07 Amazon Fine Food Reviews Analysis_Support Vector Machines

February 1, 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 500

        # 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 (5000, 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]: (4986, 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]: 99.72
```

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  B000MIDR0Q  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()
```

```
(4986, 10)
```

```
Out[13]: 1    4178
         0     808
         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)
```

```
Why is this $[...] when the same product is available for $[...] here?<br />http://www.amazon.
==================================================
I recently tried this flavor/brand and was surprised at how delicious these chips are.  The bes
==================================================
Wow.  So far, two two-star reviews.  One obviously had no idea what they were ordering; the oth
==================================================
love to order my coffee on amazon.  easy and shows up quickly.<br />This k cup is great coffee
==================================================
```

```
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)
```

```
Why is this $[...] when the same product is available for $[...] here?<br /> /><br />The Victo
```

```
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)
```

```
Why is this $[...] when the same product is available for $[...] here? />The Victor M380 and M5
==================================================
I recently tried this flavor/brand and was surprised at how delicious these chips are.  The bes
==================================================
Wow.  So far, two two-star reviews.  One obviously had no idea what they were ordering; the ot
==================================================
love to order my coffee on amazon.  easy and shows up quickly.This k cup is great coffee.  dca
```

```
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)
```

```
Wow.  So far, two two-star reviews.  One obviously had no idea what they were ordering; the oth
==================================================
```

```
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)
```

```
Why is this $[...] when the same product is available for $[...] here?<br /> /><br />The Victo
```

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

```
Wow So far two two star reviews One obviously had no idea what they were ordering the other wa
```

```
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 stopwo
             preprocessed_reviews.append(sentance.strip())
```

```
100%|| 4986/4986 [00:01<00:00, 3137.37it/s]
```

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

```
Out[23]: 'wow far two two star reviews one obviously no idea ordering wants crispy cookies hey
```

[3.2] Preprocessing Review Summary

```
In [6]: ## Similartly you can do preprocessing for review summary also.
```

5 [4] Featurization

5.1 [4.1] BAG OF WORDS

```
In [25]: #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', 'aahhhs', 'aback', 'abandon', 'abates', 'abbott', 'abby', 'abdominal
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (4986, 12997)
the number of unique words  12997
```

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

```
In [26]: #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  (4986, 3144)
the number of unique words including both unigrams and bigrams  3144
```

5.3 [4.3] TF-IDF

```
In [27]: 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) ['ability', 'able', 'able find', 'able get',
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (4986, 3144)
the number of unique words including both unigrams and bigrams  3144
```

5.4 [4.4] Word2Vec

```
In [28]: # Train your own Word2Vec model using your own text corpus
         i=0
         list_of_sentance=[]
         for sentance in preprocessed_reviews:
             list_of_sentance.append(sentance.split())
```

```
In [42]: # 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=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,
```

```
[('snack', 0.9951335191726685), ('calorie', 0.9946465492248535), ('wonderful', 0.99460321664481
==================================================
[('varieties', 0.9994194507598877), ('become', 0.9992934465408325), ('popcorn', 0.999275088310
```

```
In [36]: 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  3817
sample words  ['product', 'available', 'course', 'total', 'pretty', 'stinky', 'right', 'nearby
```

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

[4.4.1.1] Avg W2v

```
In [38]: # 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(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:
                    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%|| 4986/4986 [00:03<00:00, 1330.47it/s]


4986
50
```

[4.4.1.2] TFIDF weighted W2v

```
In [39]: # 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 [41]: # 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%|| 4986/4986 [00:20<00:00, 245.63it/s]
```

6 [5] Assignment 7: SVM

Apply SVM on these feature sets

SET 1:Review text, preprocessed one converted into vectors using (BOW)
SET 2:Review text, preprocessed one converted into vectors using (TFIDF)
SET 3:Review text, preprocessed one converted into vectors using (AVG W2v)
SET 4:Review text, preprocessed one converted into vectors using (TFIDF W2v)
Procedure
You need to work with 2 versions of SVM
Linear kernel

```
        <li>RBF kernel</li></ul>
<li>When you are working with linear kernel, use SGDClassifier with hinge loss because it is co
<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/skl
<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 penal
    <ul>
<li>Find the best hyper parameter which will give the maximum <a href='https://www.appliedaicou
<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 ta
    </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 engine
        <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 fi
<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.c
<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

```
In [2]: # after preprocessing
        df = pd.read_pickle("files/preprocessed.pkl")
        df.shape
```

```
Out[2]: (364171, 12)
```

```
In [3]: df.head()
```

```
Out[3]:             Id   ProductId          UserId                 ProfileName  \
        138706  150524  0006641040   ACITT7DI6IDDL             shari zychinski
        138688  150506  0006641040  A2IW4PEEKO2R0U                       Tracy
        138689  150507  0006641040  A1S4A3IQ2MU7V4       sally sue "sally sue"
        138690  150508  0006641040    AZGXZ2UUK6X  Catherine Hallberg "(Kate)"
        138691  150509  0006641040  A3CMRKGE0P909G                      Teresa
        HelpfulnessNumerator  HelpfulnessDenominator  Score        Time  \
138706                     0                       0      1   939340800
138688                     1                       1      1  1194739200
138689                     1                       1      1  1191456000
138690                     1                       1      1  1076025600
138691                     3                       4      1  1018396800

                                           Summary  \
138706                   EVERY book is educational
138688  Love the book, miss the hard cover version
138689               chicken soup with rice months
138690      a good swingy rhythm for reading aloud
138691             A great way to learn the months

                                                      Text  \
138706  this witty little book makes my son laugh at l...
138688  I grew up reading these Sendak books, and watc...
138689  This is a fun way for children to learn their ...
138690  This is a great little book to read aloud- it ...
138691  This is a book of poetry about the months of t...

                                               CleanedText  \
138706  witty little book makes son laugh loud recite ...
138688  grew reading sendak books watching really rosi...
138689  fun way children learn months year learn poems...
138690  great little book read aloud nice rhythm well ...
138691  book poetry months year goes month cute little...

                           CleanedSummary
138706             every book educational
138688  love book miss hard cover version
138689           chicken soup rice months
138690   good swingy rhythm reading aloud
138691             great way learn months
```

```
In [48]: #code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_
         from sklearn.model_selection import train_test_split
         from sklearn.grid_search import GridSearchCV
         from sklearn.datasets import *
         from sklearn.linear_model import LogisticRegression
         from sklearn.metrics import accuracy_score , f1_score , confusion_matrix
         from collections import Counter
         from sklearn.metrics import accuracy_score, roc_auc_score , roc_curve
         from sklearn.model_selection import train_test_split
```

```
In [49]: # take 50k sample data randomly
         sample_data = df.sample(100000)
         sample_data.shape
```

```
Out[49]: (100000, 12)
```

```
In [50]: # sorted the data using time based
         sorted_data = sample_data.sort_values('Time', axis=0, inplace=False)
         sorted_data.shape
```

```
Out[50]: (100000, 12)
```

```
In [51]: sorted_data['Score'].value_counts()
```

```
Out[51]: 1    84429
         0    15571
         Name: Score, dtype: int64
```

```
In [52]: from sklearn.model_selection import train_test_split
```

```
In [53]: X = np.array(sorted_data['CleanedText'])
         y = np.array(sorted_data['Score'])
         print(X.shape)
         print(y.shape)
```

```
(100000,)
(100000,)
```

```
In [54]: # Simple cross validation
         # split the data sent into train and test
         train , test , train_y , test_y = train_test_split(X, y, test_size = 0.3, random_stat

         # split the train data set into cross validation train and cross validation test
         train, cv , train_y, cv_y = train_test_split(train, train_y, test_size=0.3, random_sta

         print("train data = ", train.shape)
         print("cros validation = ", cv.shape)
         print("test data = ", test.shape)
```

```
train data =  (49000,)
cros validation =  (21000,)
test data =  (30000,)
```

7.1 [5.1] Linear SVM

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

```
In [3]: # Please write all the code with proper documentation
```

```
In [15]: # Please write all the code with proper documentation
         # Please write all the code with proper documentation
         #BoW
         count_vect = CountVectorizer(min_df=10) #in scikit-learn
         count_vect.fit(train)
         print("some feature names ", count_vect.get_feature_names()[:10])
         print('='*50)

         bow_train = count_vect.fit_transform(train)
         bow_cv = count_vect.transform(cv)
         bow_test = count_vect.transform(test)
         print("============Train Data=========")
         print("the type of count vectorizer ",type(bow_train))
         print("the shape of out text BOW vectorizer ",bow_train.get_shape())
         print("the number of unique words ", bow_train.get_shape()[1])
         print("============Cross validation Data=========")
         print("the type of count vectorizer ",type(bow_cv))
         print("the shape of out text BOW vectorizer ",bow_cv.get_shape())
         print("the number of unique words ", bow_cv.get_shape()[1])
         print("============Test Data=========")
         print("the type of count vectorizer ",type(bow_test))
         print("the shape of out text BOW vectorizer ",bow_test.get_shape())
         print("the number of unique words ", bow_test.get_shape()[1])
```

```
some feature names  ['aa', 'ability', 'able', 'abroad', 'absent', 'absolute', 'absolutely', 'al
==================================================
============Train Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (49000, 8771)
the number of unique words  8771
============Cross validation Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (21000, 8771)
the number of unique words  8771
============Test Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (30000, 8771)
the number of unique words  8771
```

```
In [61]: from sklearn.linear_model import SGDClassifier
         from sklearn.calibration import CalibratedClassifierCV
```

using L2 reglirization

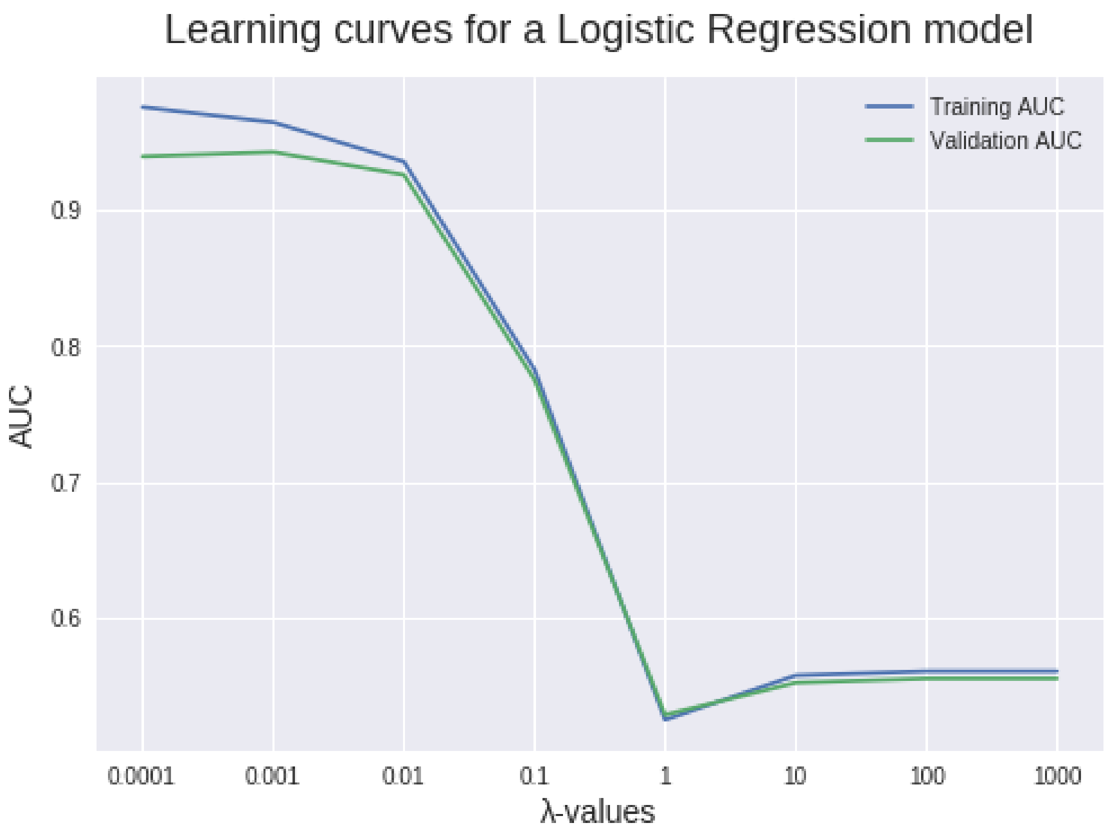
```
In [37]: alpha = [pow(10,j) for j in range(-4,4,1)]

         bow_train_auc = []
         bow_cv_auc = []
         for i in alpha:
             LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
```

```
        calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
        calibrated_clf.fit(bow_train, train_y)
        # train data
        y_prob_train = calibrated_clf.predict_proba(bow_train)[:,1]
        y_pred = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(train_y , y_prob_train)
        print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(
        bow_train_auc.append(auc_roc_train)
        # CV
        y_prob_cv = calibrated_clf.predict_proba(bow_cv)[:,1]
        y_pred = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
        print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100)))
        bow_cv_auc.append(auc_roc_cv)
        print("="*50)
```

```
Train AUC for  = 0.0001 is 97.49%

CV AUC for  = 0.0001 is 93.87%
==================================================

Train AUC for  = 0.001 is 96.37%

CV AUC for  = 0.001 is 94.19%
==================================================

Train AUC for  = 0.01 is 93.49%

CV AUC for  = 0.01 is 92.52%
==================================================

Train AUC for  = 0.1 is 78.23%

CV AUC for  = 0.1 is 77.48%
==================================================

Train AUC for  = 1 is 52.53%

CV AUC for  = 1 is 52.90%
==================================================

Train AUC for  = 10 is 55.79%

CV AUC for  = 10 is 55.25%
==================================================

Train AUC for  = 100 is 56.10%
```

```
CV AUC for  = 100 is 55.56%
==================================================

Train AUC for  = 1000 is 56.10%

CV AUC for  = 1000 is 55.56%
==================================================
```

```
In [38]: hyper = [str(pow(10,j)) for j in range(-4,4)]

         # https://www.dataquest.io/blog/learning-curves-machine-learning/

         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(hyper,bow_train_auc,label = 'Training AUC')
         plt.plot(hyper, bow_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC', fontsize = 14)
         plt.xlabel('\u03BB-values', fontsize = 14)
         plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03)
         plt.legend()

Out[38]: <matplotlib.legend.Legend at 0x7f70c50b87f0>
```



```
In [39]: i = 0.001
         LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
         calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
         calibrated_clf.fit(bow_train, train_y)
         # train data
         y_prob_train = calibrated_clf.predict_proba(bow_train)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100)
         # CV
         y_prob_cv = calibrated_clf.predict_proba(bow_cv)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
         # Test
         y_prob_test = calibrated_clf.predict_proba(bow_test)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(test_y , y_prob_test)
```

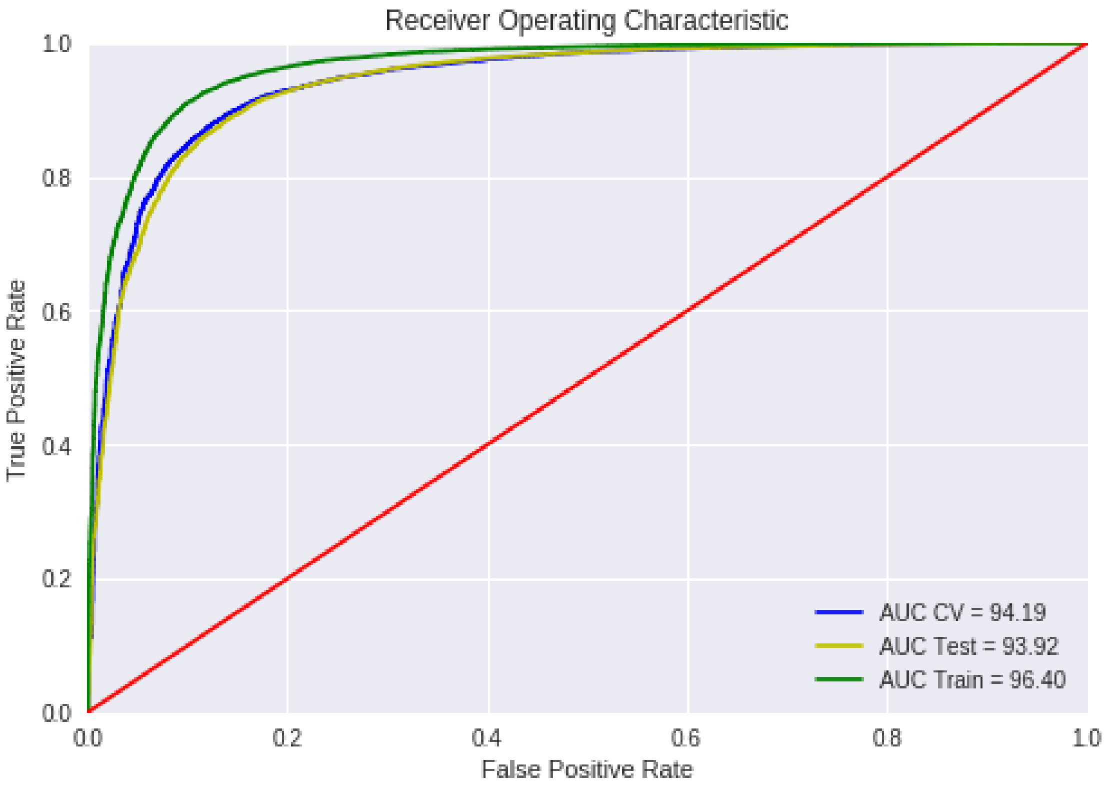
```
        print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

```
Train AUC for  = 0.001 is 96.40%

CV AUC for  = 0.001 is 94.19%

Test AUC for  = 0.001 is 93.92%
```

```
In [64]: LSVM = SGDClassifier(loss='hinge',alpha=0.001, penalty='l2')
         LSVM.fit(bow_train, train_y)

         # number of non-zero weights
         w = LSVM.coef_
         print("Number of non-zero weights : ",np.count_nonzero(w))
```

```
Number of non-zero weights :  8738
```

```
In [41]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```

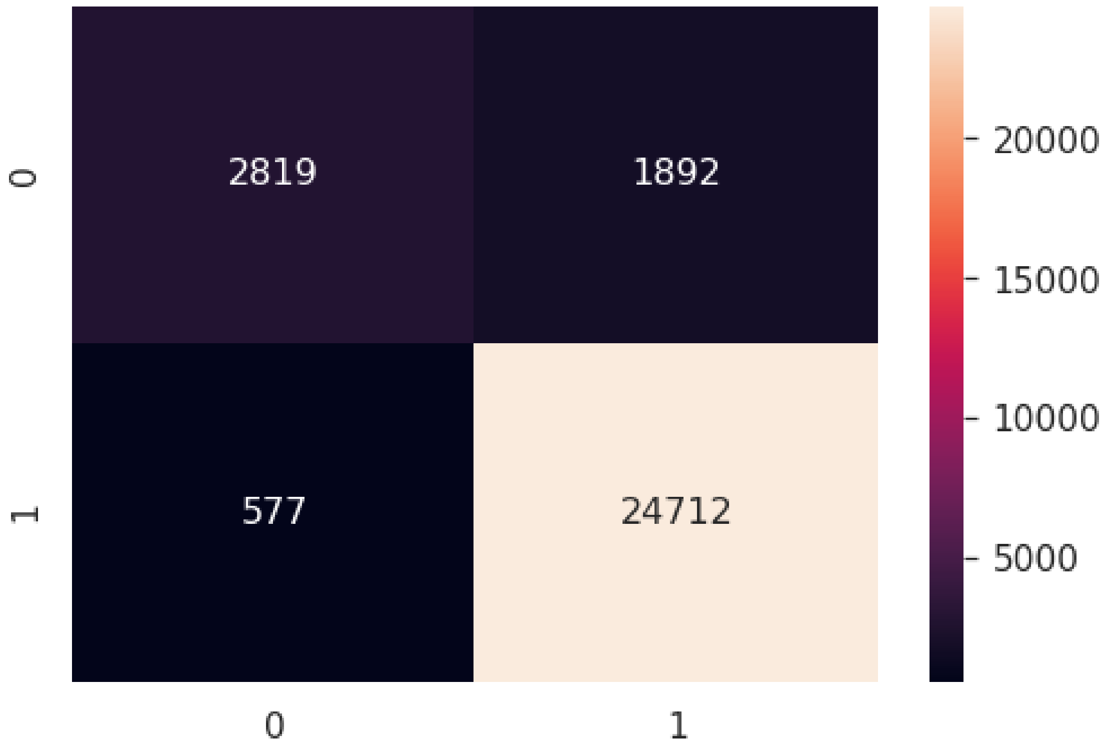


```
In [42]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.95
```

```
In [43]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[43]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70c51ba240>
```



Top 10 important features of positive class

```
In [67]: # Please write all the code with proper documentation
         # Please write all the code with proper documentation
         feture_weights = w.tolist()[0]
         feature_names = count_vect.get_feature_names()
         features = dict(zip(feture_weights,feature_names))
```

```
In [68]: features_df = pd.DataFrame.from_dict(features, orient='index')
         sorted_features = features_df.sort_index(axis=0,ascending=False )
```

```
In [69]: sorted_features.head(10)
```

```
Out[69]:                   0
         0.619961  excellent
         0.611803  delicious
         0.554702     highly
         0.534308    perfect
         0.526151    awesome
         0.501679     smooth
         0.497600       best
         0.489443    amazing
         0.485364    pleased
         0.469049      great
```

7.1.2 Top 10 important features of negative class from

```
In [70]: # Please write all the code with proper documentation
         sorted_features = features_df.sort_index(axis=0,ascending=True)
         sorted_features.head(10)
```

```
Out[70]:                        0
         -1.007436          worst
         -0.880997   disappointing
         -0.876918        terrible
         -0.856525    disappointed
         -0.758636        horrible
         -0.754557   unfortunately
         -0.738243           threw
         -0.681141          return
         -0.664826  disappointment
         -0.624039           stale
```

using L1 regulirization

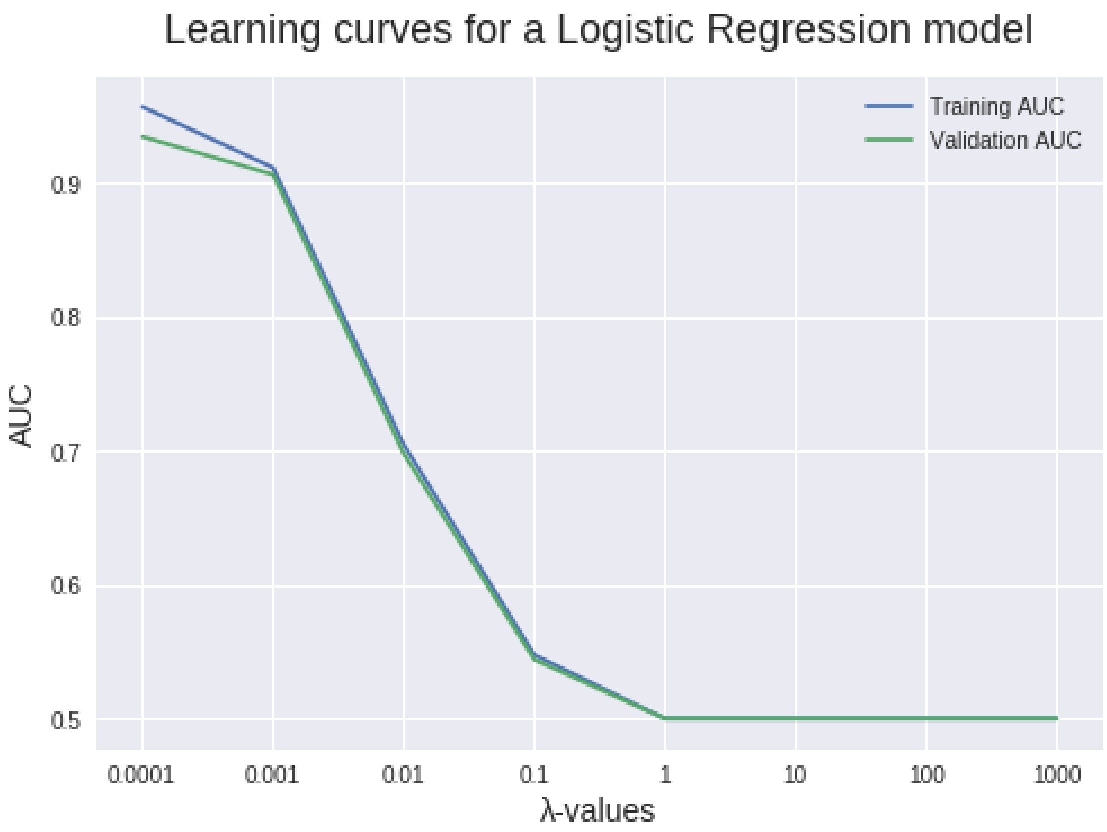
```
In [32]: alpha = [pow(10,j) for j in range(-4,4,1)]

         bow_train_auc = []
         bow_cv_auc = []
         for i in alpha:
             LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
             calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
             calibrated_clf.fit(bow_train, train_y)
             # train data
             y_prob_train = calibrated_clf.predict_proba(bow_train)[:,1]
             y_pred = np.where(y_prob_train > 0.5, 1, 0)
             auc_roc_train = roc_auc_score(train_y , y_prob_train)
             print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(
             bow_train_auc.append(auc_roc_train)
             # CV
             y_prob_cv = calibrated_clf.predict_proba(bow_cv)[:,1]
             y_pred = np.where(y_prob_cv > 0.5, 1, 0)
             auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
             print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100)))
             bow_cv_auc.append(auc_roc_cv)
             print("="*50)
```

```

Train AUC for  = 0.0001 is 95.73%

CV AUC for  = 0.0001 is 93.49%
==================================================

Train AUC for  = 0.001 is 91.17%
```

```
CV AUC for  = 0.001 is 90.66%
==================================================

Train AUC for  = 0.01 is 70.50%

CV AUC for  = 0.01 is 69.82%
==================================================

Train AUC for  = 0.1 is 54.77%

CV AUC for  = 0.1 is 54.42%
==================================================

Train AUC for  = 1 is 50.00%

CV AUC for  = 1 is 50.00%
==================================================

Train AUC for  = 10 is 50.00%

CV AUC for  = 10 is 50.00%
==================================================

Train AUC for  = 100 is 50.00%

CV AUC for  = 100 is 50.00%
==================================================

Train AUC for  = 1000 is 50.00%

CV AUC for  = 1000 is 50.00%
==================================================
```

```
In [33]: hyper = [str(pow(10,j)) for j in range(-4,4)]

         # https://www.dataquest.io/blog/learning-curves-machine-learning/

         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(hyper,bow_train_auc,label = 'Training AUC')
         plt.plot(hyper, bow_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC', fontsize = 14)
         plt.xlabel('\u03BB-values', fontsize = 14)
         plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03)
         plt.legend()
```

```
Out[33]: <matplotlib.legend.Legend at 0x7f70c57b6c50>
```



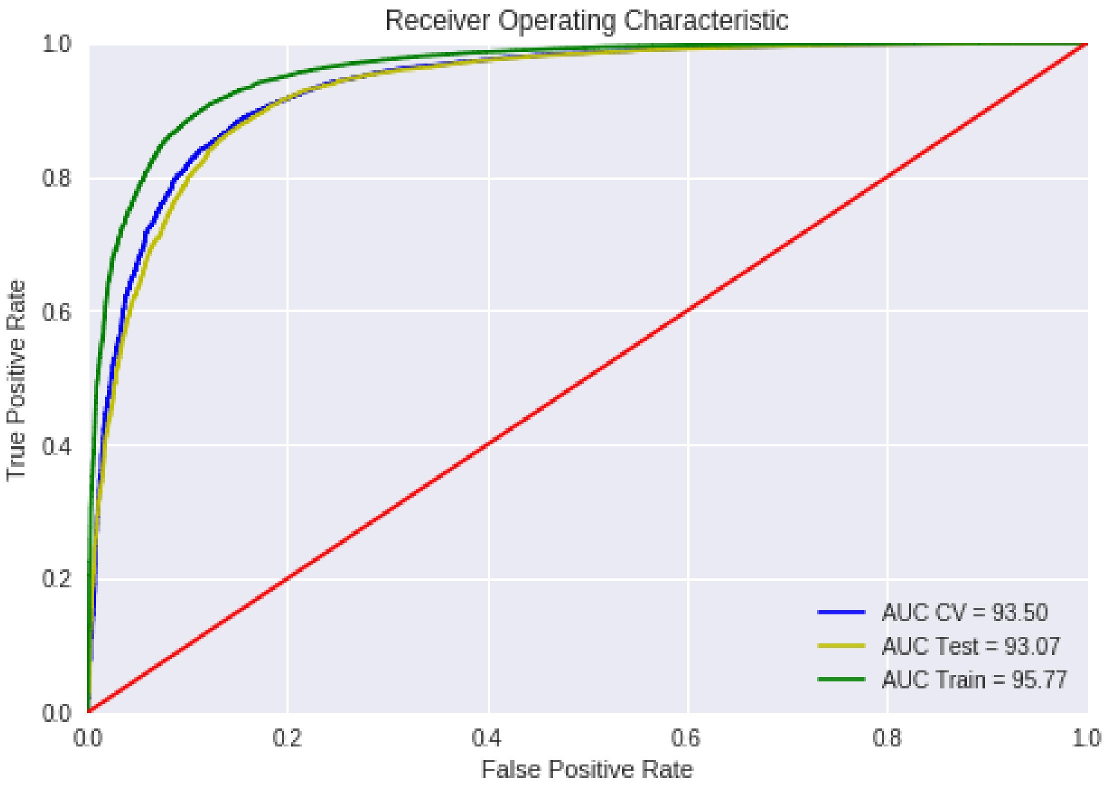
```
In [34]: i = 0.0001
         LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
         calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
         calibrated_clf.fit(bow_train, train_y)
         # train data
         y_prob_train = calibrated_clf.predict_proba(bow_train)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100)
         # CV
         y_prob_cv = calibrated_clf.predict_proba(bow_cv)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
         # Test
         y_prob_test = calibrated_clf.predict_proba(bow_test)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(test_y , y_prob_test)
         print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

```
Train AUC for  = 0.0001 is 95.77%

CV AUC for  = 0.0001 is 93.50%

Test AUC for  = 0.0001 is 93.07%
```

```
In [46]: LSVM = SGDClassifier(loss='hinge',alpha=0.0001, penalty='l1')
         LSVM.fit(bow_train, train_y)

         # number of non-zero weights
         w = LSVM.coef_
         print("Number of weights : ", w.shape[1])
         print("Number of non-zero weights : ",np.count_nonzero(w))
```

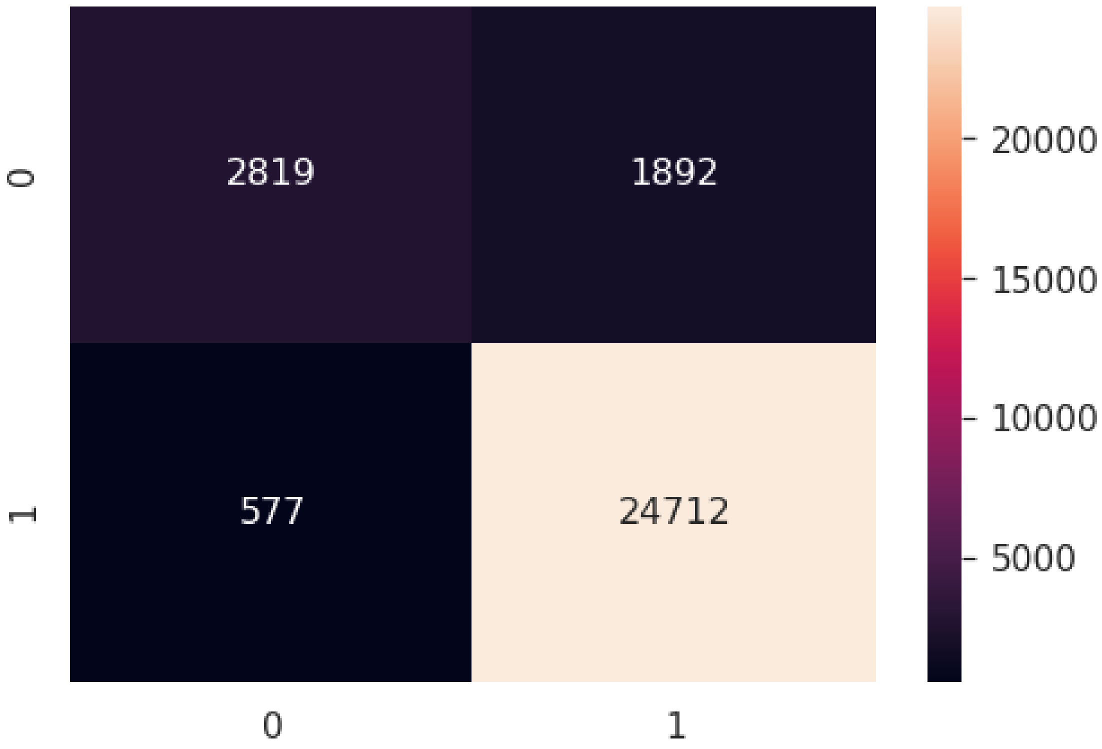
```
Number of weights :  8771
Number of non-zero weights :  2306
```

```
In [36]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```



```
In [44]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))

F1-Score on test set: 0.95
```

```
In [45]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[45]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70c5a679e8>
```



7.1.3 [5.1.2] Applying Linear SVM on TFIDF, SET 2

```
In [47]: # Please write all the code with proper documentation

         model = TfidfVectorizer(min_df=20, ngram_range=(1,2))
         #tf_idf_matrix = model.fit_transform(train)

         print("================Train Data===========")
         tf_idf_train = model.fit_transform(train)
         print("the type of count vectorizer ",type(tf_idf_train))
         print("the shape of out text TFIDF vectorizer ",tf_idf_train.get_shape())
         print("the number of unique words including both unigrams and bigrams ",tf_idf_train.g
         print("================CV Data===========")
         tf_idf_cv = model.transform(cv)
         print("the type of count vectorizer ",type(tf_idf_cv))
         print("the shape of out text TFIDF vectorizer ",tf_idf_cv.get_shape())
         print("the number of unique words including both unigrams and bigrams ",tf_idf_cv.get_
         print("================Test Data===========")
         tf_idf_test = model.transform(test)
         print("the type of count vectorizer ",type(tf_idf_test))
         print("the shape of out text TFIDF vectorizer ",tf_idf_test.get_shape())
         print("the number of unique words including both unigrams and bigrams ", tf_idf_test.g
         # 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_)))
```

```
================Train Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (49000, 13648)
the number of unique words including both unigrams and bigrams  13648
================CV Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (21000, 13648)
the number of unique words including both unigrams and bigrams  13648
================Test Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (30000, 13648)
the number of unique words including both unigrams and bigrams  13648
```

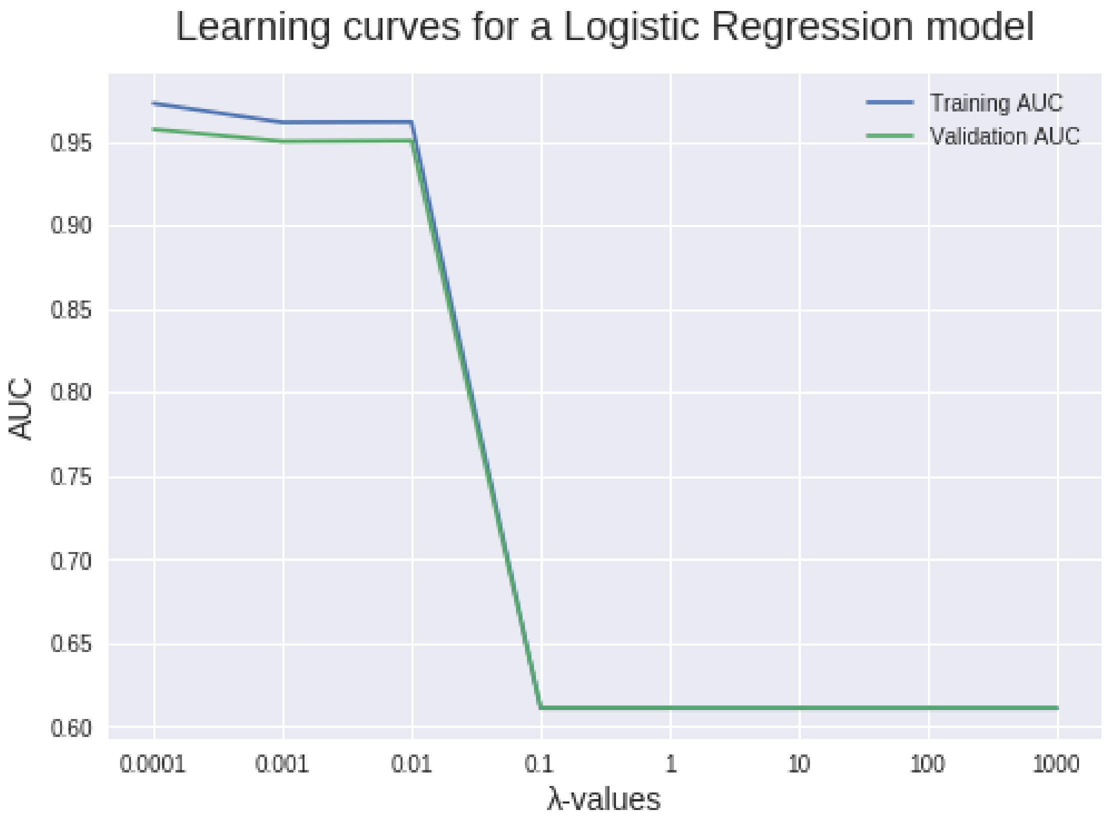
```
In [51]: alpha = [pow(10,j) for j in range(-4,4,1)]

         tfidf_train_auc = []
         tfidf_cv_auc = []
         for i in alpha:
             LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
             calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
             calibrated_clf.fit(tf_idf_train, train_y)
             # train data
             y_prob_train = calibrated_clf.predict_proba(tf_idf_train)[:,1]
             y_pred = np.where(y_prob_train > 0.5, 1, 0)
             auc_roc_train = roc_auc_score(train_y , y_prob_train)
             print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(
             tfidf_train_auc.append(auc_roc_train)
             # CV
             y_prob_cv = calibrated_clf.predict_proba(tf_idf_cv)[:,1]
             y_pred = np.where(y_prob_cv > 0.5, 1, 0)
             auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
             print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100)))
             tfidf_cv_auc.append(auc_roc_cv)
             print("="*50)
```

```
Train AUC for  = 0.0001 is 97.29%

CV AUC for  = 0.0001 is 95.73%
==================================================

Train AUC for  = 0.001 is 96.14%
```

```
CV AUC for  = 0.001 is 95.00%
==================================================

Train AUC for  = 0.01 is 96.17%

CV AUC for  = 0.01 is 95.04%
==================================================

Train AUC for  = 0.1 is 61.07%

CV AUC for  = 0.1 is 61.09%
==================================================

Train AUC for  = 1 is 61.07%

CV AUC for  = 1 is 61.09%
==================================================

Train AUC for  = 10 is 61.07%

CV AUC for  = 10 is 61.09%
==================================================

Train AUC for  = 100 is 61.07%

CV AUC for  = 100 is 61.09%
==================================================

Train AUC for  = 1000 is 61.07%

CV AUC for  = 1000 is 61.09%
==================================================
```

```
In [52]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(hyper,tfidf_train_auc,label = 'Training AUC')
         plt.plot(hyper, tfidf_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC', fontsize = 14)
         plt.xlabel('\u03BB-values', fontsize = 14)
         plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03)
         plt.legend()
```

```
Out[52]: <matplotlib.legend.Legend at 0x7f70a948abe0>
```

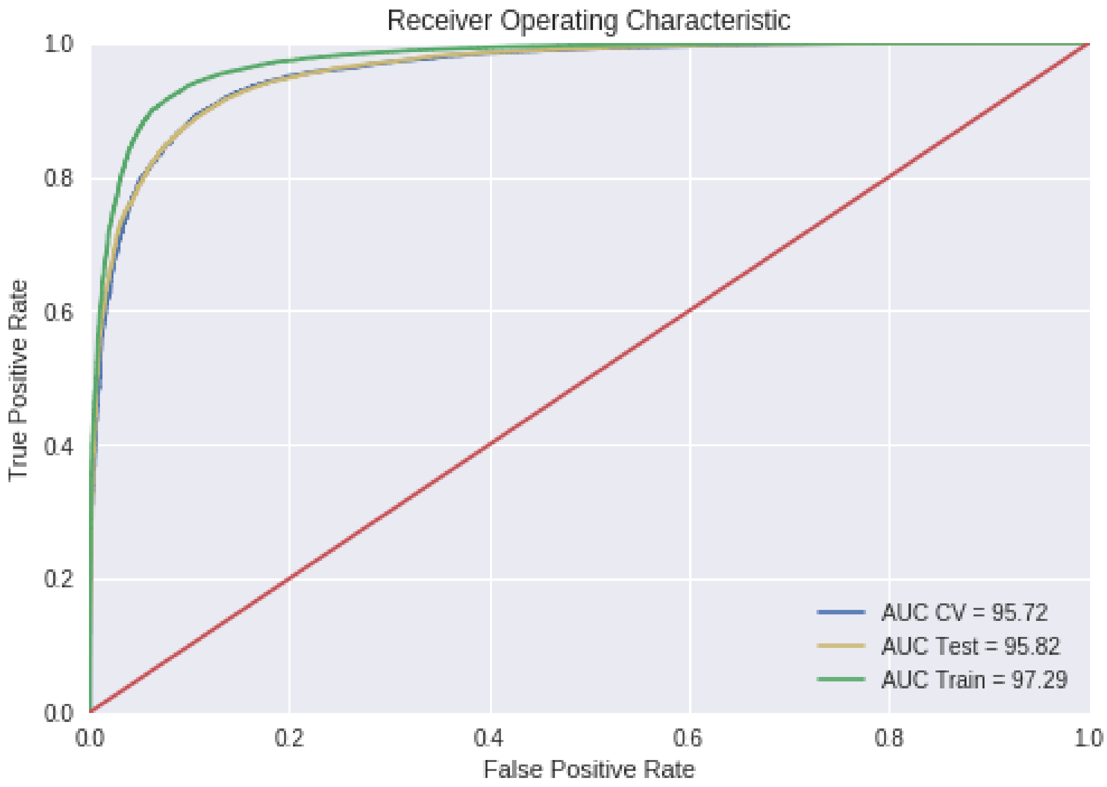


```
In [53]: i = 0.0001
         LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
         calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
         calibrated_clf.fit(tf_idf_train, train_y)
         # train data
         y_prob_train = calibrated_clf.predict_proba(tf_idf_train)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100)
         # CV
         y_prob_cv = calibrated_clf.predict_proba(tf_idf_cv)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
         # Test
         y_prob_test = calibrated_clf.predict_proba(tf_idf_test)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
```

```
y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
auc_roc_test = roc_auc_score(test_y , y_prob_test)
print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

```
Train AUC for  = 0.0001 is 97.29%

CV AUC for  = 0.0001 is 95.72%

Test AUC for  = 0.0001 is 95.82%
```

```
In [54]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.clf()
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```

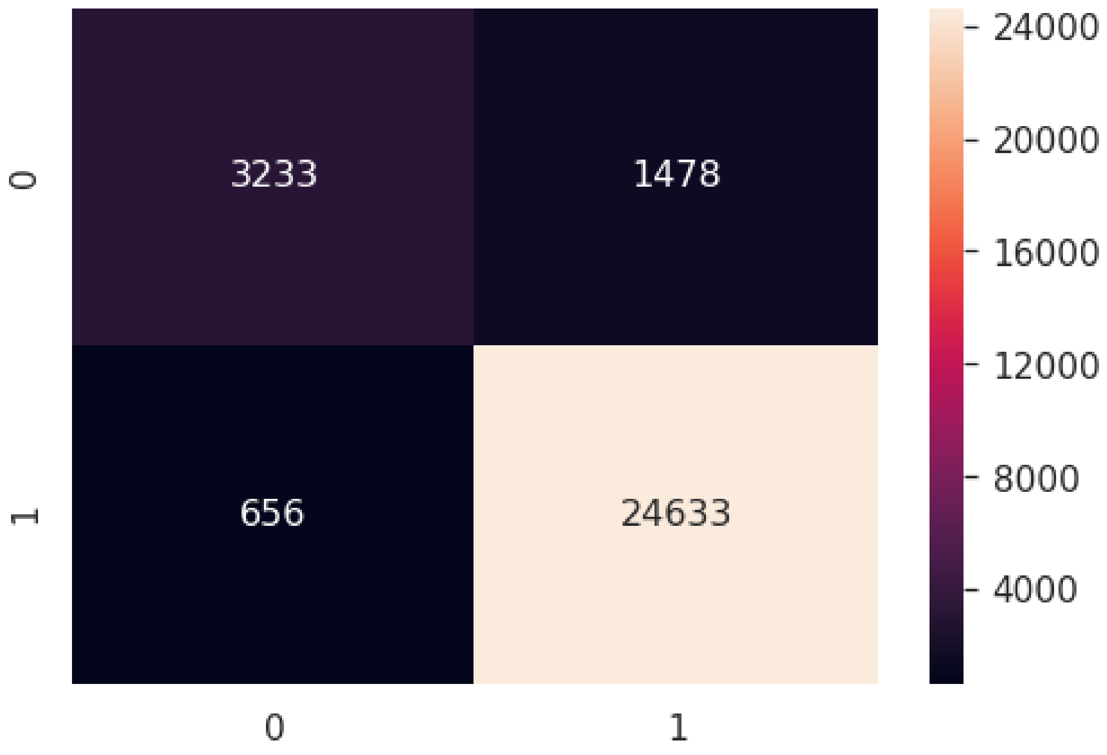


```
In [55]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.96
```

```
In [56]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[56]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70ade07f98>
```



```
In [71]: LSVM = SGDClassifier(loss='hinge',alpha=0.0001, penalty='l2')
         LSVM.fit(tf_idf_train, train_y)

         # number of non-zero weights
         w = LSVM.coef_
         print("Number of weights : ", w.shape[1])
         print("Number of non-zero weights : ",np.count_nonzero(w))
```

```
Number of weights :  13648
Number of non-zero weights :  13626
```

Top 10 important features of positive class

```
In [72]: # Please write all the code with proper documentation
         # Please write all the code with proper documentation
         feture_weights = w.tolist()[0]
         feature_names = model.get_feature_names()
         features = dict(zip(feture_weights,feature_names))
```

```
In [73]: features_df = pd.DataFrame.from_dict(features, orient='index')
         sorted_features = features_df.sort_index(axis=0,ascending=False )
```

```
In [74]: sorted_features.head(10)
```

```
Out[74]:                         0
         3.520651             great
         2.848719              best
         2.816173  not disappointed
         2.658403         delicious
         2.384709              good
         2.140364           perfect
         2.136886              love
         2.105295         excellent
         1.771214             tasty
         1.736261             loves
```

7.1.4 Top 10 important features of negative class

```
In [75]: # Please write all the code with proper documentation
         sorted_features = features_df.sort_index(axis=0,ascending=True)
         sorted_features.head(10)
```

```
Out[75]:                       0
         -4.553429   disappointed
         -3.342798          worst
         -3.265935       terrible
         -3.085888          awful
         -2.990699        not buy
         -2.934224       horrible
         -2.857275      not worth
         -2.834140       not good
         -2.823619  disappointing
         -2.783166            not
```

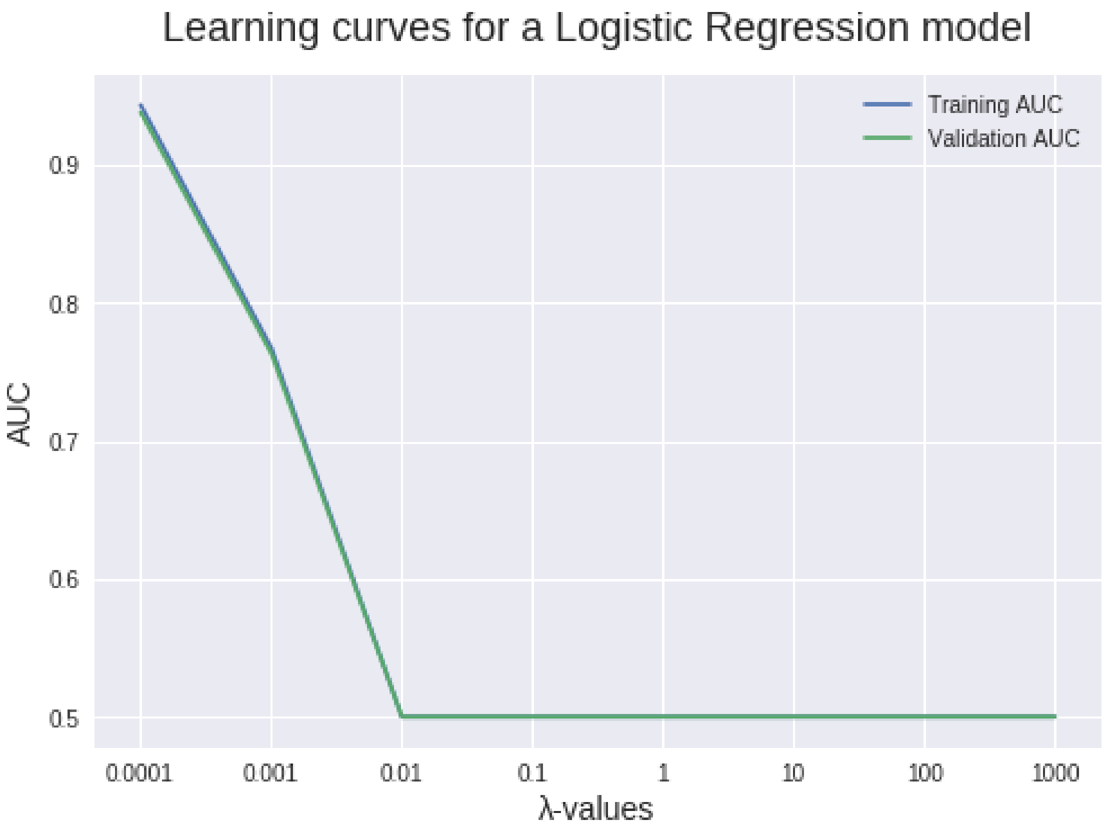
using L1 regulirization

```
In [57]: alpha = [pow(10,j) for j in range(-4,4,1)]

         tfidf_train_auc = []
         tfidf_cv_auc = []
         for i in alpha:
             LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
             calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
             calibrated_clf.fit(tf_idf_train, train_y)
             # train data
             y_prob_train = calibrated_clf.predict_proba(tf_idf_train)[:,1]
             y_pred = np.where(y_prob_train > 0.5, 1, 0)
             auc_roc_train = roc_auc_score(train_y , y_prob_train)
             print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(
             tfidf_train_auc.append(auc_roc_train)
             # CV
```

```
        y_prob_cv = calibrated_clf.predict_proba(tf_idf_cv)[:,1]
        y_pred = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
        print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100)))
        tfidf_cv_auc.append(auc_roc_cv)
        print("="*50)
```

```
Train AUC for  = 0.0001 is 94.34%

CV AUC for  = 0.0001 is 93.81%
==================================================

Train AUC for  = 0.001 is 76.74%

CV AUC for  = 0.001 is 76.31%
==================================================

Train AUC for  = 0.01 is 50.00%

CV AUC for  = 0.01 is 50.00%
==================================================

Train AUC for  = 0.1 is 50.00%

CV AUC for  = 0.1 is 50.00%
==================================================

Train AUC for  = 1 is 50.00%

CV AUC for  = 1 is 50.00%
==================================================

Train AUC for  = 10 is 50.00%

CV AUC for  = 10 is 50.00%
==================================================

Train AUC for  = 100 is 50.00%

CV AUC for  = 100 is 50.00%
==================================================

Train AUC for  = 1000 is 50.00%

CV AUC for  = 1000 is 50.00%
==================================================
In [58]: # https://www.dataquest.io/blog/learning-curves-machine-learning/

         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(hyper,tfidf_train_auc,label = 'Training AUC')
         plt.plot(hyper, tfidf_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC', fontsize = 14)
         plt.xlabel('\u03BB-values', fontsize = 14)
         plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03)
         plt.legend()
```

```
Out[58]: <matplotlib.legend.Legend at 0x7f70ad431668>
```

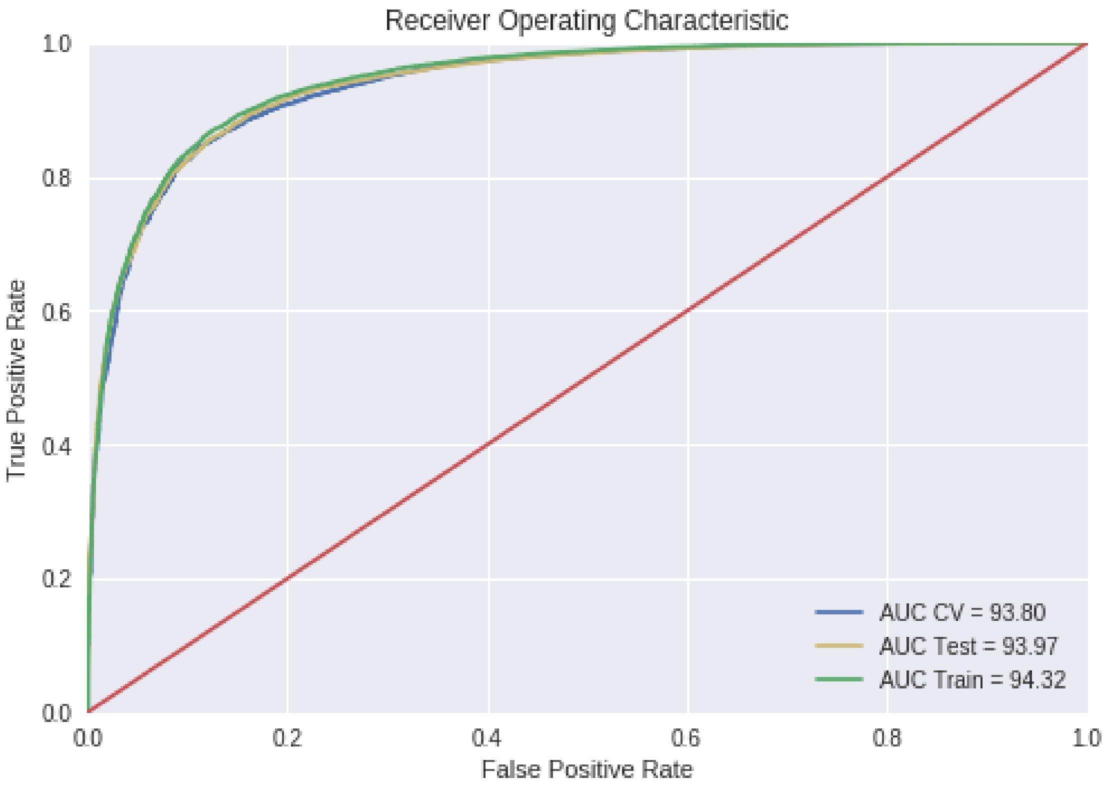


```
In [59]: i = 0.0001
         LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
         calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
         calibrated_clf.fit(tf_idf_train, train_y)
```

```
        # train data
        y_prob_train = calibrated_clf.predict_proba(tf_idf_train)[:,1]
        fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
        y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
        auc_roc_train = roc_auc_score(train_y , y_prob_train)
        print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100)
        # CV
        y_prob_cv = calibrated_clf.predict_proba(tf_idf_cv)[:,1]
        fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
        y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
        auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
        print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
        # Test
        y_prob_test = calibrated_clf.predict_proba(tf_idf_test)[:,1]
        fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
        y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
        auc_roc_test = roc_auc_score(test_y , y_prob_test)
        print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

```
Train AUC for  = 0.0001 is 94.32%

CV AUC for  = 0.0001 is 93.80%

Test AUC for  = 0.0001 is 93.97%
```

```
In [60]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.clf()
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```



```
In [61]: LSVM = SGDClassifier(loss='hinge',alpha=0.0001, penalty='l1')
         LSVM.fit(tf_idf_train, train_y)

         # number of non-zero weights
         w = LSVM.coef_
         print("Number of weights : ", w.shape[1])
         print("Number of non-zero weights : ",np.count_nonzero(w))
```

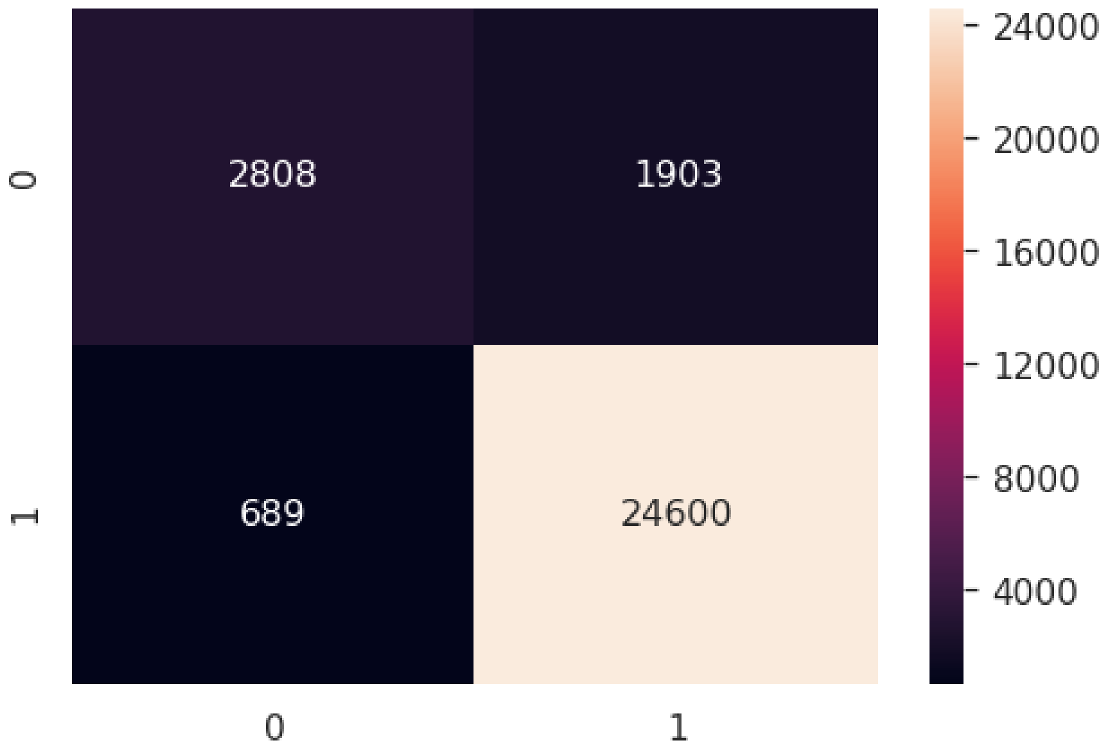
```
Number of weights :  13648
Number of non-zero weights :  397
```

```
In [62]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.95
```

```
In [63]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[63]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70ae92aac8>
```



7.1.5 [5.1.3] Applying Linear SVM on AVG W2V, SET 3

```
In [76]: # Train your own Word2Vec model using your own text corpus
         ######## Train Set #########
         i=0
         list_of_train_sentance=[]
         for sentance in train:
             list_of_train_sentance.append(sentance.split())
         ######## CV Set ###########
         i=0
         list_of_cv_sentance=[]
         for sentance in cv:
             list_of_cv_sentance.append(sentance.split())
         ######## Test Set #########
         i=0
         list_of_test_sentance=[]
         for sentance in test:
             list_of_test_sentance.append(sentance.split())
         print("Length of Train = ", len(list_of_train_sentance))
         print("Length of CV = ", len(list_of_cv_sentance))
         print("Length of Test = ", len(list_of_test_sentance))
```

```
Length of Train =  49000
Length of CV =  21000
Length of Test =  30000
```

```
In [77]: w2v_model=Word2Vec(list_of_train_sentance,min_count=15,size=100, workers=4)
         print(w2v_model.wv.most_similar('great'))
         print('='*50)
         print(w2v_model.wv.most_similar('worst'))
```

```
[('terrific', 0.7772042751312256), ('excellent', 0.7740203142166138), ('fantastic', 0.76137471
==================================================
[('best', 0.7626129984855652), ('greatest', 0.7530427575111389), ('tastiest', 0.68608349561691
```

```
In [78]: 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  7492
sample words  ['fully', 'intended', 'take', 'work', 'share', 'friend', 'addictive', 'ended', '
```

```
In [79]: ######## Train data ########
         # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this lis
         for sent in tqdm(list_of_train_sentance): # for each review/sentence
             sent_vec = np.zeros(100) # 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_train.append(sent_vec)
         print(len(sent_vectors_train))
         print(len(sent_vectors_train[0]))
```

```
100%|| 49000/49000 [02:16<00:00, 407.72it/s]

49000
100
```

```
In [80]: ######## CV data ########
         # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_cv_sentance): # for each review/sentence
             sent_vec = np.zeros(100) # 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_cv.append(sent_vec)
         print(len(sent_vectors_cv))
         print(len(sent_vectors_cv[0]))
```

```
100%|| 21000/21000 [00:58<00:00, 356.99it/s]

21000
100
```

```
In [81]: ######## Test data ########
         # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_test_sentance): # for each review/sentence
             sent_vec = np.zeros(100) # 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_test.append(sent_vec)
         print(len(sent_vectors_test))
         print(len(sent_vectors_test[0]))
```

```
100%|| 30000/30000 [01:20<00:00, 372.50it/s]

30000
100
```

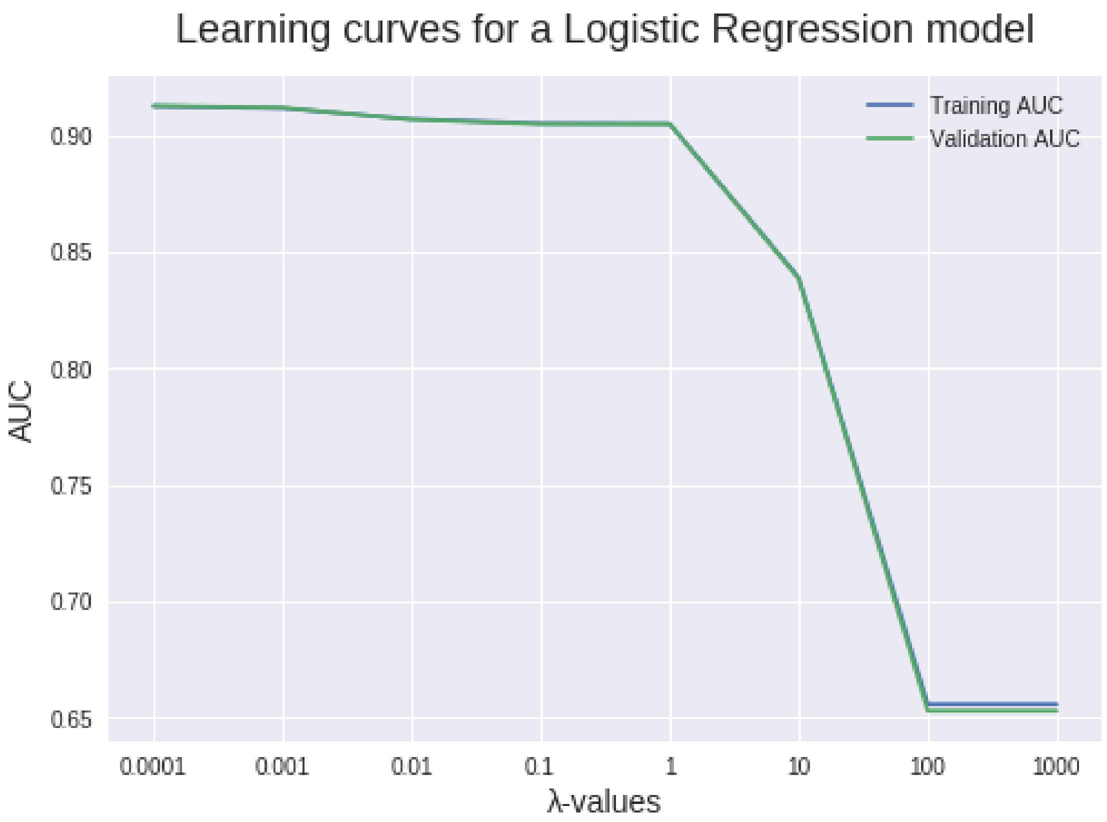
```
In [82]: # save the datasets as numpy array
         w2v_train = np.array(sent_vectors_train)
         w2v_cv = np.array(sent_vectors_cv)
         w2v_test = np.array(sent_vectors_test)
```

7.1.6 Using L2 regularization

```
In [87]: alpha = [pow(10,j) for j in range(-4,4,1)]

         w2v_train_auc = []
         w2v_cv_auc = []
         for i in alpha:
             LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
             calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
             calibrated_clf.fit(w2v_train, train_y)
             # train data
             y_prob_train = calibrated_clf.predict_proba(w2v_train)[:,1]
             y_pred = np.where(y_prob_train > 0.5, 1, 0)
             auc_roc_train = roc_auc_score(train_y , y_prob_train)
             print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(
             w2v_train_auc.append(auc_roc_train)
             # CV
             y_prob_cv = calibrated_clf.predict_proba(w2v_cv)[:,1]
             y_pred = np.where(y_prob_cv > 0.5, 1, 0)
             auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
             print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100)))
             w2v_cv_auc.append(auc_roc_cv)
             print("="*50)
```

```

Train AUC for  = 0.0001 is 91.25%

CV AUC for  = 0.0001 is 91.26%
==================================================

Train AUC for  = 0.001 is 91.16%

CV AUC for  = 0.001 is 91.19%
==================================================

Train AUC for  = 0.01 is 90.69%

CV AUC for  = 0.01 is 90.67%
==================================================
Train AUC for  = 0.1 is 90.51%

CV AUC for  = 0.1 is 90.48%
==================================================

Train AUC for  = 1 is 90.49%

CV AUC for  = 1 is 90.48%
==================================================

Train AUC for  = 10 is 83.90%

CV AUC for  = 10 is 83.83%
==================================================

Train AUC for  = 100 is 65.58%

CV AUC for  = 100 is 65.29%
==================================================

Train AUC for  = 1000 is 65.58%

CV AUC for  = 1000 is 65.29%
==================================================
```

```
In [88]: hyper = [str(pow(10,j)) for j in range(-4,4)]
         # https://www.dataquest.io/blog/learning-curves-machine-learning/

         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(hyper,w2v_train_auc,label = 'Training AUC')
         plt.plot(hyper, w2v_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC', fontsize = 14)
         plt.xlabel('\u03BB-values', fontsize = 14)
         plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03)
         plt.legend()

Out[88]: <matplotlib.legend.Legend at 0x7f7088b65400>
```

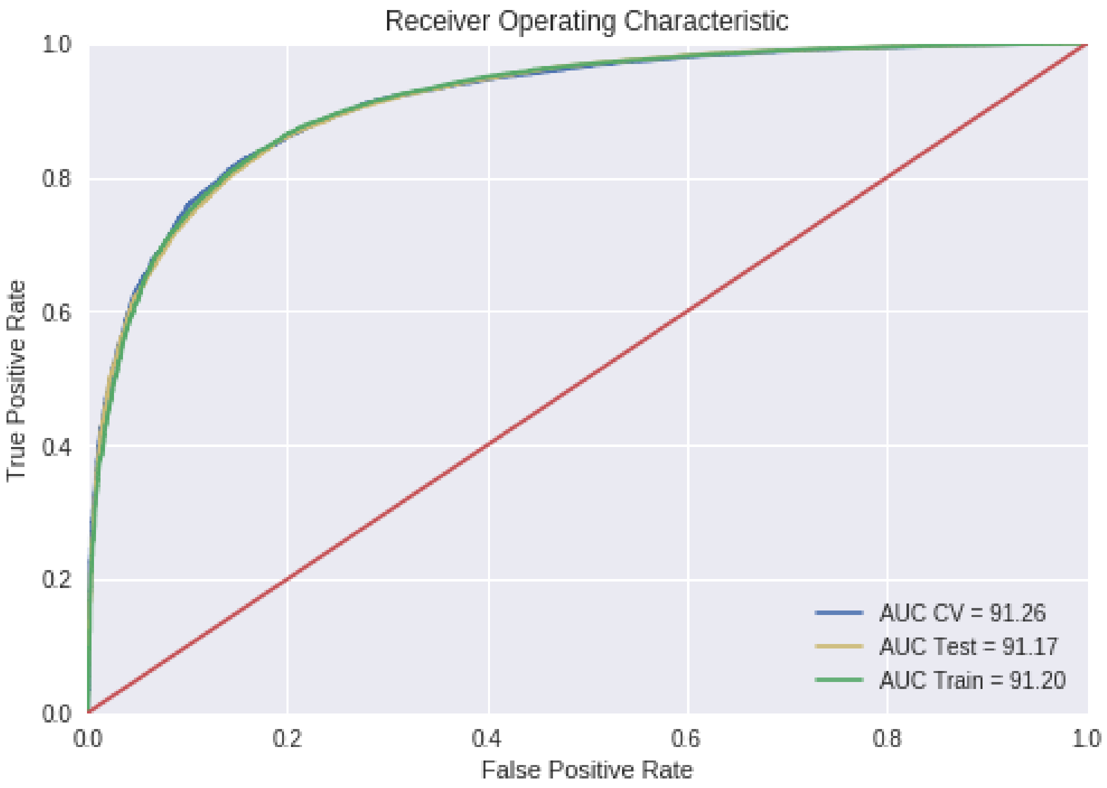


In [90]:
```
i = 0.0001
LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
calibrated_clf.fit(w2v_train, train_y)
# train data
y_prob_train = calibrated_clf.predict_proba(w2v_train)[:,1]
fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
auc_roc_train = roc_auc_score(train_y , y_prob_train)
print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100))
# CV
y_prob_cv = calibrated_clf.predict_proba(w2v_cv)[:,1]
fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
# Test
y_prob_test = calibrated_clf.predict_proba(w2v_test)[:,1]
fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
auc_roc_test = roc_auc_score(test_y , y_prob_test)
```

```
        print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

```
Train AUC for  = 0.0001 is 91.20%

CV AUC for  = 0.0001 is 91.26%

Test AUC for  = 0.0001 is 91.17%
```

```
In [91]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.clf()
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```

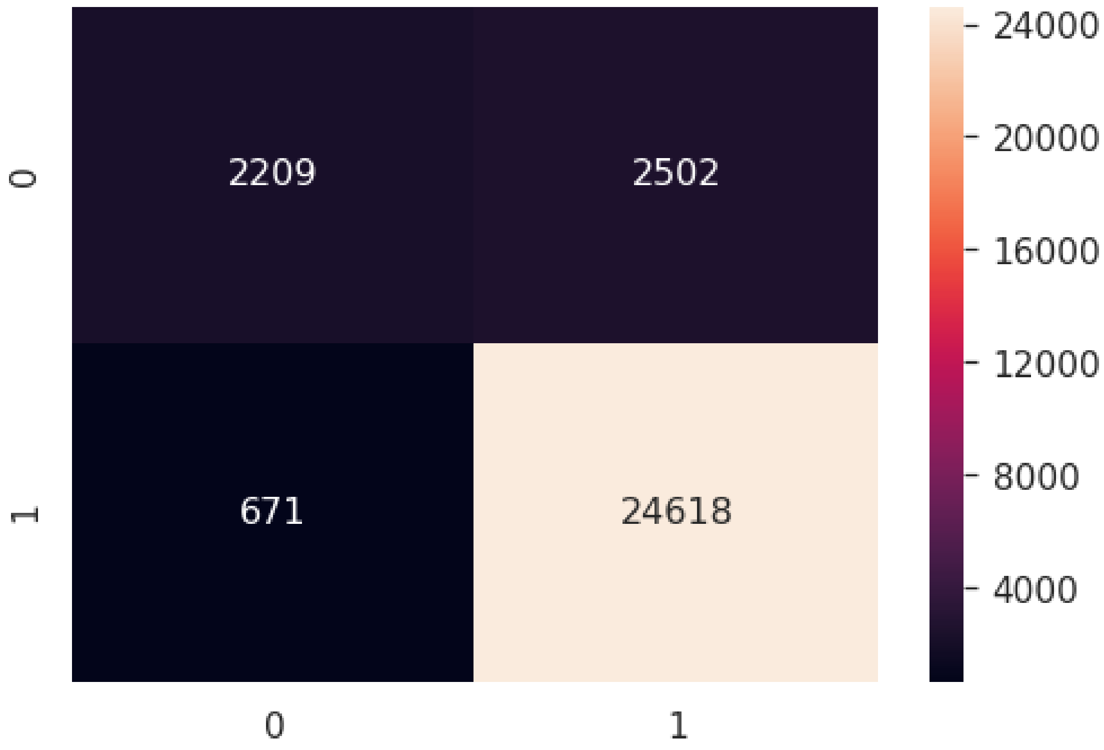


```
In [92]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.94
```

```
In [93]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[93]: <matplotlib.axes._subplots.AxesSubplot at 0x7f7088b4deb8>
```



7.1.7 using L1

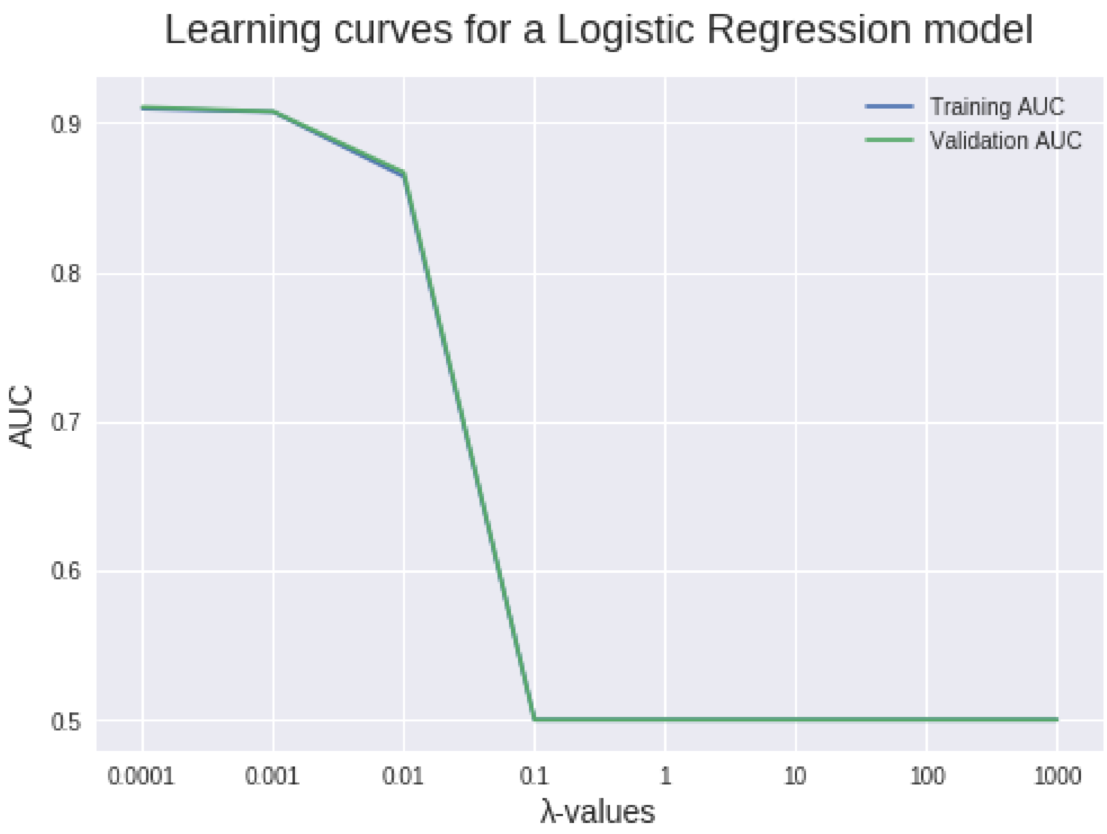
```
In [94]: alpha = [pow(10,j) for j in range(-4,4,1)]

         w2v_train_auc = []
         w2v_cv_auc = []
         for i in alpha:
             LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
             calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
```

```
            calibrated_clf.fit(w2v_train, train_y)
            # train data
            y_prob_train = calibrated_clf.predict_proba(w2v_train)[:,1]
            y_pred = np.where(y_prob_train > 0.5, 1, 0)
            auc_roc_train = roc_auc_score(train_y , y_prob_train)
            print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(
            w2v_train_auc.append(auc_roc_train)
            # CV
            y_prob_cv = calibrated_clf.predict_proba(w2v_cv)[:,1]
            y_pred = np.where(y_prob_cv > 0.5, 1, 0)
            auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
            print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100)))
            w2v_cv_auc.append(auc_roc_cv)
            print("="*50)
```

```
Train AUC for  = 0.0001 is 90.96%

CV AUC for  = 0.0001 is 91.07%
==================================================

Train AUC for  = 0.001 is 90.75%

CV AUC for  = 0.001 is 90.77%
==================================================

Train AUC for  = 0.01 is 86.41%

CV AUC for  = 0.01 is 86.68%
==================================================

Train AUC for  = 0.1 is 50.00%

CV AUC for  = 0.1 is 50.00%
==================================================

Train AUC for  = 1 is 50.00%

CV AUC for  = 1 is 50.00%
==================================================

Train AUC for  = 10 is 50.00%

CV AUC for  = 10 is 50.00%
==================================================

Train AUC for  = 100 is 50.00%
```

```
CV AUC for  = 100 is 50.00%
==================================================

Train AUC for  = 1000 is 50.00%

CV AUC for  = 1000 is 50.00%
==================================================
```

```
In [95]: hyper = [str(pow(10,j)) for j in range(-4,4)]
         # https://www.dataquest.io/blog/learning-curves-machine-learning/

         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(hyper,w2v_train_auc,label = 'Training AUC')
         plt.plot(hyper, w2v_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC', fontsize = 14)
         plt.xlabel('\u03BB-values', fontsize = 14)
         plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03)
         plt.legend()

Out[95]: <matplotlib.legend.Legend at 0x7f7088a23908>
```

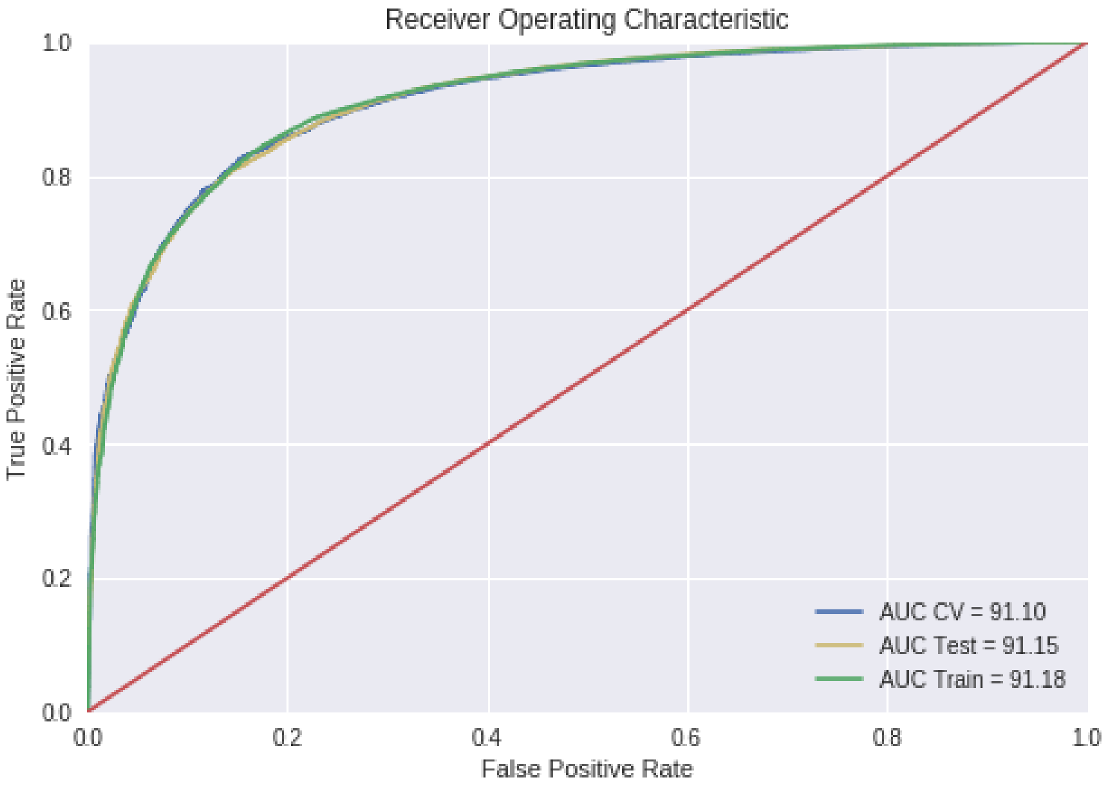


```
In [96]: i = 0.0001
         LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
         calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
         calibrated_clf.fit(w2v_train, train_y)
         # train data
         y_prob_train = calibrated_clf.predict_proba(w2v_train)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100)
         # CV
         y_prob_cv = calibrated_clf.predict_proba(w2v_cv)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
         # Test
         y_prob_test = calibrated_clf.predict_proba(w2v_test)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(test_y , y_prob_test)
```

```
        print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

```
Train AUC for  = 0.0001 is 91.18%

CV AUC for  = 0.0001 is 91.10%

Test AUC for  = 0.0001 is 91.15%
```

```
In [97]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.clf()
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```

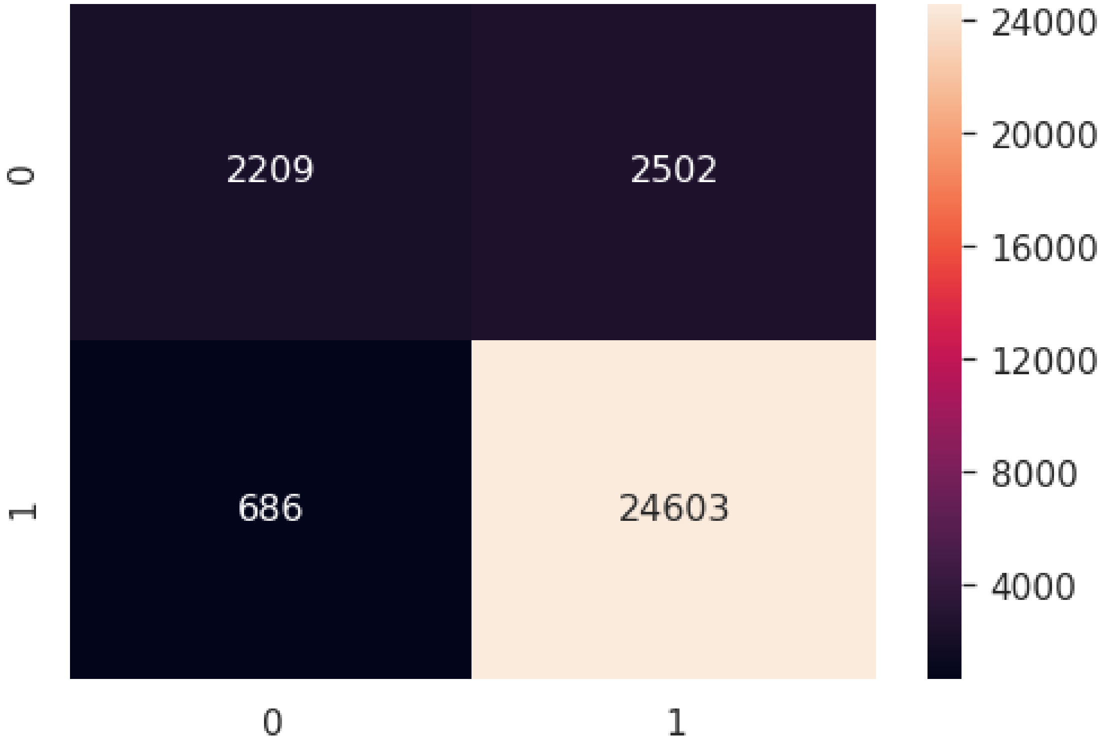


```
In [98]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.94
```

```
In [99]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[99]: <matplotlib.axes._subplots.AxesSubplot at 0x7f7088a4c780>
```



7.1.8 [5.1.4] Applying Linear SVM on TFIDF W2V, SET 4

```
In [100]: # Please write all the code with proper documentation

          model = TfidfVectorizer()
          #tf_idf_matrix = model.fit_transform(train)

          print("===============Train Data==========")
          final_tf_idf_train = model.fit_transform(train)
          print("the type of count vectorizer ",type(final_tf_idf_train))
          print("the shape of out text TFIDF vectorizer ",final_tf_idf_train.get_shape())
          print("the number of unique words including both unigrams and bigrams ", final_tf_id
          print("================CV Data===========")
          final_tf_idf_cv = model.transform(cv)
          print("the type of count vectorizer ",type(final_tf_idf_cv))
          print("the shape of out text TFIDF vectorizer ",final_tf_idf_cv.get_shape())
          print("the number of unique words including both unigrams and bigrams ", final_tf_id
          print("================Test Data===========")
          final_tf_idf_test = model.transform(test)
          print("the type of count vectorizer ",type(final_tf_idf_test))
          print("the shape of out text TFIDF vectorizer ",final_tf_idf_test.get_shape())
          print("the number of unique words including both unigrams and bigrams ", final_tf_id

          # 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_)))
```

```
================Train Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (49000, 43052)
the number of unique words including both unigrams and bigrams  43052
================CV Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (21000, 43052)
the number of unique words including both unigrams and bigrams  43052
================Test Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (30000, 43052)
the number of unique words including both unigrams and bigrams  43052
```

```
In [101]: ######## Train #######
          # 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 = tfid

          train_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in
          row=0;
          for sent in tqdm(list_of_train_sentance): # for each review/sentence
              sent_vec = np.zeros(100) # 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
        train_tfidf_sent_vectors.append(sent_vec)
        row += 1
```

```
100%|| 49000/49000 [2:48:30<00:00,  4.85it/s]
```

```
In [102]: ######## CV #######
          # 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 = tfid

          cv_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in th
          row=0;
          for sent in tqdm(list_of_cv_sentance): # for each review/sentence
              sent_vec = np.zeros(100) # 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
              cv_tfidf_sent_vectors.append(sent_vec)
              row += 1
```

```
100%|| 21000/21000 [16:02<00:00, 15.38it/s]
```

```
In [103]: ######## Train #######
          # 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 = tfid

          test_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in
          row=0;
          for sent in tqdm(list_of_test_sentance): # for each review/sentence
              sent_vec = np.zeros(100) # 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
    test_tfidf_sent_vectors.append(sent_vec)
    row += 1
```

```
100%|| 30000/30000 [24:36<00:00, 20.31it/s]
```

```
In [104]: # save the datasets as numpy array
          tfidf_w2v_train = np.array(train_tfidf_sent_vectors)
          tfidf_w2v_cv = np.array(cv_tfidf_sent_vectors)
          tfidf_w2v_test = np.array(test_tfidf_sent_vectors)
```

7.1.9 using L2 regularization

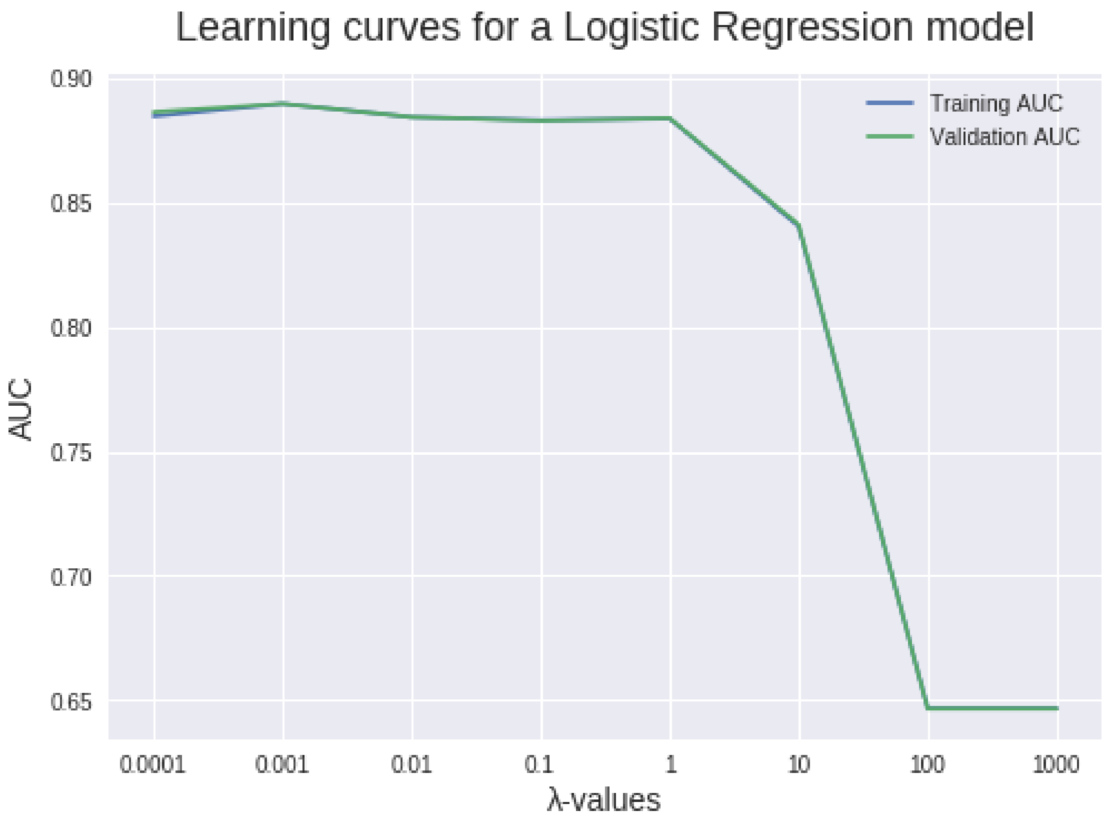
```
In [105]: alpha = [pow(10,j) for j in range(-4,4,1)]

          tfidf_w2v_train_auc = []
          tfidf_w2v_cv_auc = []
          for i in alpha:
              LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
              calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
              calibrated_clf.fit(tfidf_w2v_train, train_y)
              # train data
              y_prob_train = calibrated_clf.predict_proba(tfidf_w2v_train)[:,1]
              y_pred = np.where(y_prob_train > 0.5, 1, 0)
              auc_roc_train = roc_auc_score(train_y , y_prob_train)
              print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float
              tfidf_w2v_train_auc.append(auc_roc_train)
              # CV
              y_prob_cv = calibrated_clf.predict_proba(tfidf_w2v_cv)[:,1]
              y_pred = np.where(y_prob_cv > 0.5, 1, 0)
              auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
              print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))
              tfidf_w2v_cv_auc.append(auc_roc_cv)
              print("="*50)
```

```
Train AUC for  = 0.0001 is 88.49%
```

```
CV AUC for  = 0.0001 is 88.65%
==================================================

Train AUC for  = 0.001 is 88.98%

CV AUC for  = 0.001 is 88.99%
==================================================

Train AUC for  = 0.01 is 88.45%

CV AUC for  = 0.01 is 88.45%
==================================================

Train AUC for  = 0.1 is 88.33%

CV AUC for  = 0.1 is 88.31%
==================================================

Train AUC for  = 1 is 88.39%

CV AUC for  = 1 is 88.41%
==================================================

Train AUC for  = 10 is 84.05%

CV AUC for  = 10 is 84.13%
==================================================

Train AUC for  = 100 is 64.66%

CV AUC for  = 100 is 64.65%
==================================================

Train AUC for  = 1000 is 64.66%

CV AUC for  = 1000 is 64.65%
==================================================
```

```
In [106]: hyper = [str(pow(10,j)) for j in range(-4,4)]
          # https://www.dataquest.io/blog/learning-curves-machine-learning/

          import matplotlib.pyplot as plt
          %matplotlib inline

          plt.style.use('seaborn')
          plt.plot(hyper,tfidf_w2v_train_auc,label = 'Training AUC')
          plt.plot(hyper, tfidf_w2v_cv_auc, label = 'Validation AUC')

          plt.ylabel('AUC', fontsize = 14)
          plt.xlabel('\u03BB-values', fontsize = 14)
          plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03
          plt.legend()
```

```
Out[106]: <matplotlib.legend.Legend at 0x7f70ad2f8668>
```

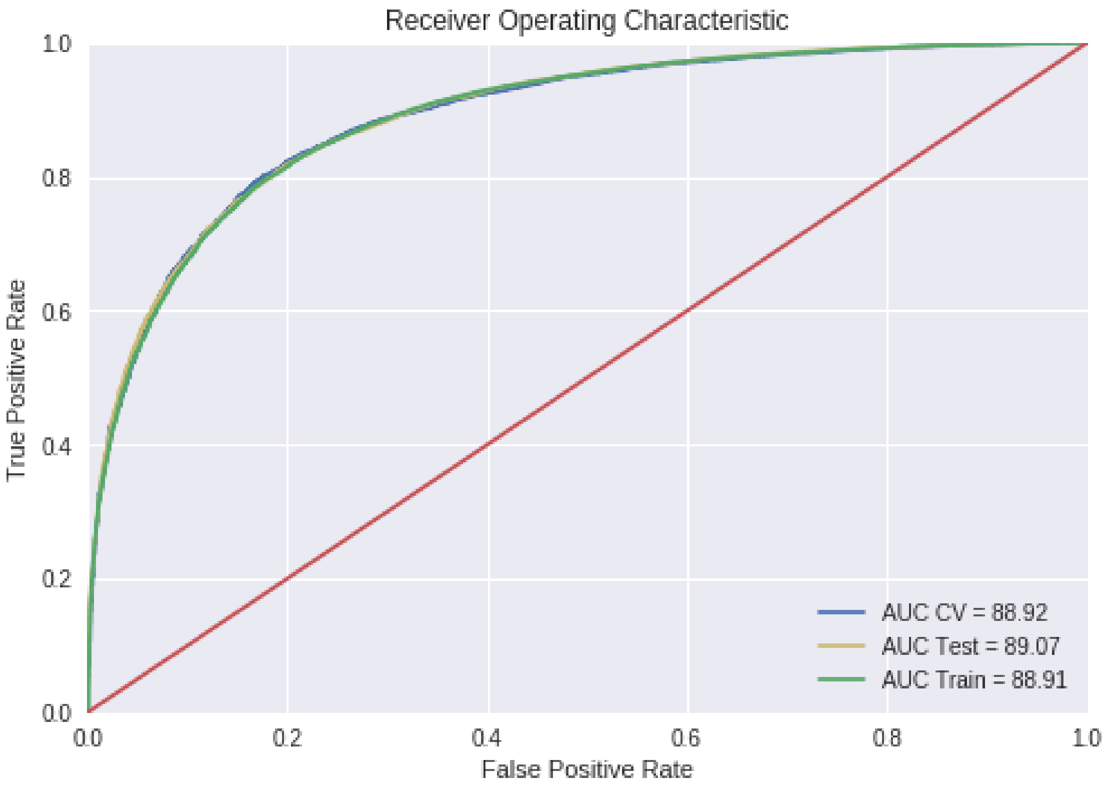


```
In [107]: i = 0.001
          LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
          calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
          calibrated_clf.fit(tfidf_w2v_train, train_y)
          # train data
          y_prob_train = calibrated_clf.predict_proba(tfidf_w2v_train)[:,1]
          fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
          y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_train = roc_auc_score(train_y , y_prob_train)
          print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100
          # CV
```

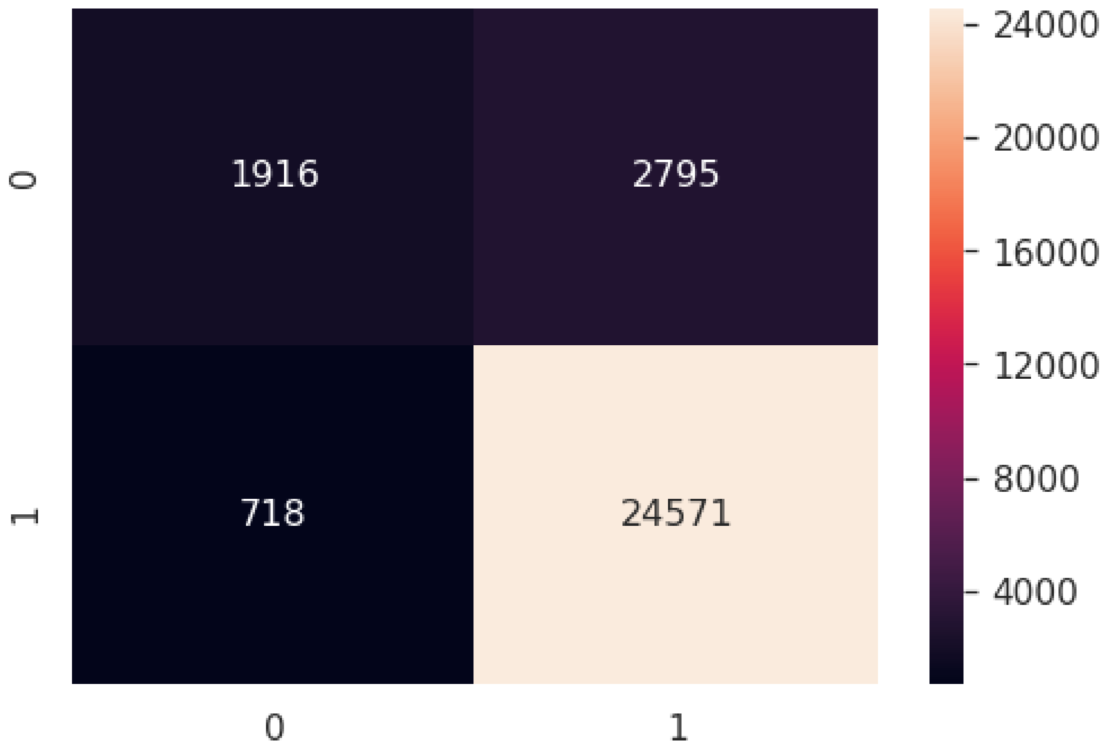
```
y_prob_cv = calibrated_clf.predict_proba(tfidf_w2v_cv)[:,1]
fprc, tprc, thrsholdc = roc_curve(cv_y, y_prob_cv)
y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
# Test
y_prob_test = calibrated_clf.predict_proba(tfidf_w2v_test)[:,1]
fprts, tprts, thrsholdts = roc_curve(test_y, y_prob_test)
y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
auc_roc_test = roc_auc_score(test_y , y_prob_test)
print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100))
```

```
Train AUC for  = 0.001 is 88.91%

CV AUC for  = 0.001 is 88.92%

Test AUC for  = 0.001 is 89.07%
```

```
In [108]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

          import matplotlib.pyplot as plt
          plt.clf()
          plt.title('Receiver Operating Characteristic')
          plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
          plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100))
          plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
          plt.legend(loc = 'lower right')
          plt.plot([0, 1], [0, 1],'r')
          plt.xlim([0, 1])
          plt.ylim([0, 1])
          plt.ylabel('True Positive Rate')
          plt.xlabel('False Positive Rate')
          plt.show()
```



```
In [109]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))

F1-Score on test set: 0.93


In [110]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
          sns.set(font_scale=1.4)
          sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[110]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70ad2faac8>
```



7.1.10 L1 regulirization

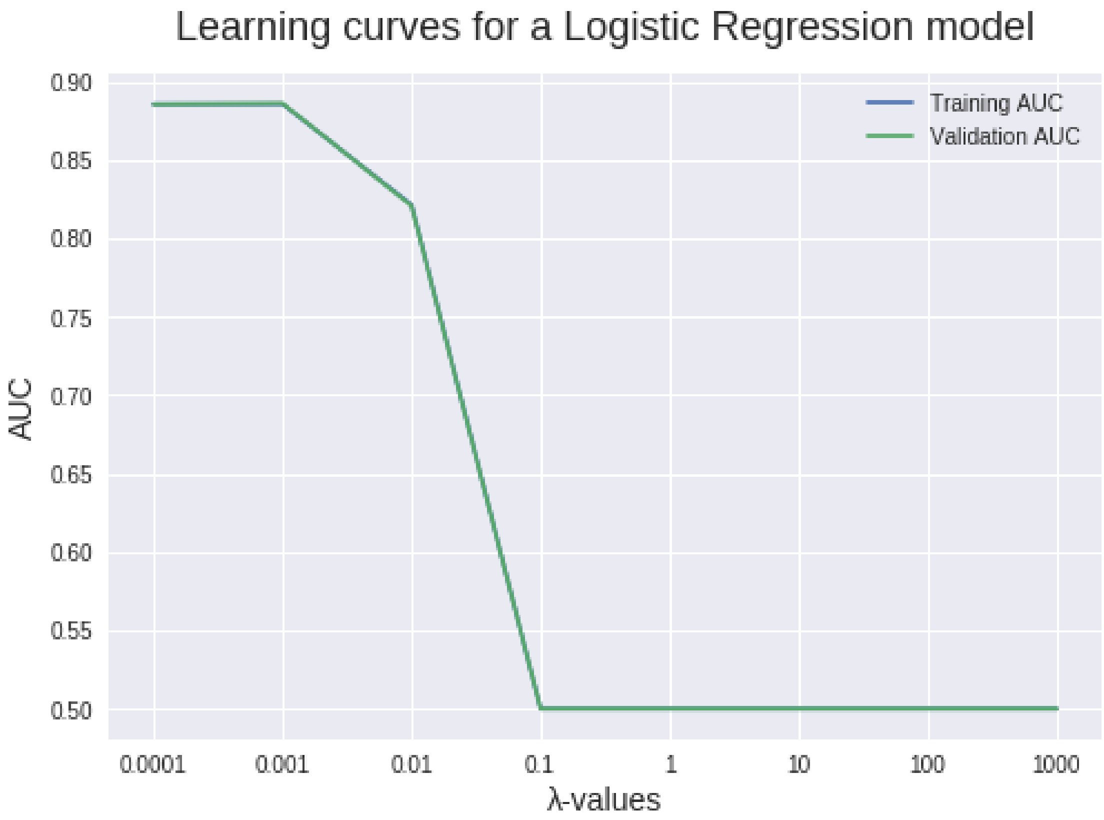
```
In [111]: alpha = [pow(10,j) for j in range(-4,4,1)]

          tfidf_w2v_train_auc = []
          tfidf_w2v_cv_auc = []
          for i in alpha:
              LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
              calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
              calibrated_clf.fit(tfidf_w2v_train, train_y)
              # train data
              y_prob_train = calibrated_clf.predict_proba(tfidf_w2v_train)[:,1]
              y_pred = np.where(y_prob_train > 0.5, 1, 0)
              auc_roc_train = roc_auc_score(train_y , y_prob_train)
              print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float
              tfidf_w2v_train_auc.append(auc_roc_train)
              # CV
              y_prob_cv = calibrated_clf.predict_proba(tfidf_w2v_cv)[:,1]
              y_pred = np.where(y_prob_cv > 0.5, 1, 0)
              auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
              print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))
              tfidf_w2v_cv_auc.append(auc_roc_cv)
              print("="*50)
```

```
Train AUC for  = 0.0001 is 88.57%

CV AUC for  = 0.0001 is 88.56%
==================================================

Train AUC for  = 0.001 is 88.57%

CV AUC for  = 0.001 is 88.62%
==================================================

Train AUC for  = 0.01 is 82.15%

CV AUC for  = 0.01 is 82.07%
==================================================

Train AUC for  = 0.1 is 50.00%

CV AUC for  = 0.1 is 50.00%
==================================================

Train AUC for  = 1 is 50.00%

CV AUC for  = 1 is 50.00%
==================================================

Train AUC for  = 10 is 50.00%

CV AUC for  = 10 is 50.00%
==================================================

Train AUC for  = 100 is 50.00%

CV AUC for  = 100 is 50.00%
==================================================

Train AUC for  = 1000 is 50.00%

CV AUC for  = 1000 is 50.00%
==================================================
```

```
In [112]: hyper = [str(pow(10,j)) for j in range(-4,4)]
          # https://www.dataquest.io/blog/learning-curves-machine-learning/

          import matplotlib.pyplot as plt
          %matplotlib inline
```

```
plt.style.use('seaborn')

plt.plot(hyper,tfidf_w2v_train_auc,label = 'Training AUC')
plt.plot(hyper, tfidf_w2v_cv_auc, label = 'Validation AUC')

plt.ylabel('AUC', fontsize = 14)
plt.xlabel('\u03BB-values', fontsize = 14)
plt.title('Learning curves for a Logistic Regression model', fontsize = 18, y = 1.03
plt.legend()
```

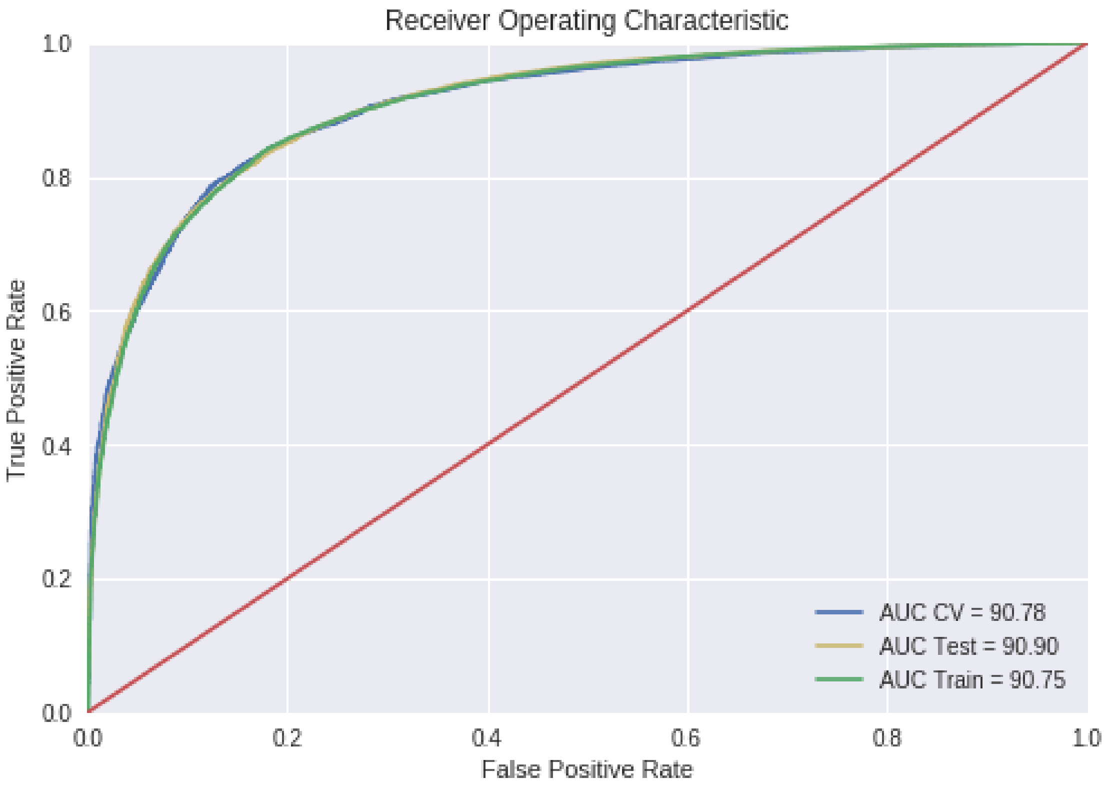
```
Out[112]: <matplotlib.legend.Legend at 0x7f70afea3780>
```



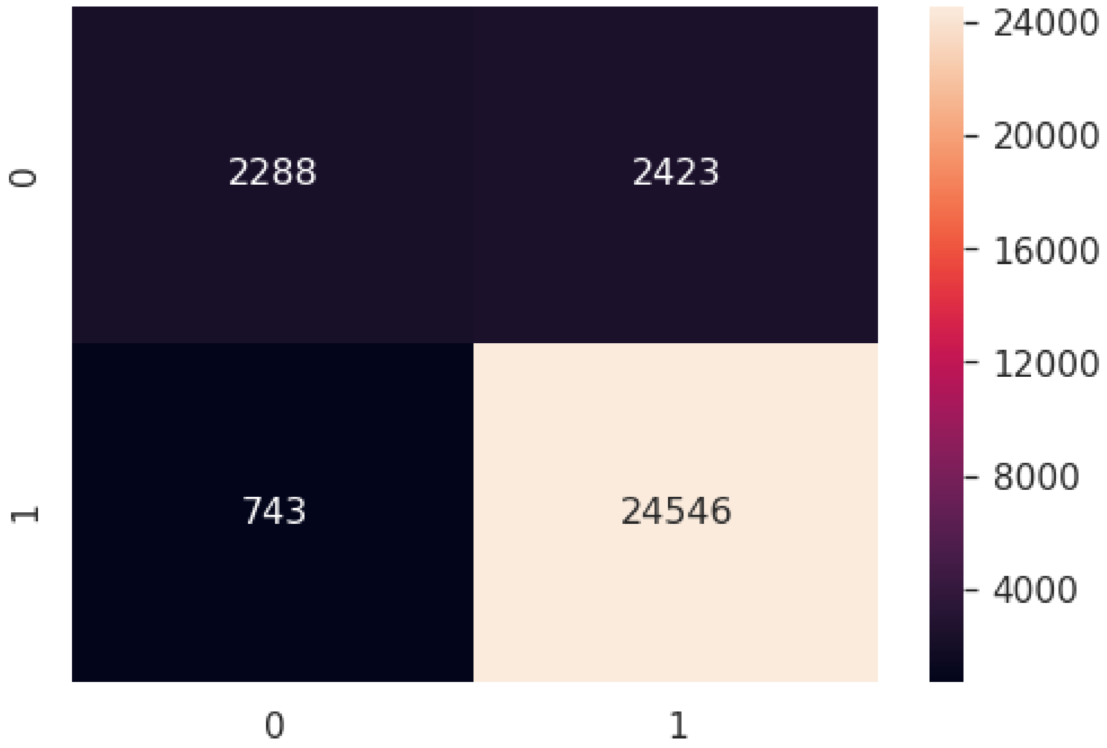
```
In [113]: i = 0.001
          LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
          calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
          calibrated_clf.fit(w2v_train, train_y)
          # train data
          y_prob_train = calibrated_clf.predict_proba(w2v_train)[:,1]
          fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
          y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_train = roc_auc_score(train_y , y_prob_train)
          print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100
          # CV
          y_prob_cv = calibrated_clf.predict_proba(w2v_cv)[:,1]
          fprc, tprc, thrsholdc = roc_curve(cv_y, y_prob_cv)
          y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
          auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
          print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
          # Test
          y_prob_test = calibrated_clf.predict_proba(w2v_test)[:,1]
          fprts, tprts, thrsholdts = roc_curve(test_y, y_prob_test)
          y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
          auc_roc_test = roc_auc_score(test_y , y_prob_test)
          print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100))
```

```
Train AUC for  = 0.001 is 90.75%

CV AUC for  = 0.001 is 90.78%

Test AUC for  = 0.001 is 90.90%
```

```
In [114]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

          import matplotlib.pyplot as plt
          plt.clf()
          plt.title('Receiver Operating Characteristic')
          plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
          plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100))
          plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
          plt.legend(loc = 'lower right')
          plt.plot([0, 1], [0, 1],'r')
          plt.xlim([0, 1])
          plt.ylim([0, 1])
          plt.ylabel('True Positive Rate')
          plt.xlabel('False Positive Rate')
          plt.show()
```



```
In [115]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))

F1-Score on test set: 0.94


In [116]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
          sns.set(font_scale=1.4)
          sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[116]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70afe91cf8>
```



7.2 [5.2] RBF SVM

7.2.1 I am used to select 20k data points randaand sord them using time based splitting

```
In [3]: # Split the data into train , test and crossvalidation datasets
        # load "preprocessed.pkl" data frame
        df = pd.read_pickle("files/preprocessed.pkl")
        df.head(1)
```

```
Out[3]:              Id   ProductId         UserId      ProfileName  \
        138706  150524  0006641040  ACITT7DI6IDDL  shari zychinski

                HelpfulnessNumerator  HelpfulnessDenominator  Score       Time  \
        138706                     0                       0      1  939340800

                                   Summary  \
        138706  EVERY book is educational

                                                            Text  \
        138706  this witty little book makes my son laugh at l...

                                                     CleanedText  \
        138706  witty little book makes son laugh loud recite ...
```

```
                       CleanedSummary
        138706  every book educational
```

```
In [4]: # take 20k sample data randomly
        sample_data = df.sample(20000)
        sample_data.shape
```

```
Out[4]: (20000, 12)
```

```
In [5]: # sorted the data using time based
        sorted_data = sample_data.sort_values('Time', axis=0, inplace=False)
        sorted_data.shape
```

```
Out[5]: (20000, 12)
```

```
In [6]: X = np.array(sorted_data['CleanedText'])
        y = np.array(sorted_data['Score'])
        print(X.shape)
        print(y.shape)
```

```
(20000,)
(20000,)
```

```
In [7]: # Simple cross validation
        # split the data sent into train and test
        train , test , train_y , test_y = train_test_split(X, y, test_size = 0.3, random_state=

        # split the train data set into cross validation train and cross validation test
        train, cv , train_y, cv_y = train_test_split(train, train_y, test_size=0.3, random_sta

        print("train data = ", train.shape)
        print("cros validation = ", cv.shape)
        print("test data = ", test.shape)
```

```
train data =  (9800,)
cros validation =  (4200,)
test data =  (6000,)
```

7.2.2 [5.2.1] Applying RBF SVM on BOW, SET 1

```
In [149]: # Please write all the code with proper documentation
          #BoW
          count_vect = CountVectorizer(min_df=10, max_features=500) #in scikit-learn
          count_vect.fit(train)
          print("some feature names ", count_vect.get_feature_names()[:10])
          print('='*50)
          bow_train = count_vect.fit_transform(train)
          bow_cv = count_vect.transform(cv)
          bow_test = count_vect.transform(test)
          print("============Train Data=========")
          print("the type of count vectorizer ",type(bow_train))
          print("the shape of out text BOW vectorizer ",bow_train.get_shape())
          print("the number of unique words ", bow_train.get_shape()[1])
          print("============Cross validation Data=========")
          print("the type of count vectorizer ",type(bow_cv))
          print("the shape of out text BOW vectorizer ",bow_cv.get_shape())
          print("the number of unique words ", bow_cv.get_shape()[1])
          print("============Test Data=========")
          print("the type of count vectorizer ",type(bow_test))
          print("the shape of out text BOW vectorizer ",bow_test.get_shape())
          print("the number of unique words ", bow_test.get_shape()[1])
```

```
some feature names  ['able', 'absolutely', 'actually', 'add', 'added', 'adding', 'aftertaste',
==================================================
============Train Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (9800, 500)
the number of unique words  500
============Cross validation Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (4200, 500)
the number of unique words  500
============Test Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (6000, 500)
the number of unique words  500
```

```
In [8]: from sklearn.svm import SVC
        from sklearn.model_selection import StratifiedShuffleSplit , GridSearchCV
```

```
In [170]: C_range = list(np.logspace(-2, 10, 4))
          gamma_range = list(np.logspace(-9, 3, 4))
          bow_train_auc = []
          bow_cv_auc = []
          for i in C_range:
              for j in gamma_range:
                  svc = SVC(C = i , gamma = j , probability=True)
                  svc.fit(bow_train, train_y)
                  # train data
                  y_prob_train = svc.predict_proba(bow_train)[:,1]
                  y_pred = np.where(y_prob_train > 0.5, 1, 0)
                  auc_roc_train = roc_auc_score(train_y , y_prob_train)
```

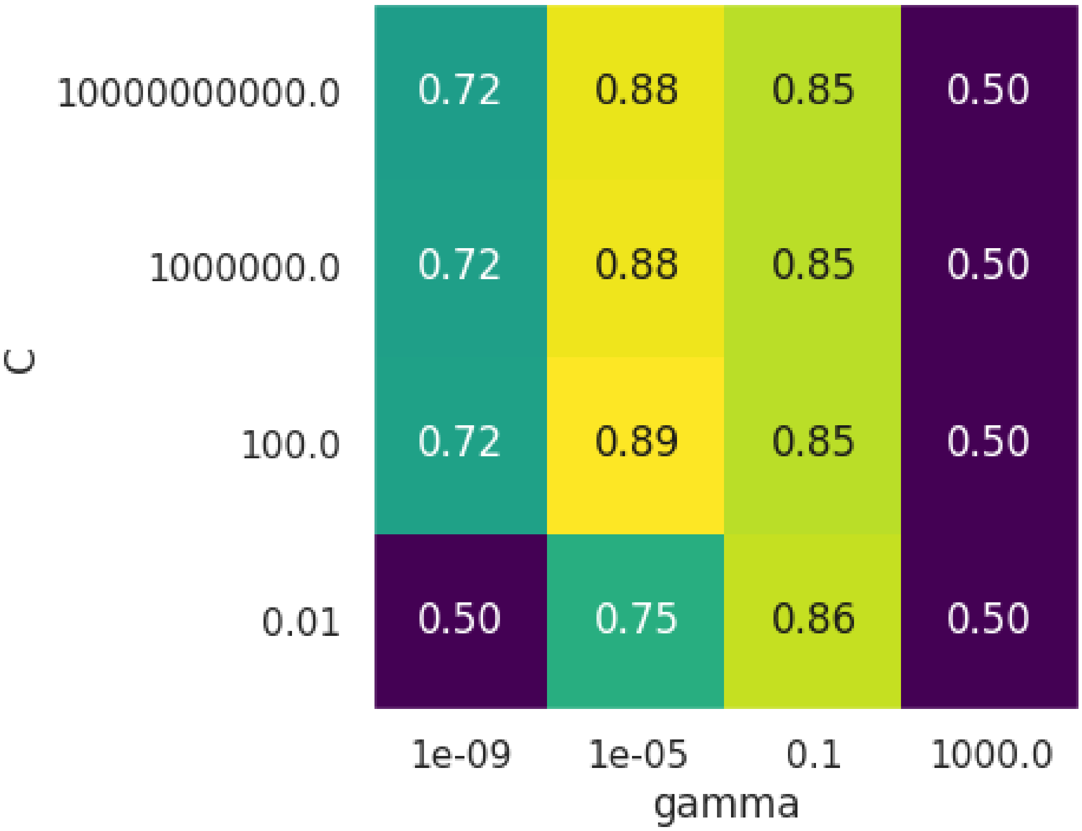
```
                print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(a
                bow_train_auc.append(auc_roc_train)
                # CV
                y_prob_cv = svc.predict_proba(bow_cv)[:,1]
                y_pred = np.where(y_prob_cv > 0.5, 1, 0)
                auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
                print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_
                bow_cv_auc.append(auc_roc_cv)
                print("="*50)
```

```
Train AUC for  = 1e-09 and C = 0.01 is 50.00%

CV AUC for  = 1e-09 and C = 0.01 is 50.00%
==================================================

Train AUC for  = 1e-05 and C = 0.01 is 75.32%

CV AUC for  = 1e-05 and C = 0.01 is 74.61%
==================================================

Train AUC for  = 0.1 and C = 0.01 is 99.24%

CV AUC for  = 0.1 and C = 0.01 is 85.85%
==================================================

Train AUC for  = 1000.0 and C = 0.01 is 0.21%

CV AUC for  = 1000.0 and C = 0.01 is 49.89%
==================================================

Train AUC for  = 1e-09 and C = 100.0 is 71.75%

CV AUC for  = 1e-09 and C = 100.0 is 72.45%
==================================================

Train AUC for  = 1e-05 and C = 100.0 is 90.41%

CV AUC for  = 1e-05 and C = 100.0 is 89.38%
==================================================

Train AUC for  = 0.1 and C = 100.0 is 99.96%

CV AUC for  = 0.1 and C = 100.0 is 85.36%
==================================================

Train AUC for  = 1000.0 and C = 100.0 is 0.17%
```

```
CV AUC for  = 1000.0 and C = 100.0 is 49.89%
==================================================

Train AUC for  = 1e-09 and C = 1000000.0 is 71.36%

CV AUC for  = 1e-09 and C = 1000000.0 is 72.01%
==================================================

Train AUC for  = 1e-05 and C = 1000000.0 is 92.03%

CV AUC for  = 1e-05 and C = 1000000.0 is 88.38%
==================================================

Train AUC for  = 0.1 and C = 1000000.0 is 99.98%

CV AUC for  = 0.1 and C = 1000000.0 is 85.36%
==================================================

Train AUC for  = 1000.0 and C = 1000000.0 is 0.17%

CV AUC for  = 1000.0 and C = 1000000.0 is 49.89%
==================================================

Train AUC for  = 1e-09 and C = 10000000000.0 is 71.16%

CV AUC for  = 1e-09 and C = 10000000000.0 is 71.77%
==================================================

Train AUC for  = 1e-05 and C = 10000000000.0 is 91.70%

CV AUC for  = 1e-05 and C = 10000000000.0 is 88.01%
==================================================

Train AUC for  = 0.1 and C = 10000000000.0 is 99.92%

CV AUC for  = 0.1 and C = 10000000000.0 is 85.36%
==================================================

Train AUC for  = 1000.0 and C = 10000000000.0 is 0.17%

CV AUC for  = 1000.0 and C = 10000000000.0 is 49.89%
==================================================
```

```
In [174]: scores = np.array(bow_cv_auc).reshape(len(C_range),len(gamma_range))
          # plot the mean cross-validation scores
          mglearn.tools.heatmap(scores, xlabel='gamma', xticklabels=gamma_range,
                                ylabel='C', yticklabels=C_range, cmap="viridis")
```

```
Out[174]: <matplotlib.collections.PolyCollection at 0x7f70c56dff98>
```

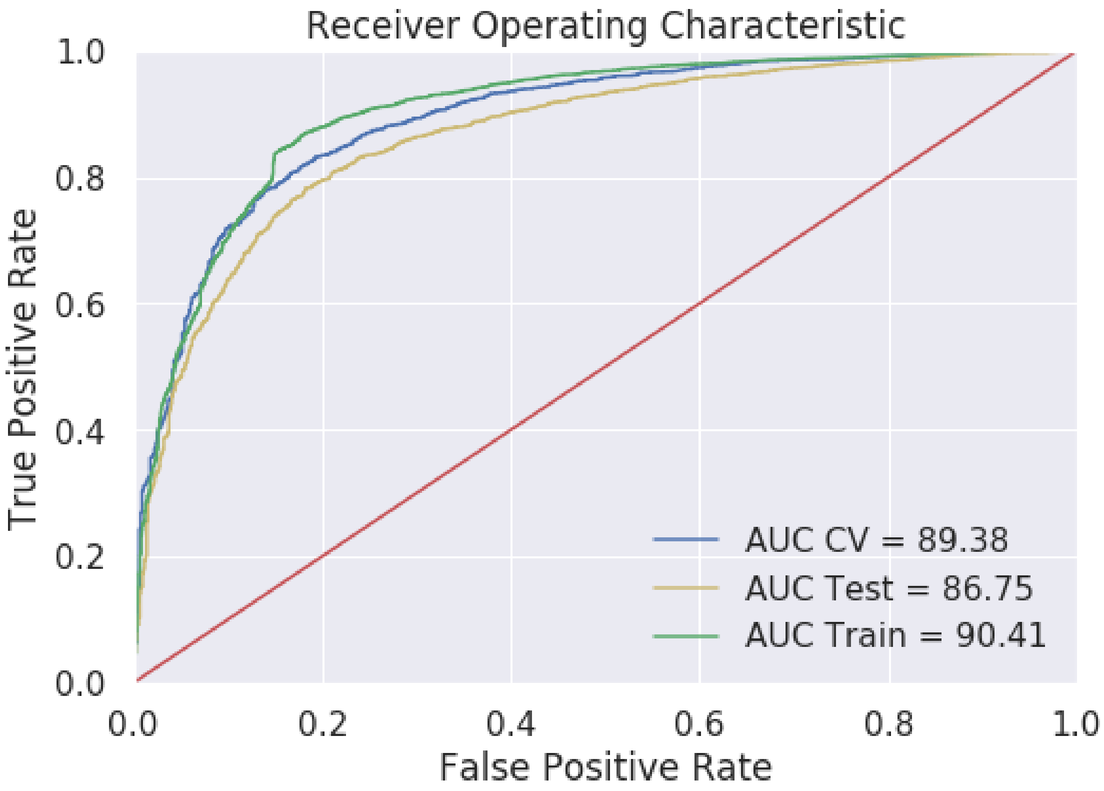


```
In [176]: i = 100
          j = 1e-05
          svc = SVC(C = i , gamma = j , probability=True)
          svc.fit(bow_train, train_y)
          # train data
          y_prob_train = svc.predict_proba(bow_train)[:,1]
          fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
          y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
          auc_roc_train = roc_auc_score(train_y , y_prob_train)
          print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_
          # CV
          y_prob_cv = svc.predict_proba(bow_cv)[:,1]
          fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
          y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
          auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
          print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_cv
          # Test
          y_prob_test = svc.predict_proba(bow_test)[:,1]
```

```
fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
auc_roc_test = roc_auc_score(test_y , y_prob_test)
print('\nTest AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_te
```

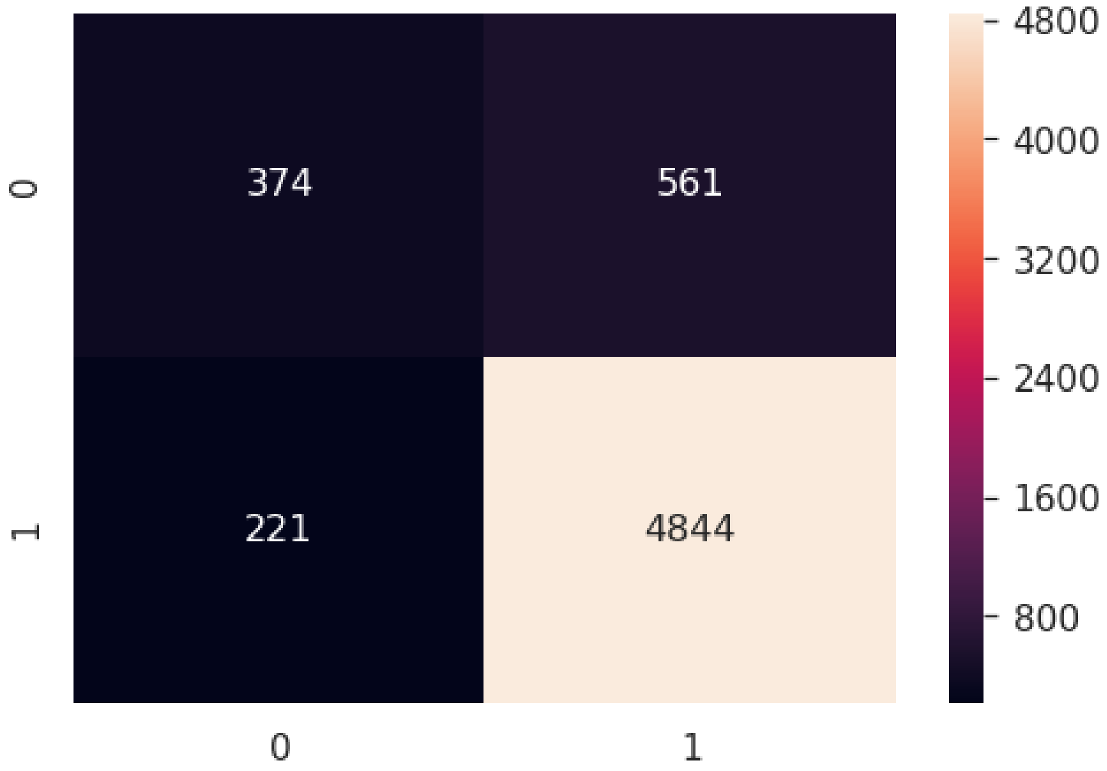
```
Train AUC for  = 1e-05 and C = 100 is 90.41%

CV AUC for  = 1e-05 and C = 100 is 89.38%

Test AUC for  = 1e-05 and C = 100 is 86.75%
```

In [177]:
```
# https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

import matplotlib.pyplot as plt
plt.clf()
plt.title('Receiver Operating Characteristic')
plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```



```
In [178]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))

F1-Score on test set: 0.93
```

```
In [179]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
          sns.set(font_scale=1.4)
          sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[179]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70c5644f28>
```



7.2.3 [5.2.2] Applying RBF SVM on TFIDF, SET 2

```
In [186]: # Please write all the code with proper documentation
          # Please write all the code with proper documentation

          model = TfidfVectorizer(min_df=10, ngram_range=(1,2), max_features=500)
          #tf_idf_matrix = model.fit_transform(train)

          print("================Train Data===========")
          tf_idf_train = model.fit_transform(train)
          print("the type of count vectorizer ",type(tf_idf_train))
          print("the shape of out text TFIDF vectorizer ",tf_idf_train.get_shape())
          print("the number of unique words including both unigrams and bigrams ",tf_idf_train
          print("================CV Data===========")
          tf_idf_cv = model.transform(cv)
          print("the type of count vectorizer ",type(tf_idf_cv))
          print("the shape of out text TFIDF vectorizer ",tf_idf_cv.get_shape())
          print("the number of unique words including both unigrams and bigrams ",tf_idf_cv.ge
          print("================Test Data===========")
          tf_idf_test = model.transform(test)
          print("the type of count vectorizer ",type(tf_idf_test))
          print("the shape of out text TFIDF vectorizer ",tf_idf_test.get_shape())
          print("the number of unique words including both unigrams and bigrams ", tf_idf_test

          # 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_)))
```

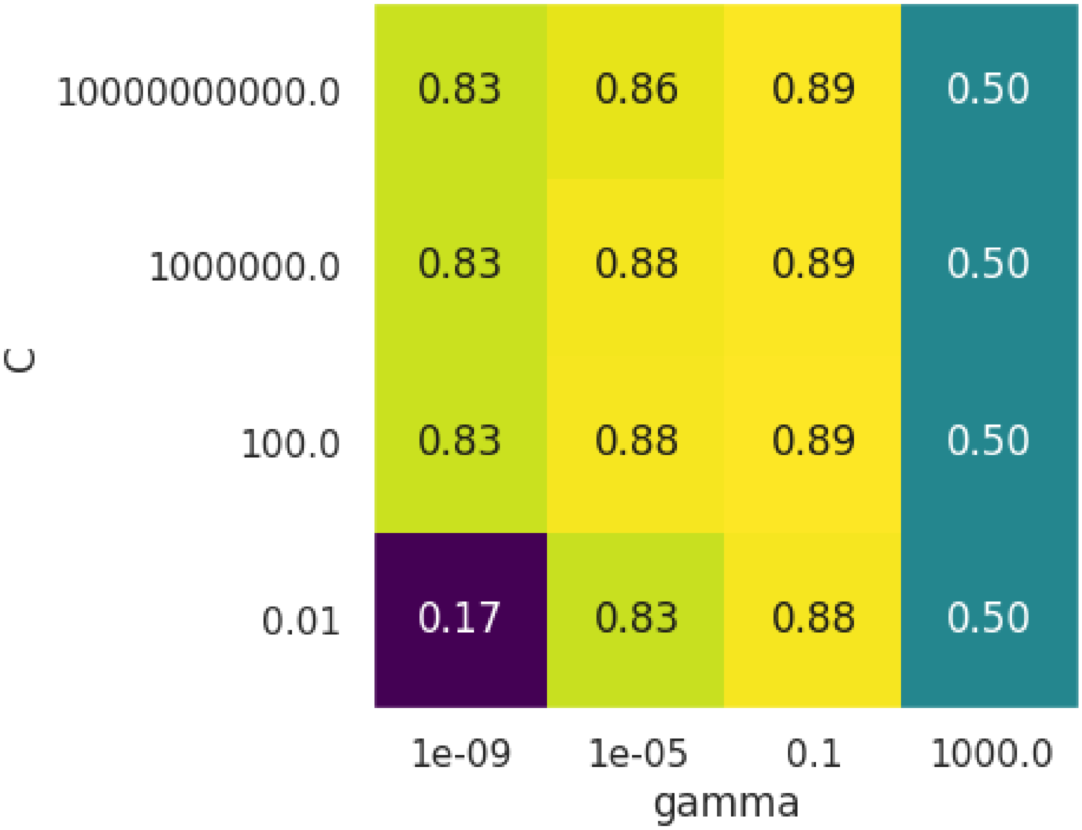
```
================Train Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (9800, 500)
the number of unique words including both unigrams and bigrams  500
================CV Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (4200, 500)
the number of unique words including both unigrams and bigrams  500
================Test Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (6000, 500)
the number of unique words including both unigrams and bigrams  500
```

```
In [187]: C_range = list(np.logspace(-2, 10, 4))
          gamma_range = list(np.logspace(-9, 3, 4))
          tfidf_train_auc = []
          tfidf_cv_auc = []
          for i in C_range:
              for j in gamma_range:
                  svc = SVC(C = i , gamma = j , probability=True)
                  svc.fit(tf_idf_train, train_y)
                  # train data
                  y_prob_train = svc.predict_proba(tf_idf_train)[:,1]
                  y_pred = np.where(y_prob_train > 0.5, 1, 0)
                  auc_roc_train = roc_auc_score(train_y , y_prob_train)
                  print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(a
                  tfidf_train_auc.append(auc_roc_train)
                  # CV
                  y_prob_cv = svc.predict_proba(tf_idf_cv)[:,1]
                  y_pred = np.where(y_prob_cv > 0.5, 1, 0)
                  auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
                  print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_
                  tfidf_cv_auc.append(auc_roc_cv)
                  print("="*50)
```

```

Train AUC for  = 1e-09 and C = 0.01 is 50.31%

CV AUC for  = 1e-09 and C = 0.01 is 16.63%
==================================================

Train AUC for  = 1e-05 and C = 0.01 is 49.79%
```

```
CV AUC for  = 1e-05 and C = 0.01 is 82.97%
==================================================

Train AUC for  = 0.1 and C = 0.01 is 49.58%

CV AUC for  = 0.1 and C = 0.01 is 88.05%
==================================================

Train AUC for  = 1000.0 and C = 0.01 is 50.03%

CV AUC for  = 1000.0 and C = 0.01 is 49.91%
==================================================

Train AUC for  = 1e-09 and C = 100.0 is 49.70%

CV AUC for  = 1e-09 and C = 100.0 is 83.37%
==================================================

Train AUC for  = 1e-05 and C = 100.0 is 50.12%

CV AUC for  = 1e-05 and C = 100.0 is 88.05%
==================================================

Train AUC for  = 0.1 and C = 100.0 is 49.89%

CV AUC for  = 0.1 and C = 100.0 is 89.10%
==================================================

Train AUC for  = 1000.0 and C = 100.0 is 50.03%

CV AUC for  = 1000.0 and C = 100.0 is 49.91%
==================================================

Train AUC for  = 1e-09 and C = 1000000.0 is 49.69%

CV AUC for  = 1e-09 and C = 1000000.0 is 83.37%
==================================================

Train AUC for  = 1e-05 and C = 1000000.0 is 49.85%

CV AUC for  = 1e-05 and C = 1000000.0 is 87.81%
==================================================

Train AUC for  = 0.1 and C = 1000000.0 is 49.91%

CV AUC for  = 0.1 and C = 1000000.0 is 88.70%
==================================================
Train AUC for  = 1000.0 and C = 1000000.0 is 50.03%

CV AUC for  = 1000.0 and C = 1000000.0 is 49.91%
===================================================

Train AUC for  = 1e-09 and C = 10000000000.0 is 49.70%

CV AUC for  = 1e-09 and C = 10000000000.0 is 83.37%
===================================================

Train AUC for  = 1e-05 and C = 10000000000.0 is 50.34%

CV AUC for  = 1e-05 and C = 10000000000.0 is 86.31%
===================================================

Train AUC for  = 0.1 and C = 10000000000.0 is 49.91%

CV AUC for  = 0.1 and C = 10000000000.0 is 88.70%
===================================================

Train AUC for  = 1000.0 and C = 10000000000.0 is 50.03%

CV AUC for  = 1000.0 and C = 10000000000.0 is 49.91%
===================================================
```

```
In [189]: scores = np.array(tfidf_cv_auc).reshape(len(C_range),len(gamma_range))
          # plot the mean cross-validation scores
          mglearn.tools.heatmap(scores, xlabel='gamma', xticklabels=gamma_range,
                                ylabel='C', yticklabels=C_range, cmap="viridis")

Out[189]: <matplotlib.collections.PolyCollection at 0x7f70af2ba080>
```

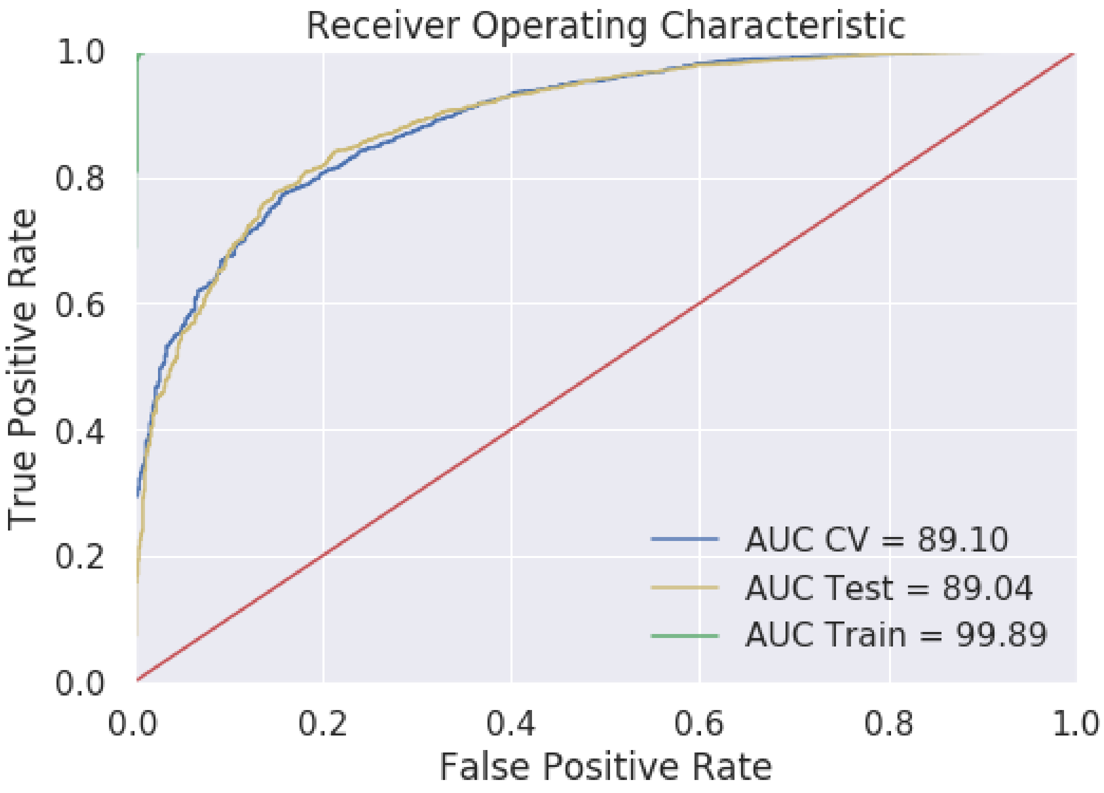


In [191]:
```
i = 100
j = 0.1
svc = SVC(C = i , gamma = j , probability=True)
svc.fit(tf_idf_train, train_y)
# train data
y_prob_train = svc.predict_proba(tf_idf_train)[:,1]
fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
auc_roc_train = roc_auc_score(train_y , y_prob_train)
print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_
# CV
y_prob_cv = svc.predict_proba(tf_idf_cv)[:,1]
fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_cv
# Test
y_prob_test = svc.predict_proba(tf_idf_test)[:,1]
fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
```

```
        auc_roc_test = roc_auc_score(test_y , y_prob_test)
        print('\nTest AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_te
```

```
Train AUC for  = 0.1 and C = 100 is 99.89%

CV AUC for  = 0.1 and C = 100 is 89.10%

Test AUC for  = 0.1 and C = 100 is 89.04%
```

```
In [193]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

          import matplotlib.pyplot as plt
          plt.clf()
          plt.title('Receiver Operating Characteristic')
          plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
          plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100))
          plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
          plt.legend(loc = 'lower right')
          plt.plot([0, 1], [0, 1],'r')
          plt.xlim([0, 1])
          plt.ylim([0, 1])
          plt.ylabel('True Positive Rate')
          plt.xlabel('False Positive Rate')
          plt.show()
```

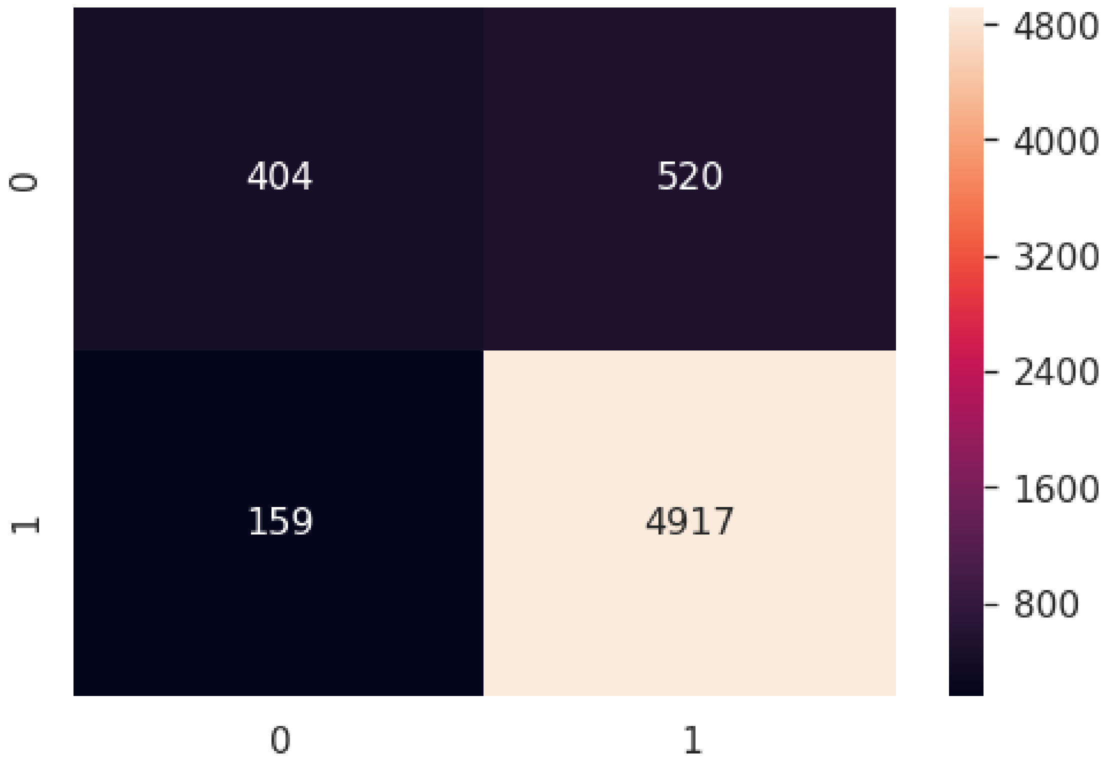


```
In [194]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.94
```

```
In [195]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
          sns.set(font_scale=1.4)
          sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[195]: <matplotlib.axes._subplots.AxesSubplot at 0x7f70aba36128>
```



7.2.4 [5.2.3] Applying RBF SVM on AVG W2V, SET 3

```
In [9]: # Please write all the code with proper documentation
        # Train your own Word2Vec model using your own text corpus
        ######## Train Set #########
        i=0
        list_of_train_sentance=[]
        for sentance in train:
            list_of_train_sentance.append(sentance.split())
        ######## CV Set ###########
        i=0
        list_of_cv_sentance=[]
        for sentance in cv:
            list_of_cv_sentance.append(sentance.split())
        ######## Test Set #########
        i=0
        list_of_test_sentance=[]
        for sentance in test:
            list_of_test_sentance.append(sentance.split())
        print("Length of Train = ", len(list_of_train_sentance))
        print("Length of CV = ", len(list_of_cv_sentance))
        print("Length of Test = ", len(list_of_test_sentance))
```

```
Length of Train =  9800
Length of CV =  4200
Length of Test =  6000
```

```
In [10]: w2v_model=Word2Vec(list_of_train_sentance,min_count=15,size=50, workers=4)
         print(w2v_model.wv.most_similar('great'))
         print('='*50)
         print(w2v_model.wv.most_similar('worst'))
```

```
[('excellent', 0.8764510750770569), ('good', 0.8501964807510376), ('especially', 0.84445118904
==================================================
[('american', 0.9778188467025757), ('none', 0.9739011526107788), ('favorites', 0.97263443470000
```

```
In [11]: 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  2955
sample words  ['smell', 'coming', 'cans', 'bought', 'three', 'separate', 'bad', 'thought', 'wou
```

```
In [12]: ######## Train data ########
         # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this lis
         for sent in tqdm(list_of_train_sentance): # 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:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
```

```
            if cnt_words != 0:
                sent_vec /= cnt_words
            sent_vectors_train.append(sent_vec)
        print(len(sent_vectors_train))
        print(len(sent_vectors_train[0]))
```

```
100%|| 9800/9800 [00:19<00:00, 502.95it/s]

9800
50
```

```
In [13]: ######## CV data ########
         # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_cv_sentance): # 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:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             sent_vectors_cv.append(sent_vec)
         print(len(sent_vectors_cv))
         print(len(sent_vectors_cv[0]))
```

```
100%|| 4200/4200 [00:08<00:00, 472.86it/s]

4200
50
```

```
In [14]: ######## Test data ########
         # average Word2Vec
         # compute average word2vec for each review.
         sent_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_test_sentance): # 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:
                     vec = w2v_model.wv[word]
                     sent_vec += vec
                     cnt_words += 1
             if cnt_words != 0:
                 sent_vec /= cnt_words
             sent_vectors_test.append(sent_vec)
         print(len(sent_vectors_test))
         print(len(sent_vectors_test[0]))
```

```
100%|| 6000/6000 [00:12<00:00, 482.55it/s]

6000
50
```

```
In [15]: # save the datasets as numpy array
         w2v_train = np.array(sent_vectors_train)
         w2v_cv = np.array(sent_vectors_cv)
         w2v_test = np.array(sent_vectors_test)
```

```
In [16]: C_range = [pow(10,j) for j in range(-2,2,1)]
         gamma_range = [pow(10,j) for j in range(-2,2,1)]
         w2v_train_auc = []
         w2v_cv_auc = []
         for i in C_range:
             for j in gamma_range:
                 svc = SVC(C = i , gamma = j , probability=True)
                 svc.fit(w2v_train, train_y)
                 # train data
                 y_prob_train = svc.predict_proba(w2v_train)[:,1]
                 y_pred = np.where(y_prob_train > 0.5, 1, 0)
                 auc_roc_train = roc_auc_score(train_y , y_prob_train)
                 print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(au
                 w2v_train_auc.append(auc_roc_train)
                 # CV
                 y_prob_cv = svc.predict_proba(w2v_cv)[:,1]
                 y_pred = np.where(y_prob_cv > 0.5, 1, 0)
                 auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
                 print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_
                 w2v_cv_auc.append(auc_roc_cv)
                 print("="*50)
```

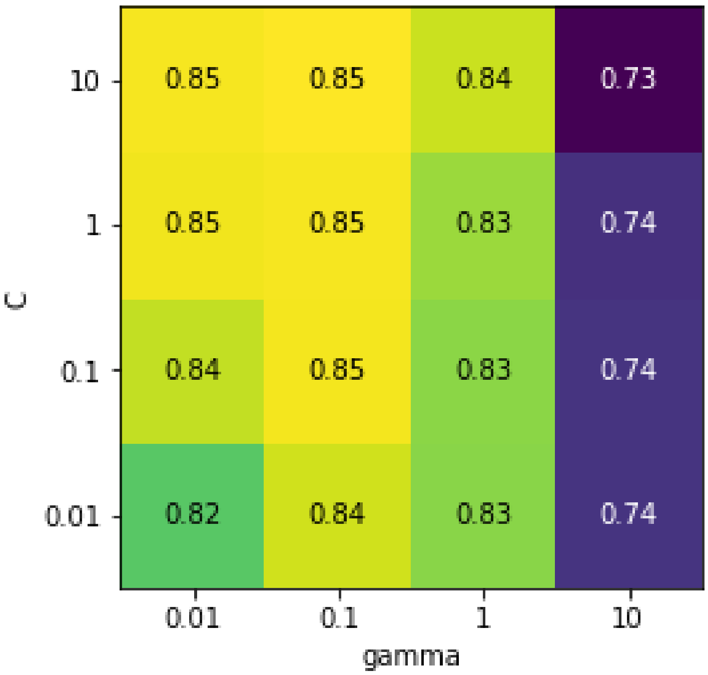
```
Train AUC for  = 0.01 and C = 0.01 is 82.13%
```

```
CV AUC for  = 0.01 and C = 0.01 is 81.95%
==================================================

Train AUC for  = 0.1 and C = 0.01 is 86.04%

CV AUC for  = 0.1 and C = 0.01 is 84.35%
==================================================

Train AUC for  = 1 and C = 0.01 is 87.31%

CV AUC for  = 1 and C = 0.01 is 83.03%
==================================================

Train AUC for  = 10 and C = 0.01 is 99.18%

CV AUC for  = 10 and C = 0.01 is 74.43%
==================================================

Train AUC for  = 0.01 and C = 0.1 is 85.53%

CV AUC for  = 0.01 and C = 0.1 is 84.10%
==================================================

Train AUC for  = 0.1 and C = 0.1 is 87.01%

CV AUC for  = 0.1 and C = 0.1 is 85.06%
==================================================

Train AUC for  = 1 and C = 0.1 is 87.39%

CV AUC for  = 1 and C = 0.1 is 83.07%
==================================================

Train AUC for  = 10 and C = 0.1 is 99.17%

CV AUC for  = 10 and C = 0.1 is 74.44%
==================================================

Train AUC for  = 0.01 and C = 1 is 86.89%

CV AUC for  = 0.01 and C = 1 is 85.02%
==================================================

Train AUC for  = 0.1 and C = 1 is 87.07%

CV AUC for  = 0.1 and C = 1 is 85.10%
==================================================
Train AUC for  = 1 and C = 1 is 88.10%

CV AUC for  = 1 and C = 1 is 83.34%
==================================================

Train AUC for  = 10 and C = 1 is 99.60%

CV AUC for  = 10 and C = 1 is 74.31%
==================================================

Train AUC for  = 0.01 and C = 10 is 86.97%

CV AUC for  = 0.01 and C = 10 is 85.08%
==================================================

Train AUC for  = 0.1 and C = 10 is 87.24%

CV AUC for  = 0.1 and C = 10 is 85.27%
==================================================

Train AUC for  = 1 and C = 10 is 92.85%

CV AUC for  = 1 and C = 10 is 84.24%
==================================================

Train AUC for  = 10 and C = 10 is 99.93%

CV AUC for  = 10 and C = 10 is 72.54%
==================================================
```

```
In [19]: import mglearn
```

```
In [20]: scores = np.array(w2v_cv_auc).reshape(len(C_range),len(gamma_range))
         # plot the mean cross-validation scores
         mglearn.tools.heatmap(scores, xlabel='gamma', xticklabels=gamma_range,
                               ylabel='C', yticklabels=C_range, cmap="viridis")
```

```
Out[20]: <matplotlib.collections.PolyCollection at 0x7f3018032ef0>
```

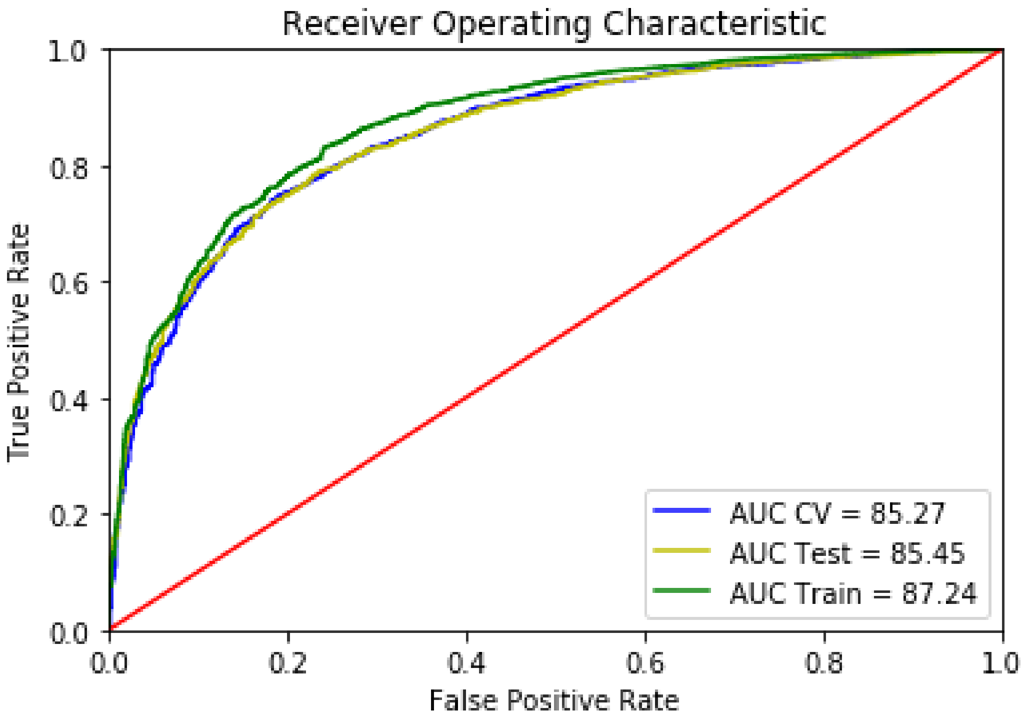


```
In [21]: i = 10
         j = 0.1
         svc = SVC(C = i , gamma = j , probability=True)
         svc.fit(w2v_train, train_y)
         # train data
         y_prob_train = svc.predict_proba(w2v_train)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_t
         # CV
         y_prob_cv = svc.predict_proba(w2v_cv)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_cv *
         # Test
         y_prob_test = svc.predict_proba(w2v_test)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(test_y , y_prob_test)
         print('\nTest AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_te
```

```
Train AUC for  = 0.1 and C = 10 is 87.24%
```

```
CV AUC for  = 0.1 and C = 10 is 85.27%

Test AUC for  = 0.1 and C = 10 is 85.45%
```

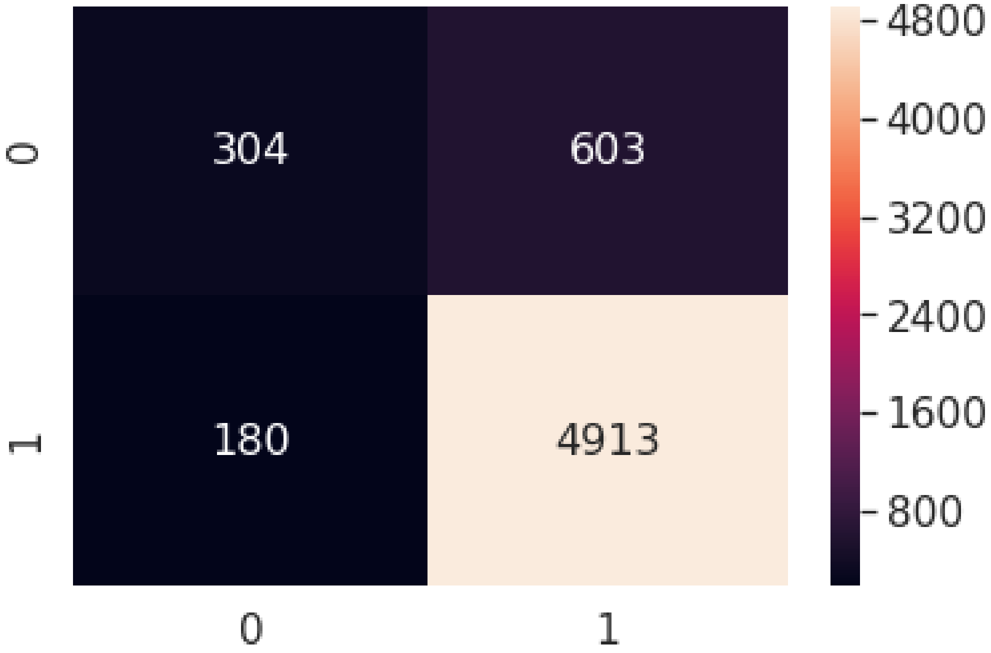
```
In [22]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.clf()
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```



```
In [23]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.93
```

```
In [24]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[24]: <matplotlib.axes._subplots.AxesSubplot at 0x7f30010d65f8>
```



7.2.5 [5.2.4] Applying RBF SVM on TFIDF W2V, SET 4

```
In [26]: # Please write all the code with proper documentation

         model = TfidfVectorizer(min_df=10 , max_features=500, ngram_range=(1,2))
         #tf_idf_matrix = model.fit_transform(train)

         print("================Train Data===========")
         final_tf_idf_train = model.fit_transform(train)
         print("the type of count vectorizer ",type(final_tf_idf_train))
         print("the shape of out text TFIDF vectorizer ",final_tf_idf_train.get_shape())
         print("the number of unique words including both unigrams and bigrams ", final_tf_idf_
         print("================CV Data===========")
         final_tf_idf_cv = model.transform(cv)
         print("the type of count vectorizer ",type(final_tf_idf_cv))
         print("the shape of out text TFIDF vectorizer ",final_tf_idf_cv.get_shape())
         print("the number of unique words including both unigrams and bigrams ", final_tf_idf_
         print("================Test Data===========")
         final_tf_idf_test = model.transform(test)
         print("the type of count vectorizer ",type(final_tf_idf_test))
         print("the shape of out text TFIDF vectorizer ",final_tf_idf_test.get_shape())
         print("the number of unique words including both unigrams and bigrams ", final_tf_idf_

         # 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_)))
```

```
================Train Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (9800, 500)
the number of unique words including both unigrams and bigrams  500
================CV Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (4200, 500)
the number of unique words including both unigrams and bigrams  500
================Test Data===========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (6000, 500)
the number of unique words including both unigrams and bigrams  500
```

```
In [28]: ######## Train #######
         # 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

         train_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in
         row=0;
         for sent in tqdm(list_of_train_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
             train_tfidf_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 9800/9800 [00:26<00:00, 373.16it/s]
```

```
In [29]: ######## CV #######
         # 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

         cv_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in thi
         row=0;
         for sent in tqdm(list_of_cv_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
             cv_tfidf_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 4200/4200 [00:10<00:00, 397.58it/s]
```

```
In [31]: ######## Train #######
         # 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

         test_tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in t
         row=0;
         for sent in tqdm(list_of_test_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
             test_tfidf_sent_vectors.append(sent_vec)
             row += 1
```

```
100%|| 6000/6000 [00:16<00:00, 358.53it/s]
```

```
In [32]: # save the datasets as numpy array
         tfidf_w2v_train = np.array(train_tfidf_sent_vectors)
         tfidf_w2v_cv = np.array(cv_tfidf_sent_vectors)
         tfidf_w2v_test = np.array(test_tfidf_sent_vectors)
```

```
In [34]: C_range = [pow(10,j) for j in range(-4,3,1)]
         gamma_range = [pow(10,j) for j in range(-4,3,1)]
         tfidf_w2v_train_auc = []
         tfidf_w2v_cv_auc = []
         for i in C_range:
             for j in gamma_range:
                 svc = SVC(C = i , gamma = j , probability=True)
                 svc.fit(tfidf_w2v_train, train_y)
                 # train data
                 y_prob_train = svc.predict_proba(tfidf_w2v_train)[:,1]
                 y_pred = np.where(y_prob_train > 0.5, 1, 0)
                 auc_roc_train = roc_auc_score(train_y , y_prob_train)
                 print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(au
                 tfidf_w2v_train_auc.append(auc_roc_train)
                 # CV
                 y_prob_cv = svc.predict_proba(tfidf_w2v_cv)[:,1]
                 y_pred = np.where(y_prob_cv > 0.5, 1, 0)
                 auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
                 print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_
                 tfidf_w2v_cv_auc.append(auc_roc_cv)
                 print("="*50)
```

```

Train AUC for  = 0.0001 and C = 0.0001 is 50.00%

CV AUC for  = 0.0001 and C = 0.0001 is 50.00%
==================================================

Train AUC for  = 0.001 and C = 0.0001 is 75.05%

CV AUC for  = 0.001 and C = 0.0001 is 72.48%
==================================================
Train AUC for  = 0.01 and C = 0.0001 is 75.93%

CV AUC for  = 0.01 and C = 0.0001 is 73.40%
==================================================

Train AUC for  = 0.1 and C = 0.0001 is 71.06%

CV AUC for  = 0.1 and C = 0.0001 is 69.93%
==================================================

Train AUC for  = 1 and C = 0.0001 is 67.47%

CV AUC for  = 1 and C = 0.0001 is 64.72%
==================================================

Train AUC for  = 10 and C = 0.0001 is 98.53%

CV AUC for  = 10 and C = 0.0001 is 56.96%
==================================================

Train AUC for  = 100 and C = 0.0001 is 99.94%

CV AUC for  = 100 and C = 0.0001 is 52.95%
==================================================

Train AUC for  = 0.0001 and C = 0.001 is 75.25%

CV AUC for  = 0.0001 and C = 0.001 is 72.68%
==================================================

Train AUC for  = 0.001 and C = 0.001 is 75.05%

CV AUC for  = 0.001 and C = 0.001 is 72.48%
==================================================

Train AUC for  = 0.01 and C = 0.001 is 77.59%

CV AUC for  = 0.01 and C = 0.001 is 76.06%
==================================================

Train AUC for  = 0.1 and C = 0.001 is 81.17%

CV AUC for  = 0.1 and C = 0.001 is 78.83%
==================================================

Train AUC for  = 1 and C = 0.001 is 85.89%

CV AUC for  = 1 and C = 0.001 is 74.94%
```

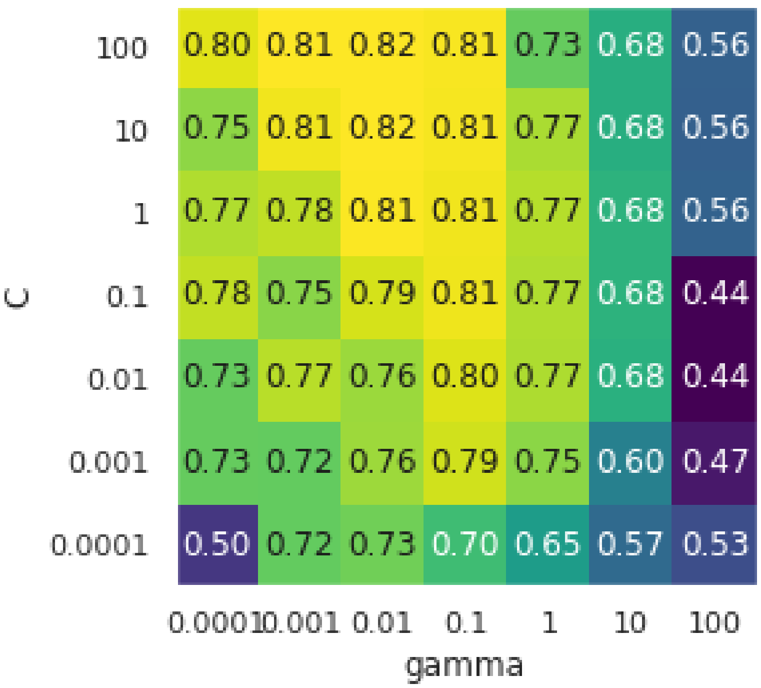
```
==================================================

Train AUC for  = 10 and C = 0.001 is 99.90%

CV AUC for  = 10 and C = 0.001 is 60.23%
==================================================

Train AUC for  = 100 and C = 0.001 is 0.05%

CV AUC for  = 100 and C = 0.001 is 46.55%
==================================================

Train AUC for  = 0.0001 and C = 0.01 is 75.25%

CV AUC for  = 0.0001 and C = 0.01 is 72.69%
==================================================

Train AUC for  = 0.001 and C = 0.01 is 78.74%

CV AUC for  = 0.001 and C = 0.01 is 77.44%
==================================================

Train AUC for  = 0.01 and C = 0.01 is 77.97%

CV AUC for  = 0.01 and C = 0.01 is 75.87%
==================================================

Train AUC for  = 0.1 and C = 0.01 is 83.66%

CV AUC for  = 0.1 and C = 0.01 is 79.57%
==================================================

Train AUC for  = 1 and C = 0.01 is 90.35%

CV AUC for  = 1 and C = 0.01 is 76.95%
==================================================

Train AUC for  = 10 and C = 0.01 is 99.84%

CV AUC for  = 10 and C = 0.01 is 67.91%
==================================================

Train AUC for  = 100 and C = 0.01 is 0.17%

CV AUC for  = 100 and C = 0.01 is 44.22%
==================================================

Train AUC for  = 0.0001 and C = 0.1 is 79.53%
```

```
CV AUC for  = 0.0001 and C = 0.1 is 78.11%
===================================================

Train AUC for  = 0.001 and C = 0.1 is 77.20%

CV AUC for  = 0.001 and C = 0.1 is 74.85%
===================================================

Train AUC for  = 0.01 and C = 0.1 is 81.75%

CV AUC for  = 0.01 and C = 0.1 is 79.03%
===================================================

Train AUC for  = 0.1 and C = 0.1 is 85.16%

CV AUC for  = 0.1 and C = 0.1 is 80.61%
===================================================

Train AUC for  = 1 and C = 0.1 is 90.56%

CV AUC for  = 1 and C = 0.1 is 77.05%
===================================================

Train AUC for  = 10 and C = 0.1 is 99.83%

CV AUC for  = 10 and C = 0.1 is 68.17%
===================================================

Train AUC for  = 100 and C = 0.1 is 0.09%

CV AUC for  = 100 and C = 0.1 is 44.14%
===================================================

Train AUC for  = 0.0001 and C = 1 is 79.20%

CV AUC for  = 0.0001 and C = 1 is 77.08%
===================================================

Train AUC for  = 0.001 and C = 1 is 80.82%

CV AUC for  = 0.001 and C = 1 is 77.90%
===================================================

Train AUC for  = 0.01 and C = 1 is 85.00%

CV AUC for  = 0.01 and C = 1 is 81.34%
===================================================
Train AUC for  = 0.1 and C = 1 is 85.22%

CV AUC for  = 0.1 and C = 1 is 80.70%
==================================================

Train AUC for  = 1 and C = 1 is 91.48%

CV AUC for  = 1 and C = 1 is 77.39%
==================================================

Train AUC for  = 10 and C = 1 is 99.82%

CV AUC for  = 10 and C = 1 is 68.18%
==================================================

Train AUC for  = 100 and C = 1 is 99.98%

CV AUC for  = 100 and C = 1 is 55.81%
==================================================

Train AUC for  = 0.0001 and C = 10 is 78.14%

CV AUC for  = 0.0001 and C = 10 is 75.21%
==================================================

Train AUC for  = 0.001 and C = 10 is 84.16%

CV AUC for  = 0.001 and C = 10 is 80.78%
==================================================

Train AUC for  = 0.01 and C = 10 is 85.21%

CV AUC for  = 0.01 and C = 10 is 81.50%
==================================================

Train AUC for  = 0.1 and C = 10 is 86.04%

CV AUC for  = 0.1 and C = 10 is 80.94%
==================================================

Train AUC for  = 1 and C = 10 is 96.83%

CV AUC for  = 1 and C = 10 is 76.74%
==================================================

Train AUC for  = 10 and C = 10 is 99.92%
```

```
CV AUC for  = 10 and C = 10 is 67.59%
==================================================

Train AUC for  = 100 and C = 10 is 99.86%

CV AUC for  = 100 and C = 10 is 55.52%
==================================================

Train AUC for  = 0.0001 and C = 100 is 82.99%

CV AUC for  = 0.0001 and C = 100 is 79.89%
==================================================

Train AUC for  = 0.001 and C = 100 is 84.96%

CV AUC for  = 0.001 and C = 100 is 81.48%
==================================================

Train AUC for  = 0.01 and C = 100 is 85.22%

CV AUC for  = 0.01 and C = 100 is 81.51%
==================================================

Train AUC for  = 0.1 and C = 100 is 89.12%

CV AUC for  = 0.1 and C = 100 is 81.18%
==================================================

Train AUC for  = 1 and C = 100 is 99.80%

CV AUC for  = 1 and C = 100 is 72.67%
==================================================

Train AUC for  = 10 and C = 100 is 99.92%

CV AUC for  = 10 and C = 100 is 67.59%
==================================================

Train AUC for  = 100 and C = 100 is 99.85%

CV AUC for  = 100 and C = 100 is 55.64%
==================================================
```

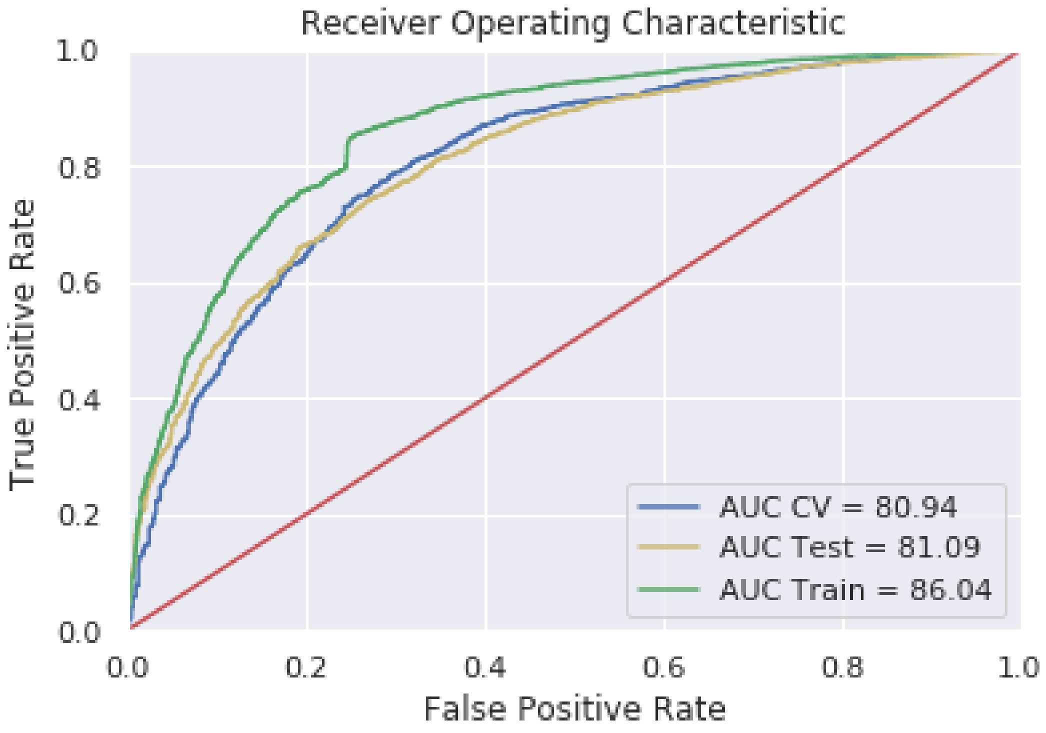
```
In [42]: scores = np.array(tfidf_w2v_cv_auc).reshape(len(C_range),len(gamma_range))
         # plot the mean cross-validation scores
         mglearn.tools.heatmap(scores, xlabel='gamma', xticklabels=gamma_range,
                               ylabel='C', yticklabels=C_range, cmap="viridis")
```

```
Out[42]: <matplotlib.collections.PolyCollection at 0x7f2ff6c8af28>
```



```
In [43]: i = 10
         j = 0.1
         svc = SVC(C = i , gamma = j , probability=True)
         svc.fit(tfidf_w2v_train, train_y)
         # train data
         y_prob_train = svc.predict_proba(tfidf_w2v_train)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_t
         # CV
         y_prob_cv = svc.predict_proba(tfidf_w2v_cv)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_cv *
         # Test
         y_prob_test = svc.predict_proba(tfidf_w2v_test)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(test_y , y_prob_test)
         print('\nTest AUC for \u03B3 = %s and C = %s is %0.2f%%' % (str(j),str(i),(auc_roc_tes
Train AUC for  = 0.1 and C = 10 is 86.04%

CV AUC for  = 0.1 and C = 10 is 80.94%

Test AUC for  = 0.1 and C = 10 is 81.09%
```

```
In [44]: # https://stackoverflow.com/questions/25009284/how-to-plot-roc-curve-in-python

         import matplotlib.pyplot as plt
         plt.clf()
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprc, tprc, 'b' , label ='AUC CV = %0.2f' % (auc_roc_cv * float(100)))
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.plot(fprt, tprt, 'g', label='AUC Train = %0.2f' % (auc_roc_train * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```

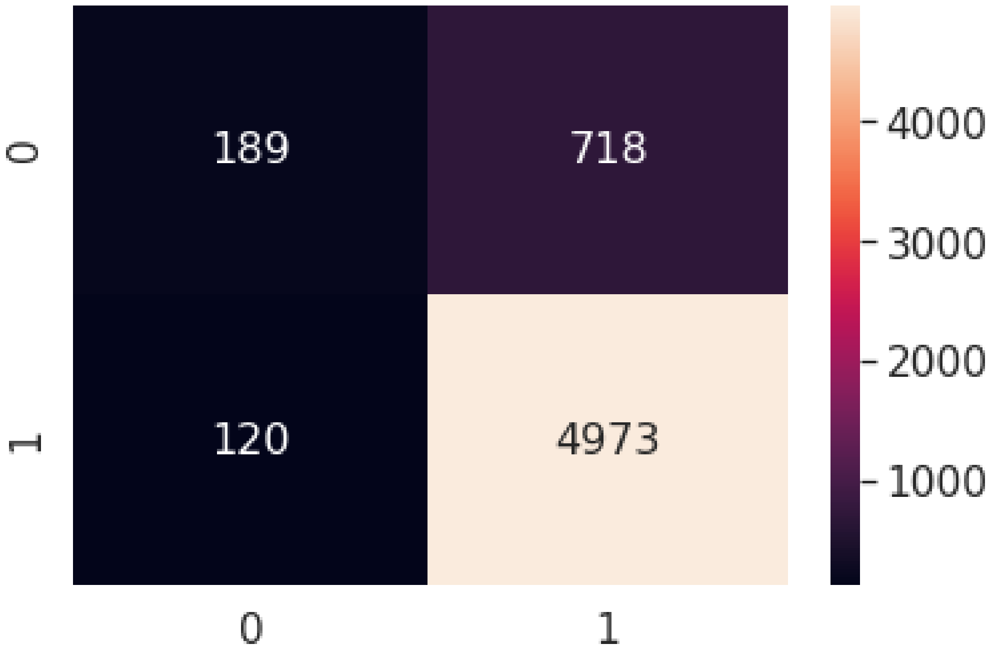


```
In [45]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))
```

```
F1-Score on test set: 0.92
```

```
In [46]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')
```

```
Out[46]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2ff74efa58>
```



```
In [55]: # Please compare all your models using Prettytable library
         X_review = np.array(sorted_data['CleanedText'])
         X_summary = np.array(sorted_data['Summary'])
         y = np.array(sorted_data['Score'])
         print(X_review.shape)
         print(X_summary.shape)
         print(y.shape)
```

```
(100000,)
(100000,)
(100000,)
```

```
In [56]: # Simple cross validation
         # split the data sent into train and test
         train_review , test_review, train_summary, test_summary , train_y , test_y = train_te

         # split the train data set into cross validation train and cross validation test
         train_review, cv_review, train_summary, cv_summary , train_y, cv_y = train_test_split

         print("train review", train_review.shape)
         print("cv review", cv_review.shape)
         print("test review", test_review.shape)
         print("train summary", train_summary.shape)
         print("cv summary", cv_summary.shape)
         print("test summary", test_summary.shape)
```

```
train review (49000,)
cv review (21000,)
test review (30000,)
train summary (49000,)
cv summary (21000,)
test summary (30000,)
```

```
In [59]: # bow for summary
         # Please write all the code with proper documentation
         #BoW
         count_vect = CountVectorizer(min_df=15, ngram_range=(1,2)) #in scikit-learn
         count_vect.fit(train_summary)
         print("some feature names ", count_vect.get_feature_names()[:10])
         print('='*50)

         bow_train_summary = count_vect.fit_transform(train_summary)
         bow_cv_summary = count_vect.transform(cv_summary)
         bow_test_summary = count_vect.transform(test_summary)
         print("============Train Data=========")
         print("the type of count vectorizer ",type(bow_train_summary))
         print("the shape of out text BOW vectorizer ",bow_train_summary.get_shape())
         print("the number of unique words ", bow_train_summary.get_shape()[1])
         print("============Cross validation Data=========")
         print("the type of count vectorizer ",type(bow_cv_summary))
         print("the shape of out text BOW vectorizer ",bow_cv_summary.get_shape())
         print("the number of unique words ", bow_cv_summary.get_shape()[1])
         print("============Test Data=========")
         print("the type of count vectorizer ",type(bow_test_summary))
         print("the shape of out text BOW vectorizer ",bow_test_summary.get_shape())
         print("the number of unique words ", bow_test_summary.get_shape()[1])
```

```
some feature names  ['10', '100', '12', '15', '20', '24', '50', 'about', 'about it', 'about the
==================================================
============Train Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (49000, 2299)
the number of unique words  2299
============Cross validation Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (21000, 2299)
the number of unique words  2299
============Test Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (30000, 2299)
the number of unique words  2299
```

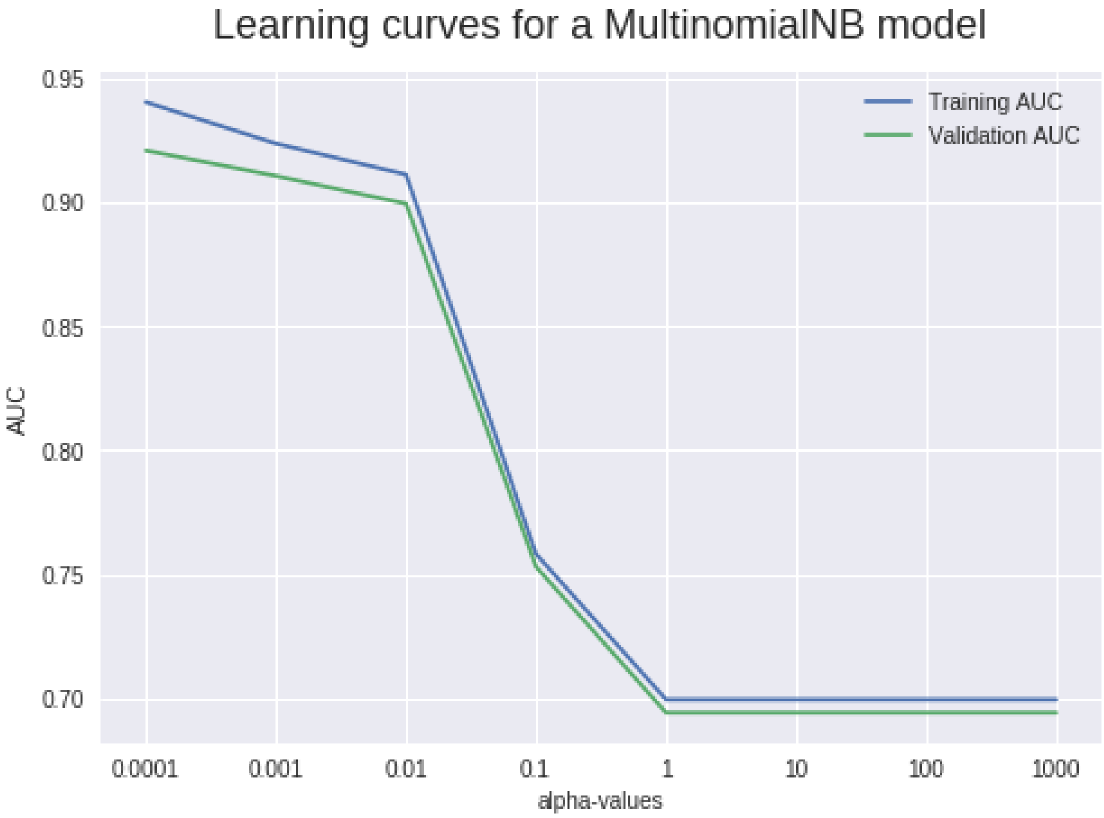
```
In [62]: alpha = [pow(10,j) for j in range(-4,4,1)]

         bow_train_auc = []
         bow_cv_auc = []
         for i in alpha:
             LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
             calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
             calibrated_clf.fit(bow_train_summary, train_y)
             # train data
             y_prob_train = calibrated_clf.predict_proba(bow_train_summary)[:,1]
             y_pred = np.where(y_prob_train > 0.5, 1, 0)
             auc_roc_train = roc_auc_score(train_y , y_prob_train)
             print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(
             bow_train_auc.append(auc_roc_train)
             # CV
             y_prob_cv = calibrated_clf.predict_proba(bow_cv_summary)[:,1]
             y_pred = np.where(y_prob_cv > 0.5, 1, 0)
             auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
             print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100)))
             bow_cv_auc.append(auc_roc_cv)
             print("="*50)
```

```
Train AUC for  = 0.0001 is 94.04%

CV AUC for  = 0.0001 is 92.10%
==================================================

Train AUC for  = 0.001 is 92.38%

CV AUC for  = 0.001 is 91.07%
==================================================

Train AUC for  = 0.01 is 91.13%

CV AUC for  = 0.01 is 89.95%
```

```
==================================================

Train AUC for  = 0.1 is 75.82%

CV AUC for  = 0.1 is 75.30%
==================================================

Train AUC for  = 1 is 69.94%

CV AUC for  = 1 is 69.41%
==================================================

Train AUC for  = 10 is 69.94%

CV AUC for  = 10 is 69.41%
==================================================

Train AUC for  = 100 is 69.94%

CV AUC for  = 100 is 69.41%
==================================================

Train AUC for  = 1000 is 69.94%

CV AUC for  = 1000 is 69.41%
==================================================
```

```
In [64]: hyper = [str(pow(10,j)) for j in range(-4,4)]
         import matplotlib.pyplot as plt
         %matplotlib inline

         plt.style.use('seaborn')

         plt.plot(hyper,bow_train_auc,label = 'Training AUC')
         plt.plot(hyper, bow_cv_auc, label = 'Validation AUC')

         plt.ylabel('AUC')
         plt.xlabel('alpha-values', fontsize = 10)
         plt.title('Learning curves for a MultinomialNB model', fontsize = 18, y = 1.03)
         plt.legend()
```

```
Out[64]: <matplotlib.legend.Legend at 0x7f2ff82f14a8>
```



```
In [65]: # summary text
         i = 0.0001
         LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l2')
         calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
         calibrated_clf.fit(bow_train_summary, train_y)
         # train data
         y_prob_train = calibrated_clf.predict_proba(bow_train_summary)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100)
         # CV
         y_prob_cv = calibrated_clf.predict_proba(bow_cv_summary)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
         # Test
         y_prob_test = calibrated_clf.predict_proba(bow_test_summary)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
```

```
auc_roc_test = roc_auc_score(test_y , y_prob_test)
print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

```
Train AUC for  = 0.0001 is 94.21%

CV AUC for  = 0.0001 is 92.34%

Test AUC for  = 0.0001 is 92.48%
```

```
In [66]: # bow for review
         # Please write all the code with proper documentation
         #BoW
         count_vect = CountVectorizer(min_df=15, ngram_range=(1,2)) #in scikit-learn
         count_vect.fit(train_review)
         print("some feature names ", count_vect.get_feature_names()[:10])
         print('='*50)

         bow_train_review = count_vect.fit_transform(train_review)
         bow_cv_review = count_vect.transform(cv_review)
         bow_test_review = count_vect.transform(test_review)
         print("============Train Data=========")
         print("the type of count vectorizer ",type(bow_train_review))
         print("the shape of out text BOW vectorizer ",bow_train_review.get_shape())
         print("the number of unique words ", bow_train_review.get_shape()[1])
         print("============Cross validation Data=========")
         print("the type of count vectorizer ",type(bow_cv_review))
         print("the shape of out text BOW vectorizer ",bow_cv_review.get_shape())
         print("the number of unique words ", bow_cv_review.get_shape()[1])
         print("============Test Data=========")
         print("the type of count vectorizer ",type(bow_test_review))
         print("the shape of out text BOW vectorizer ",bow_test_review.get_shape())
         print("the number of unique words ", bow_test_review.get_shape()[1])
```

```
some feature names  ['ability', 'able', 'able buy', 'able drink', 'able eat', 'able enjoy', 'al
==================================================
============Train Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (49000, 18421)
the number of unique words  18421
============Cross validation Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (21000, 18421)
the number of unique words  18421
============Test Data=========
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (30000, 18421)
the number of unique words  18421
```

```
In [67]: # bow for review
         i = 0.0001
         LSVM = SGDClassifier(loss='hinge',alpha=i, penalty='l1')
         calibrated_clf = CalibratedClassifierCV(LSVM, cv=5, method='sigmoid')
         calibrated_clf.fit(bow_train_review, train_y)
         # train data
         y_prob_train = calibrated_clf.predict_proba(bow_train_review)[:,1]
         fprt, tprt, throsholdt = roc_curve(train_y, y_prob_train)
         y_pred_train = np.where(y_prob_train > 0.5, 1, 0)
         auc_roc_train = roc_auc_score(train_y , y_prob_train)
         print('\nTrain AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_train * float(100)
         # CV
         y_prob_cv = calibrated_clf.predict_proba(bow_cv_review)[:,1]
         fprc, tprc, throsholdc = roc_curve(cv_y, y_prob_cv)
         y_pred_cv = np.where(y_prob_cv > 0.5, 1, 0)
         auc_roc_cv = roc_auc_score(cv_y , y_prob_cv)
         print('\nCV AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_cv * float(100))))
         # Test
         y_prob_test_review = calibrated_clf.predict_proba(bow_test_review)[:,1]
         fprts, tprts, throsholdts = roc_curve(test_y, y_prob_test_review)
         y_pred_test = np.where(y_prob_test > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(test_y , y_prob_test)
         print('\nTest AUC for \u03BB = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

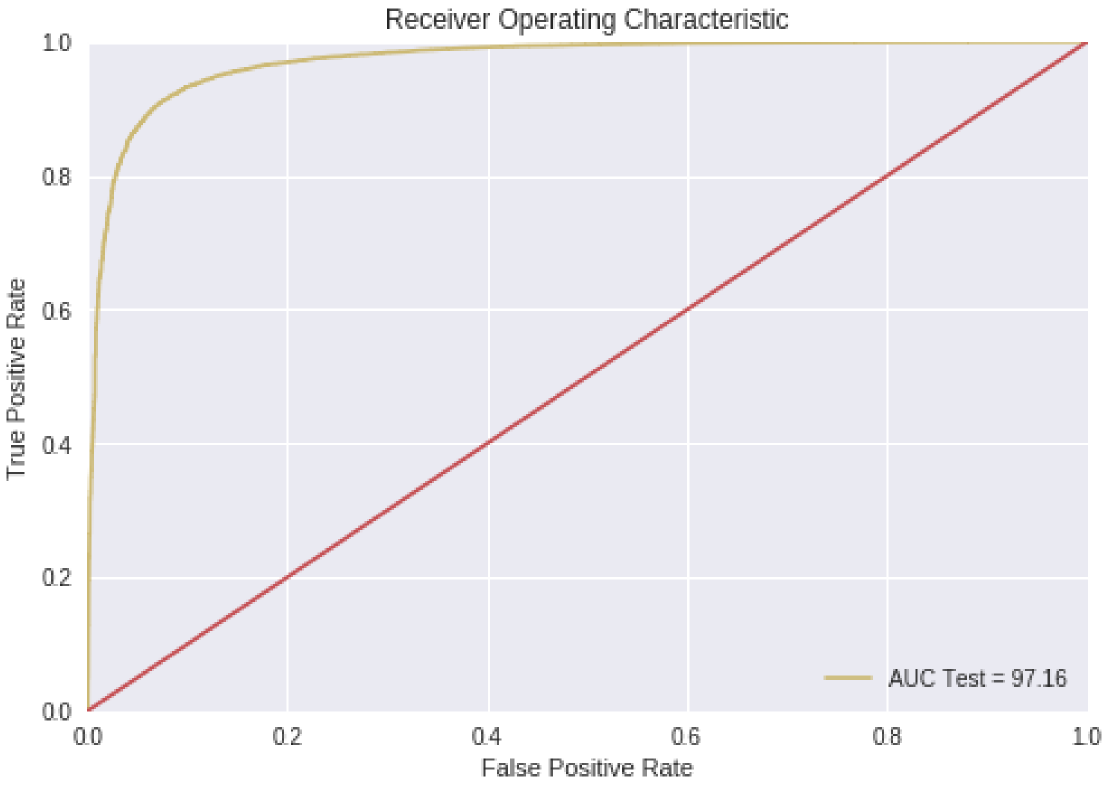
```
Train AUC for  = 0.0001 is 96.88%

CV AUC for  = 0.0001 is 94.20%

Test AUC for  = 0.0001 is 92.48%
```

```
In [68]: # adding both summary and review test probabilitys and average
         new_proba = (y_prob_test_review + y_prob_test) / 2
```

```
In [69]: fprts, tprts, throsholdts = roc_curve(test_y, new_proba)
         y_pred_test = np.where(new_proba > 0.5, 1, 0)
         auc_roc_test = roc_auc_score(test_y , new_proba)
         print('\nTest AUC for alpha = %s is %0.2f%%' % (str(i), (auc_roc_test * float(100)))
```

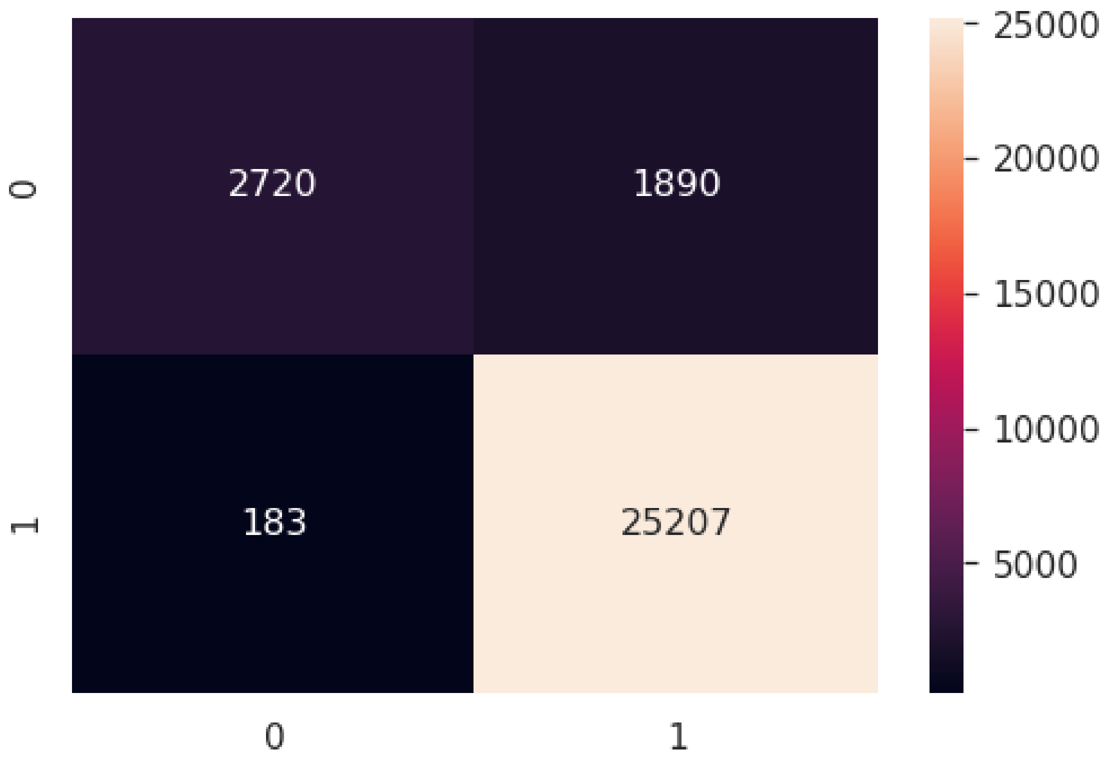
```
Test AUC for alpha = 0.0001 is 97.16%
```

```
In [70]: import matplotlib.pyplot as plt
         plt.clf()
         plt.title('Receiver Operating Characteristic')
         plt.plot(fprts, tprts, 'y' , label ='AUC Test = %0.2f' % (auc_roc_test * float(100)))
         plt.legend(loc = 'lower right')
         plt.plot([0, 1], [0, 1],'r')
         plt.xlim([0, 1])
         plt.ylim([0, 1])
         plt.ylabel('True Positive Rate')
         plt.xlabel('False Positive Rate')
         plt.show()
```



```
In [71]: print("F1-Score on test set: %0.2f"%(f1_score(test_y, y_pred_test)))

F1-Score on test set: 0.96
```

```
In [72]: df_cm = pd.DataFrame(confusion_matrix(test_y, y_pred_test), range(2), range(2))
         sns.set(font_scale=1.4)
         sns.heatmap(df_cm, annot=True, annot_kws={"size": 16}, fmt='g')

Out[72]: <matplotlib.axes._subplots.AxesSubplot at 0x7f2ff79204e0>
```



Observation : : adding two models we get better results. we see the 97.16% AUC and F1 score is 0.96

8 [6] Conclusions

8.1 Linear SVM

```
In [73]: # Please compare all your models using Prettytable library
         from prettytable import PrettyTable

         x = PrettyTable(["Vectorizer" , "Regularization","Hyper parameter \u03BB", "AUC", "F1

         x.add_row(["BOW", "L2" ,0.001, "93.92%", 0.95])
         x.add_row(["BOW","L1" , 0.0001,"93.07%", 0.95])
         x.add_row(["TFIDF", "L2" ,0.0001, "95.82%", 0.96])
         x.add_row(["TFIDF","L1" , 0.0001,"93.97%", 0.95])
         x.add_row(["AVG-W2V", "L2" ,0.0001, "91.97%", 0.94])
         x.add_row(["AVG-W2V","L1" , 0.0001,"91.15%", 0.94])
         x.add_row(["TFIDF-W2V", "L2" ,0.001, "89.07%", 0.94])
         x.add_row(["TFIDF-W2V","L1" , 0.001,"91.06%", 0.94])

         print(x.get_string(title="Linear SVM"))
```

```
+------------+----------------+-------------------+--------+----------+
| Vectorizer | Regularization | Hyper parameter   |  AUC   | F1 Score |
+------------+----------------+-------------------+--------+----------+
|    BOW     |       L2       |       0.001       | 93.92% |   0.95   |
|    BOW     |       L1       |       0.0001      | 93.07% |   0.95   |
|   TFIDF    |       L2       |       0.0001      | 95.82% |   0.96   |
|   TFIDF    |       L1       |       0.0001      | 93.97% |   0.95   |
|  AVG-W2V   |       L2       |       0.0001      | 91.97% |   0.94   |
|  AVG-W2V   |       L1       |       0.0001      | 91.15% |   0.94   |
| TFIDF-W2V  |       L2       |       0.001       | 89.07% |   0.94   |
| TFIDF-W2V  |       L1       |       0.001       | 91.06% |   0.94   |
+------------+----------------+-------------------+--------+----------+
```

8.2 RBF

```
In [74]: x = PrettyTable(["Vectorizer","Hyper parameter C", "gamma", "AUC", "F1 Score"])

         x.add_row(["BOW" ,100,"le-05" ,"86.72%", 0.93])
         x.add_row(["TFIDF" ,100,0.1 ,"89.04%", 0.94])
         x.add_row(["AVG-W2V",10 ,0.1, "85.45%", 0.93])
         x.add_row(["TFIDF-W2V",10 ,0.1, "81.09%", 0.92])

         print(x.get_string(title="RBF SVM"))
```

```
+------------+-------------------+-------+--------+----------+
| Vectorizer | Hyper parameter C | gamma |  AUC   | F1 Score |
+------------+-------------------+-------+--------+----------+
|    BOW     |        100        | le-05 | 86.72% |   0.93   |
|   TFIDF    |        100        |  0.1  | 89.04% |   0.94   |
|  AVG-W2V   |         10        |  0.1  | 85.45% |   0.93   |
| TFIDF-W2V  |         10        |  0.1  | 81.09% |   0.92   |
+------------+-------------------+-------+--------+----------+
```

8.3 Feature engineering

```
In [75]: x = PrettyTable(["Feature" , "Vectorizer" , "Regularization","Hyper parameter \u03BB"

         x.add_row(["Test length", "BOW", "L2", 0.0001, "92.48%", 0.95])
         x.add_row(["Summary + Review", "BOW", "L2",0.0001 , "97.16%", 0.97])

         print(x.get_string(title="Linear SVM Model"))
```

```
+------------------+------------+----------------+-------------------+--------+----------+
|     Feature      | Vectorizer | Regularization | Hyper parameter   |  AUC   | F1 Score |
+------------------+------------+----------------+-------------------+--------+----------+
|   Test length    |    BOW     |       L2       |       0.0001      | 92.48% |   0.95   |
| Summary + Review |    BOW     |       L2       |       0.0001      | 97.16% |   0.97   |
+------------------+------------+----------------+-------------------+--------+----------+
```