimized_clf.predict(bow_test_vect)
          predict_y_train = optimized_clf.predict(bow_train_vect)
          probab_y_test = optimized_clf.predict_proba(bow_test_vect)[:,1]
          auc = roc_auc_score(Y_test,probab_y_test)

          print("The optimized model is",optimized_clf)
          print("Accuracy of best model is",optimized_clf.score(bow_test_vect,Y_test))
          print("Auc of best model is {:.3f}".format(auc))
```

```
The optimized model is SVC(C=10, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma='auto', kernel='rbf',
  max_iter=-1, probability=True, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
Accuracy of best model is 0.8768333333333334
Auc of best model is 0.873
```

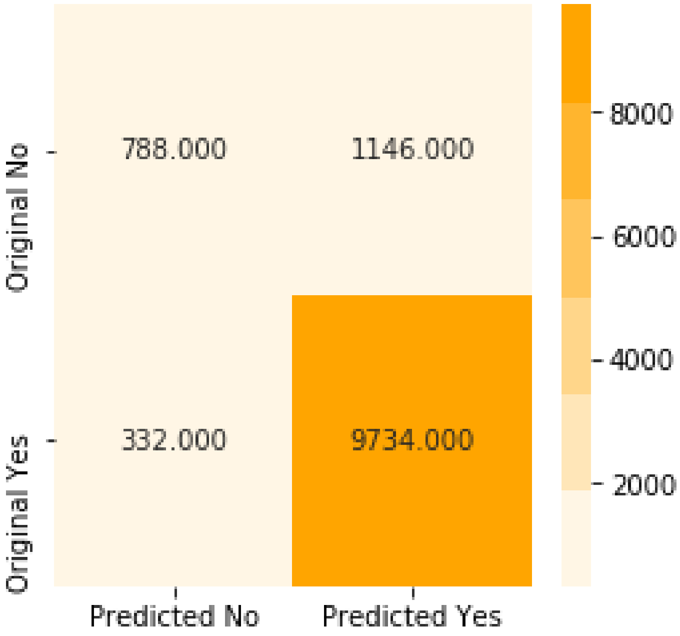
```
In [111]: # Taking best value of alpha = 1 for trainig final model
          # Initializing model
          clf = SVC(C=10,tol=0.001,max_iter=-1,probability=True)
          # Training model on best value
          clf.fit(bow_train_vect,Y_train)


          predict_y_test = clf.predict(bow_test_vect)
          # Getting probability values from CalibratedClassifier as SGDClassifier dont have me
          probab_y_test = clf.predict_proba(bow_test_vect)[:,1] # Returns probability for posi
          probab_y_train = clf.predict_proba(bow_train_vect)[:,1] # Returns probability for po
          predict_y_train = clf.predict(bow_train_vect)
```

```
auc = roc_auc_score(Y_test,probab_y_test)
print("Final AUC for feature engineered BoW vectorized RBF SVM is {:.3f}".format(auc
```

```
Final AUC for feature engineered BoW vectorized RBF SVM is 0.873
```

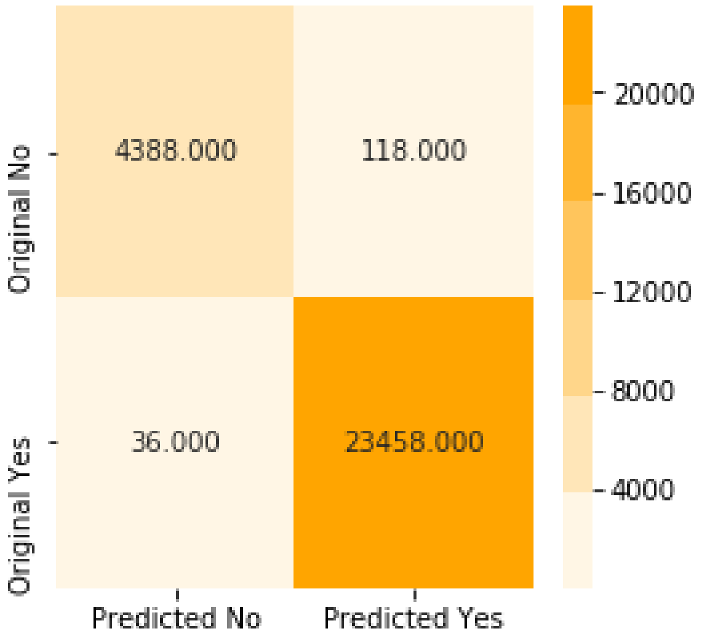
```
In [112]: # Plotting confusion matrix
          print("For test dataset")
          confusion_matrix_plot(Y_test,predict_y_test)
```

```
For test dataset
Confusion matrix
```

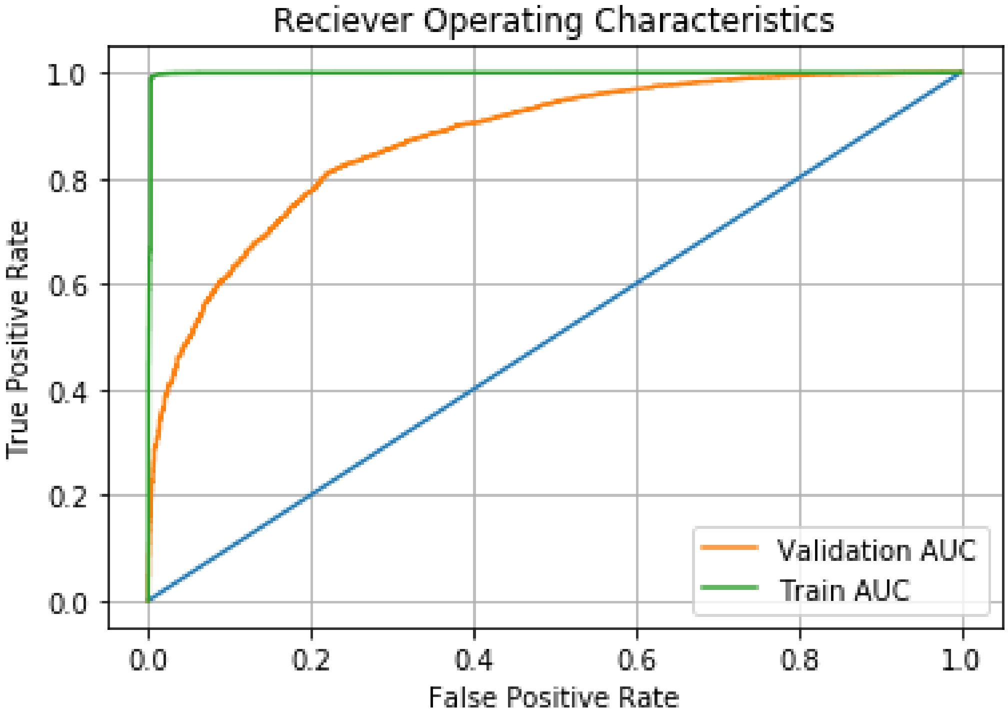


```
In [113]: # Plotting confusion matrix
          print("For train dataset")
          confusion_matrix_plot(Y_train,predict_y_train)
```

```
For train dataset
Confusion matrix
```



```
In [114]: #Plotting ROC Curve
          plot_roc_curve(Y_test,probab_y_test,Y_train,probab_y_train)
```



8 [6] Conclusions

```
In [117]: from prettytable import PrettyTable

          # Initializing table object
          print("For Linear SVM")
          x = PrettyTable()

          x.field_names = ["Vectorizer","Model","Hyper-Parameter alpha","Area Under Curve"]

          x.add_row([ "Bow","Linear SVM L1 regularized","0.0001","0.893" ])
          x.add_row([ "Bow","Linear SVM L2 regularized","0.1","0.905" ])
          x.add_row([ "Tfidf","Linear SVM L1 regularized","0.0001","0.897" ])
          x.add_row([ "Tfidf","Linear SVM L2 regularized","0.1","0.912" ])
          x.add_row([ "AvgW2V","Linear SVM L1 regularized","0.0001","0.928" ])
          x.add_row([ "AvgW2V","Linear SVM L2 regularized","0.0001","0.928" ])
          x.add_row([ "Tfidf weighted W2V","Linear SVM L1 regularized","0.0001","0.878" ])
          x.add_row([ "Tfidf weighted W2V","Linear SVM L2 regularized","0.0001","0.877" ])
          x.add_row([ "Bow with review length ","Linear SVM L1 regularized","0.0001","0.892" ]
          x.add_row([ "Bow with summary feature","Linear SVM L1 regularized","0.0001","0.930" ]

          print(x)
```

```
For Linear SVM
+--------------------------+---------------------------+-----------------------+---------------
|        Vectorizer        |           Model           | Hyper-Parameter alpha | Area Under Cu
+--------------------------+---------------------------+-----------------------+---------------
|           Bow            | Linear SVM L1 regularized |         0.0001        |       0.893
|           Bow            | Linear SVM L2 regularized |          0.1          |       0.905
|          Tfidf           | Linear SVM L1 regularized |         0.0001        |       0.897
|          Tfidf           | Linear SVM L2 regularized |          0.1          |       0.912
|          AvgW2V          | Linear SVM L1 regularized |         0.0001        |       0.928
|          AvgW2V          | Linear SVM L2 regularized |         0.0001        |       0.928
|    Tfidf weighted W2V    | Linear SVM L1 regularized |         0.0001        |       0.878
|    Tfidf weighted W2V    | Linear SVM L2 regularized |         0.0001        |       0.877
| Bow with review length   | Linear SVM L1 regularized |         0.0001        |       0.892
| Bow with summary feature | Linear SVM L1 regularized |         0.0001        |       0.930
+--------------------------+---------------------------+-----------------------+---------------
```

```
In [116]: from prettytable import PrettyTable

          # Initializing table object
          print("For RBF Kernel SVM")
          x = PrettyTable()

          x.field_names = ["Vectorizer","Model","Hyper-Parameter C","Area Under Curve"]
```

```
x.add_row([ "Bow","RBF SVM ","10","0.895" ])
x.add_row([ "Tfidf","RBF SVM","10","0.909" ])
x.add_row([ "AvgW2V","RBF SVM ","1000","0.892" ])
x.add_row([ "Tfidf weighted W2V","RBF SVM ","10000","0.840" ])
x.add_row([ "Bow with review length ","RBF SVM ","100","0.756" ])
x.add_row([ "Bow with summary feature","RBF SVM ","10","0.873" ])

print(x)
```

```
For RBF Kernel SVM
+--------------------------+----------+-------------------+------------------+
|        Vectorizer        |  Model   | Hyper-Parameter C | Area Under Curve |
+--------------------------+----------+-------------------+------------------+
|           Bow            | RBF SVM  |         10        |      0.895       |
|          Tfidf           | RBF SVM  |         10        |      0.909       |
|          AvgW2V          | RBF SVM  |        1000       |      0.892       |
|    Tfidf weighted W2V    | RBF SVM  |       10000       |      0.840       |
| Bow with review length   | RBF SVM  |        100        |      0.756       |
| Bow with summary feature | RBF SVM  |         10        |      0.873       |
+--------------------------+----------+-------------------+------------------+
```

Explaination

Data was cleaned and then we split data into train and test dataset with 70:30 ratio.

Train and test dataset were vectorized using fit_transform and transform methods to prevent data lekage.

We wrote our own for loops to to hyper parameter tunning by potting the train and cross validation AUC and then selecting the hyper-parameter corresponding to best cross-validation AUC.

In Linear SVM trained on BoW vectorization the model in which l1 regularization was used performed better than l2 regularized model.

To get the AUC Score for linear SVM we used calibrated classifier and to print top 10 features we used linear SGD with hinge loss as penalty.

To print top 10 positive features we arranged the weight vectors in ascending order using argsort and took the features corresponding to last 10 indexes. For top 10 negative features features corresponding to top 10 indexes were printed.

In feature engineering section we used review length and bag of words vectorization of summary and concatenated it with our reviews vectors using hstack but this could not improve our AUC.

Feature engineering did not improved the AUC of linear SVM.

The linear SVM model trained on bow feature engineered with summary as a feature gave the best AUC of 0.930

Linear SVM models performed better than RBF kernal SVM models.

Linear SVM models had an AUC as high as 0.930 and highest AUC for RBF SVM was 0.909

Feature engineering did improved the AUC for RBF kernel SVM.