SVM

March 21, 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 TfidfVectorizer
from sklearn.model_selection import train_test_split, GridSearchCV

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix,roc_curve, auc,f1_score
from sklearn.calibration import CalibratedClassifierCV
from nltk.stem.porter import PorterStemmer
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC

import re
from bs4 import BeautifulSoup
# 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('./Dataset/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 points
# 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 500
        # for tsne assignment you can take 5k data points

        filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3""", con)

        # Give reviews with Score>3 a positive rating(1), and reviews with a score<3 a negative
        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 (525814, 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	Text	COUNT(*)
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK when considering the price...	2
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recurring extreme muscle spasms, u...	3
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horrible and unfortunately not ...	2
3	#oc-R11O5J5ZVQE25C	B005HG9ET0	Penguin Chick	1346889600	5	This will be the bottle that you grab from the...	3
4	#oc-R12KPBODL2B5ZD	B007OSBE1U	Christopher P. Presta	1348617600	1	I didnt like this coffee. Instead of telling y...	2

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

Out[5]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
80638	AZY10LLTJ71NX	B006P7E5ZI	undertheshrine "undertheshrine"	1334707200	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	HelpfulnessDenominator	Score	Time	Summary	Text
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOVE IT	I bought this 6 pack because my dog is allergi...
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOVE IT	I bought this 6 pack because my dog is allergi...
2	138277	B000HDOPYM	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1399507200	LOVE IT	I bought this 6 pack because my dog is allergi...

```
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=False
```

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

```
Out[9]: (364173, 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]: 69.25890143662969
```

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

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

         display.head()
```

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

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

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

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

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

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

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

```
(364171, 10)
```

```
Out[13]: 1    307061
         0     57110
         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)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're driving along
==================================================
I was really looking forward to these pods based on the reviews.  Starbucks is good, but I prefe
==================================================
Great ingredients although, chicken should have been 1st rather than chicken broth, the only thi
==================================================
Can't do sugar.  Have tried scores of SF Syrups.  NONE of them can touch the excellence of this
==================================================
```

```
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)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're driving along
```

In [16]:
```
# https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all-t
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)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're driving along
==================================================
I was really looking forward to these pods based on the reviews.  Starbucks is good, but I prefe
==================================================
Great ingredients although, chicken should have been 1st rather than chicken broth, the only thi
==================================================
Can't do sugar.  Have tried scores of SF Syrups.  NONE of them can touch the excellence of this
```

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)
```

```
Great ingredients although, chicken should have been 1st rather than chicken broth, the only thi
==================================================
```

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)
```

```
this witty little book makes my son laugh at loud. i recite it in the car as we're driving along
```

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

```
Great ingredients although chicken should have been 1st rather than chicken broth the only thing
```

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', 'ourselves
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 't
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "th
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'ha
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through'
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'ov
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too'
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'no
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't",
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'migh
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'w
            'won', "won't", 'wouldn', "wouldn't"])
```

```
In [22]: # Combining all the above stundents
         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 stopwor
             preprocessed_reviews.append(sentance.strip())
```

```
100%|| 364171/364171 [02:34<00:00, 2357.19it/s]
```

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

```
Out[23]: 'great ingredients although chicken rather chicken broth thing not think belongs canola
```

[3.2] Preprocessing Review Summary

```
In [24]: ## Similartly you can do preprocessing for review summary also.
         def concatenateSummaryWithText(str1, str2):
             return str1 + ' ' + str2

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

         preprocessed_reviews = list(map(concatenateSummaryWithText, preprocessed_reviews, prepr
         final['CleanedText'] = preprocessed_reviews
         final['CleanedText'] = final['CleanedText'].astype('str')
```

```
100%|| 364171/364171 [00:08<00:00, 44607.29it/s]
```

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])
```

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
```

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_name
# 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
```

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 [29]:
```
# # 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.b
#         print(w2v_model.wv.most_similar('great'))
#         print(w2v_model.wv.most_similar('worst'))
#     else:
#         print("you don't have gogole's word2vec file, keep want_to_train_w2v = True,
```

In [30]:
```
# 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])
```

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

[4.4.1.1] Avg W2v

In [31]:
```
# # 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]))
```

[4.4.1.2] TFIDF weighted W2v

In [32]:
```
# # 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 [33]:
```
# # 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
```

6 [5] Assignment 7: SVM

```
<li><strong>Apply SVM on these feature sets</strong>
    <ul>
        <li><font color='red'>SET 1:</font>Review text, preprocessed one converted into vectors
        <li><font color='red'>SET 2:</font>Review text, preprocessed one converted into vectors
        <li><font color='red'>SET 3:</font>Review text, preprocessed one converted into vectors
        <li><font color='red'>SET 4:</font>Review text, preprocessed one converted into vectors
    </ul>
```

```
</li>
<br>
<li><strong>Procedure</strong>
    <ul>
<li>You need to work with 2 versions of SVM
    <ul><li>Linear kernel</li>
        <li>RBF kernel</li></ul>
<li>When you are working with linear kernel, use SGDClassifier with hinge loss because it is com
<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/skle
<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 penalt
    <ul>
<li>Find the best hyper parameter which will give the maximum <a href='https://www.appliedaicour
<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 tas
    </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 enginee
        <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 e
<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 fin
<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.co
<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 form
    <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

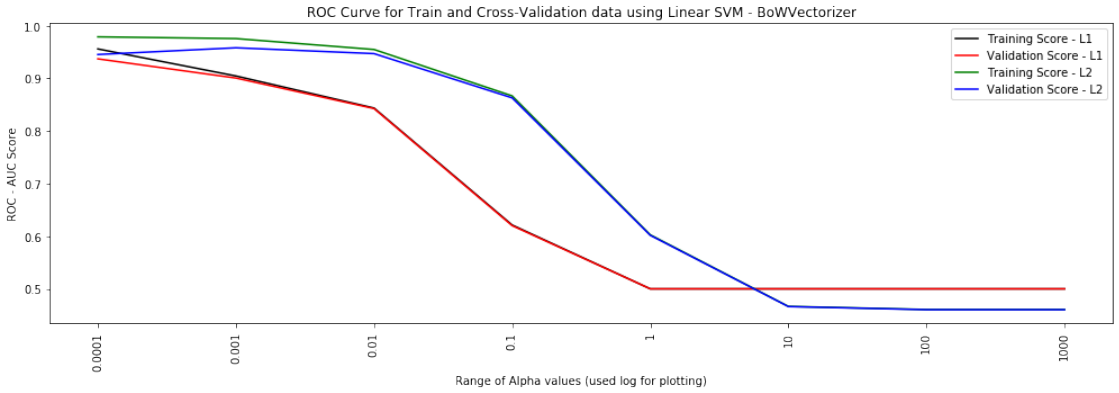
```
In [34]: global result_report
         result_report = pd.DataFrame(columns=['VECTORIZER', 'MODEL', 'DATASET-SIZE', 'HYPERPARA

In [35]: #Sorting according to the time for time-based splitting
         final['Time'] = pd.to_datetime(final['Time'], unit='s')
         final = final.sort_values(by='Time', ascending=True)

In [36]: #Using only 100k points for LINEAR-SVM
         min_final = final.sample(n=100000)
         x_train, x_test, y_train, y_test = train_test_split(min_final['CleanedText'], min_final

         alpha_range = list([10 ** i for i in range(-4, 4, 1)])
         penalty_range = list(['l1', 'l2'])
```

7.1 [5.1] Linear SVM

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

```
In [37]: # Applying BOW Vectorizer
         bow_model = CountVectorizer()
         bow_model.fit(x_train)

         x_train_bow = bow_model.transform(x_train)
         x_test_bow = bow_model.transform(x_test)
```

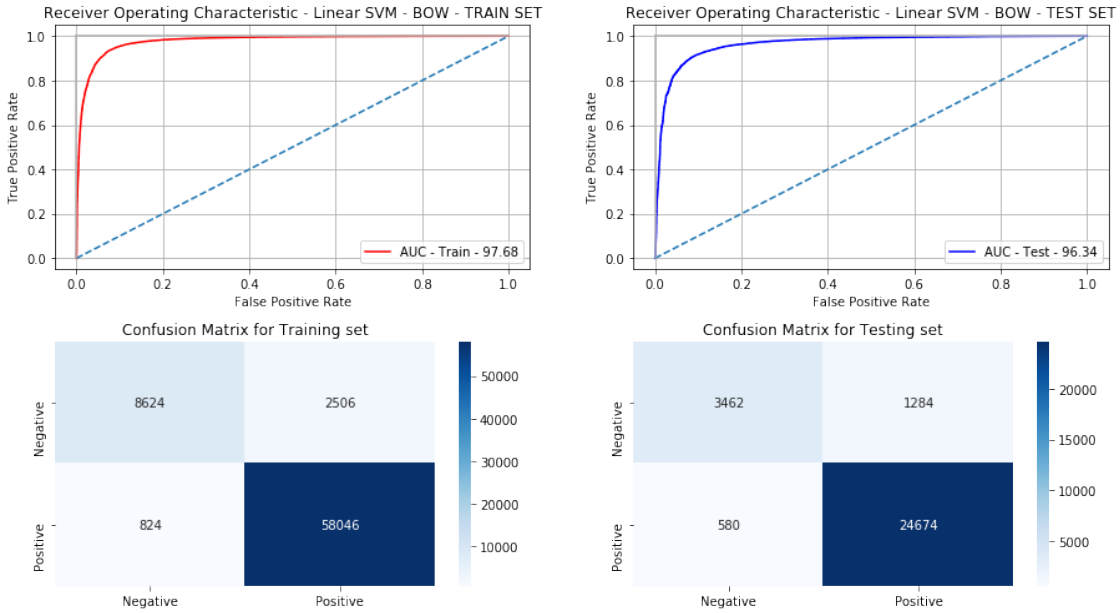
In [38]:
```
# Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
sgd = SGDClassifier()
parameters = {'alpha': alpha_range, 'penalty': penalty_range}
clf = GridSearchCV(sgd, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
clf.fit(x_train_bow, y_train)

def returnScoresForHyperparameters(scores, params):
    i = 0
    score_l1 = []
    score_l2 = []
    train_scores = scores
    for paramsObj in params:
        value = train_scores[i]
        if paramsObj['penalty'] == 'l1':
            score_l1.append(value)
        elif paramsObj['penalty'] == 'l2':
            score_l2.append(value)
        i+=1
    return score_l1, score_l2

mean_train_score_l1, mean_train_score_l2 = returnScoresForHyperparameters(clf.cv_result
                                                                          clf.cv_result
mean_test_score_l1, mean_test_score_l2 = returnScoresForHyperparameters(clf.cv_results_
                                                                        clf.cv_result


plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(np.log(alpha_range), mean_train_score_l1, label='Training Score - L1', color='
plt.plot(np.log(alpha_range), mean_test_score_l1, label='Validation Score - L1', color=
plt.plot(np.log(alpha_range), mean_train_score_l2, label='Training Score - L2', color='
plt.plot(np.log(alpha_range), mean_test_score_l2, label='Validation Score - L2', color=
plt.xticks(np.log(alpha_range), alpha_range, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Linear SVM - BoWVectoriz
plt.xlabel("Range of Alpha values (used log for plotting)")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")
plt.show()
```



In [39]:
```
optimal_alpha = clf.best_params_['alpha']
optimal_penalty = clf.best_params_['penalty']

sgd = SGDClassifier(loss = 'hinge', alpha = optimal_alpha, penalty=optimal_penalty)
ccv_clf = CalibratedClassifierCV(sgd, cv=10)
ccv_clf.fit(x_train_bow, y_train)

# Get predicted values for test data
pred_train = ccv_clf.predict(x_train_bow)
pred_test = ccv_clf.predict(x_test_bow)
pred_proba_train = ccv_clf.predict_proba(x_train_bow)[:,1]
pred_proba_test = ccv_clf.predict_proba(x_test_bow)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Alpha: {} with Penalty: {} with AUC: {:.2f}%".format(optimal_alpha, opti
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'Bag of Words(BoW)',
                                      'MODEL': 'LINEAR-SVM',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': optimal_penalty,
                                      'HYPERPARAMETER': optimal_alpha,
                                      'F1_SCORE': f1_sc, 'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
```

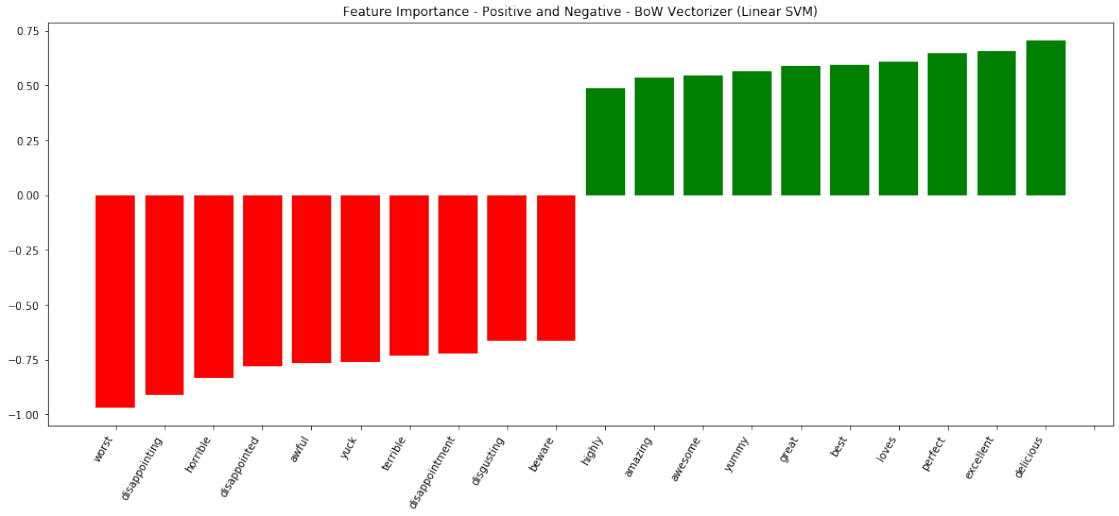
```
        # Plot ROC curve for training set
        plt.subplot(2, 2, 1)
        plt.title('Receiver Operating Characteristic - Linear SVM - BOW - TRAIN SET')
        plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
        plt.plot([0, 1], ls="--")
        plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.grid()
        plt.legend(loc='best')

        # Plot ROC curve for test set
        plt.subplot(2, 2, 2)
        plt.title('Receiver Operating Characteristic - Linear SVM - BOW - TEST SET')
        plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
        plt.plot([0, 1], ls="--")
        plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.grid()
        plt.legend(loc='best')

        #Plotting the confusion matrix for train
        plt.subplot(2, 2, 3)
        plt.title('Confusion Matrix for Training set')
        df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        #Plotting the confusion matrix for test
        plt.subplot(2, 2, 4)
        plt.title('Confusion Matrix for Testing set')
        df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        plt.tight_layout()
        plt.show()
```

```
Optimal Alpha: 0.001 with Penalty: l2 with AUC: 96.34%
```



7.1.2 [5.1.1.1] Feature Importance (Linear SVM on BoW)

```
In [40]: sgd_clf = SGDClassifier(loss = 'hinge', alpha = optimal_alpha, penalty=optimal_penalty)
         sgd_clf.fit(x_train_bow, y_train)
         coef = sgd_clf.coef_.ravel()
         feature_names = bow_model.get_feature_names()
         top_positive_coef = np.argsort(coef)[-10:]
         top_negative_coef = np.argsort(coef)[:10]
         top_coefficients = np.hstack([top_negative_coef, top_positive_coef])

         plt.figure(figsize=(18, 7))
         plt.title("Feature Importance - Positive and Negative - BoW Vectorizer (Linear SVM)")
         colors = ['red' if c < 0 else 'green' for c in coef[top_coefficients]]
         plt.bar(np.arange(2 * 10), coef[top_coefficients], color=colors)
         feature_names = np.array(feature_names)
         plt.xticks(np.arange(0, 1 + 2 * 10), feature_names[top_coefficients], rotation=60, ha='
         plt.show()
```

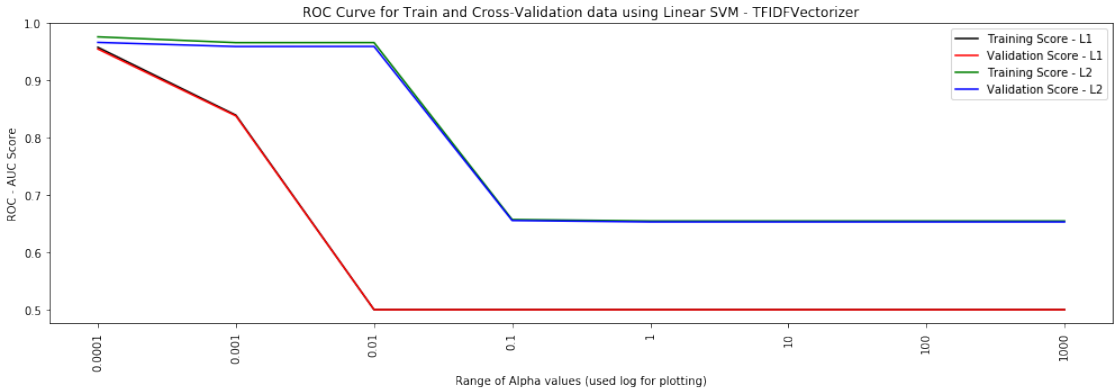


7.1.3 [5.1.2] Applying Linear SVM on TFIDF, SET 2

In [41]:
```
# Applying TFIDF Vectorizer
tfidf_model = TfidfVectorizer()
tfidf_model.fit(x_train)

x_train_tfidf = tfidf_model.transform(x_train)
x_test_tfidf = tfidf_model.transform(x_test)
```

In [42]:
```
# Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
sgd = SGDClassifier()
parameters = {'alpha': alpha_range, 'penalty': penalty_range}
clf = GridSearchCV(sgd, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
clf.fit(x_train_tfidf, y_train)

def returnScoresForHyperparameters(scores, params):
    i = 0
    score_l1 = []
    score_l2 = []
    train_scores = scores
    for paramsObj in params:
        value = train_scores[i]
        if paramsObj['penalty'] == 'l1':
            score_l1.append(value)
        elif paramsObj['penalty'] == 'l2':
            score_l2.append(value)
        i+=1
    return score_l1, score_l2

mean_train_score_l1, mean_train_score_l2 = returnScoresForHyperparameters(clf.cv_result
```

```
                                                                                clf.cv_result
mean_test_score_l1, mean_test_score_l2 = returnScoresForHyperparameters(clf.cv_results_
                                                                                clf.cv_result


plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(np.log(alpha_range), mean_train_score_l1, label='Training Score - L1', color='
plt.plot(np.log(alpha_range), mean_test_score_l1, label='Validation Score - L1', color=
plt.plot(np.log(alpha_range), mean_train_score_l2, label='Training Score - L2', color='
plt.plot(np.log(alpha_range), mean_test_score_l2, label='Validation Score - L2', color=
plt.xticks(np.log(alpha_range), alpha_range, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Linear SVM - TFIDFVector
plt.xlabel("Range of Alpha values (used log for plotting)")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")
plt.show()
```

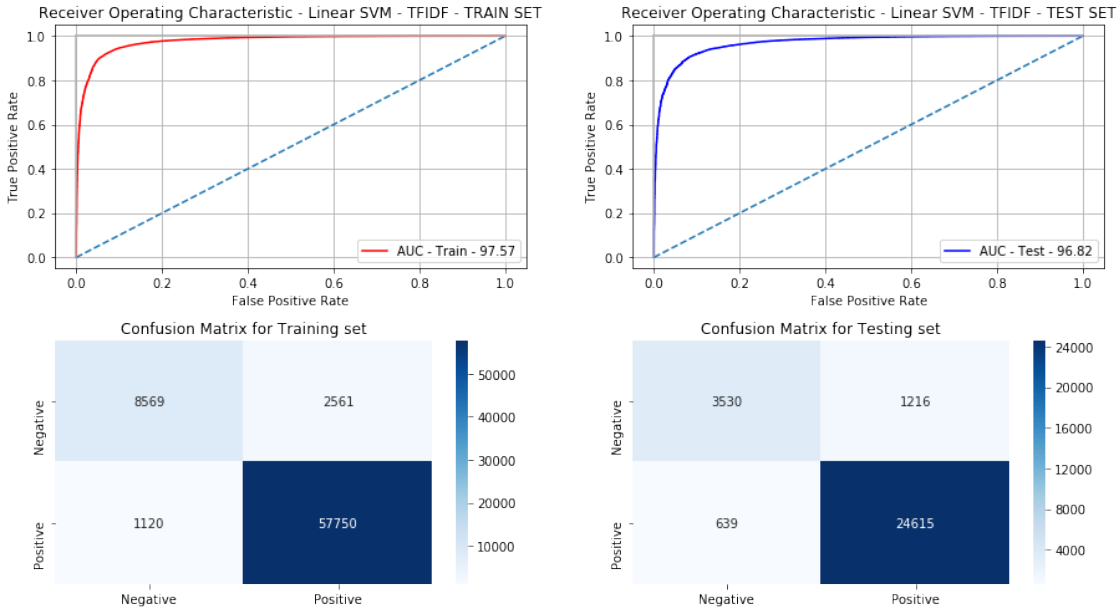


In [43]:
```
optimal_alpha = clf.best_params_['alpha']
optimal_penalty = clf.best_params_['penalty']

sgd = SGDClassifier(loss = 'hinge', alpha = optimal_alpha, penalty=optimal_penalty)
ccv_clf = CalibratedClassifierCV(sgd, cv=10)
ccv_clf.fit(x_train_tfidf, y_train)

# Get predicted values for test data
pred_train = ccv_clf.predict(x_train_tfidf)
pred_test = ccv_clf.predict(x_test_tfidf)
pred_proba_train = ccv_clf.predict_proba(x_train_tfidf)[:,1]
pred_proba_test = ccv_clf.predict_proba(x_test_tfidf)[:,1]
```

```
fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Alpha: {} with Penalty: {} with AUC: {:.2f}%".format(optimal_alpha, opti
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'TF-IDF',
                                      'MODEL': 'LINEAR-SVM',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': optimal_penalty,
                                      'HYPERPARAMETER': optimal_alpha,
                                      'F1_SCORE': f1_sc, 'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Linear SVM - TFIDF - TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Linear SVM - TFIDF - TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')
```

```
        #Plotting the confusion matrix for test
        plt.subplot(2, 2, 4)
        plt.title('Confusion Matrix for Testing set')
        df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        plt.tight_layout()
        plt.show()
```

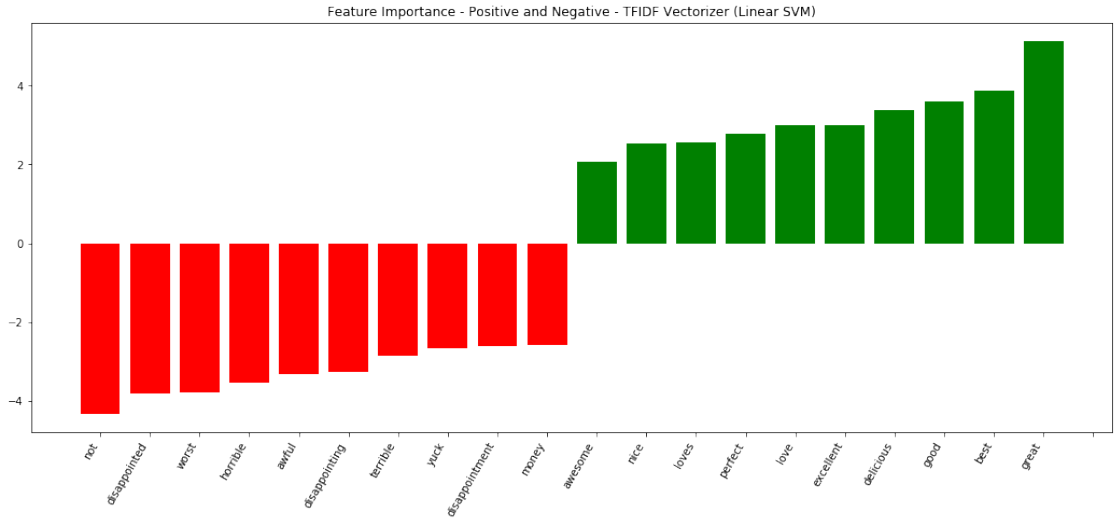
```
Optimal Alpha: 0.0001 with Penalty: l2 with AUC: 96.82%
```



7.1.4 [5.1.2.1] Feature Importance (Linear SVM on TF-IDF)

```
In [44]: sgd_clf = SGDClassifier(loss = 'hinge', alpha = optimal_alpha, penalty=optimal_penalty)
         sgd_clf.fit(x_train_tfidf, y_train)
         coef = sgd_clf.coef_.ravel()
         feature_names = tfidf_model.get_feature_names()
         top_positive_coef = np.argsort(coef)[-10:]
         top_negative_coef = np.argsort(coef)[:10]
         top_coefficients = np.hstack([top_negative_coef, top_positive_coef])

         plt.figure(figsize=(18, 7))
         plt.title("Feature Importance - Positive and Negative - TFIDF Vectorizer (Linear SVM)")
         colors = ['red' if c < 0 else 'green' for c in coef[top_coefficients]]
```

```
        plt.bar(np.arange(2 * 10), coef[top_coefficients], color=colors)
        feature_names = np.array(feature_names)
        plt.xticks(np.arange(0, 1 + 2 * 10), feature_names[top_coefficients], rotation=60, ha='
        plt.show()
```



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

```
In [45]: list_of_sent_train = []
         list_of_sent_test = []

         for sent in x_train:
             list_of_sent_train.append(sent.split())
         for sent in x_test:
             list_of_sent_test.append(sent.split())

         w2v_model=Word2Vec(list_of_sent_train,min_count=5,size=50, workers=8)
         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  16643
sample words  ['cramp', 'handling', 'branch', 'debated', 'slather', 'expedient', 'si', 'pillows'
```

```
In [46]: # compute average word2vec for each review for train data
         avgw2v_train = [] # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_sent_train): # for each review/sentence
             sent_vec = np.zeros(50)
             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
            avgw2v_train.append(sent_vec)
        print(len(avgw2v_train))
        print(len(avgw2v_train[0]))
```

```
100%|| 70000/70000 [16:55<00:00, 68.94it/s]
```

```
70000
50
```

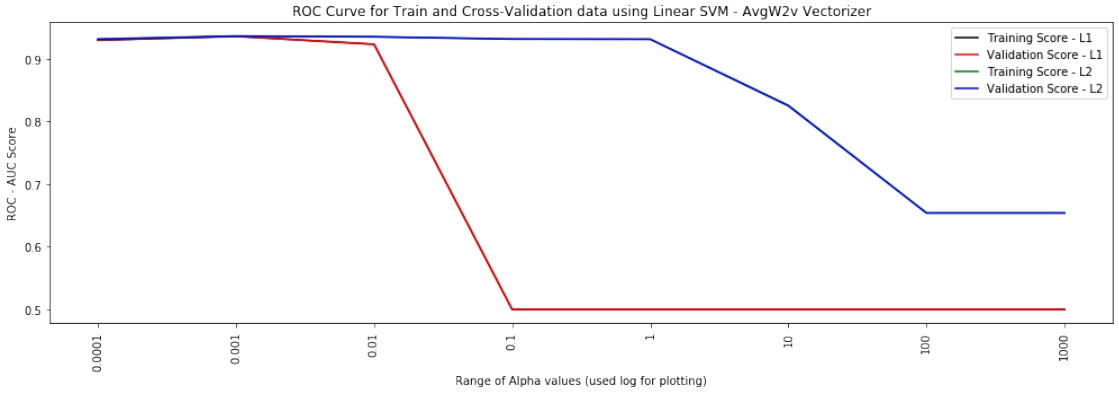
In [47]:
```
# compute average word2vec for each review for test data
avgw2v_test = [] # the avg-w2v for each sentence/review is stored in this list
for sent in tqdm(list_of_sent_test): # for each review/sentence
    sent_vec = np.zeros(50)
    cnt_words = 0 # num of words with a valid vector in the 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
    avgw2v_test.append(sent_vec)
print(len(avgw2v_test))
print(len(avgw2v_test[0]))
```

```
100%|| 30000/30000 [07:05<00:00, 70.55it/s]
```

```
30000
50
```

In [48]:
```
# Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
sgd = SGDClassifier()
parameters = {'alpha': alpha_range, 'penalty': penalty_range}
clf = GridSearchCV(sgd, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
clf.fit(avgw2v_train, y_train)
```

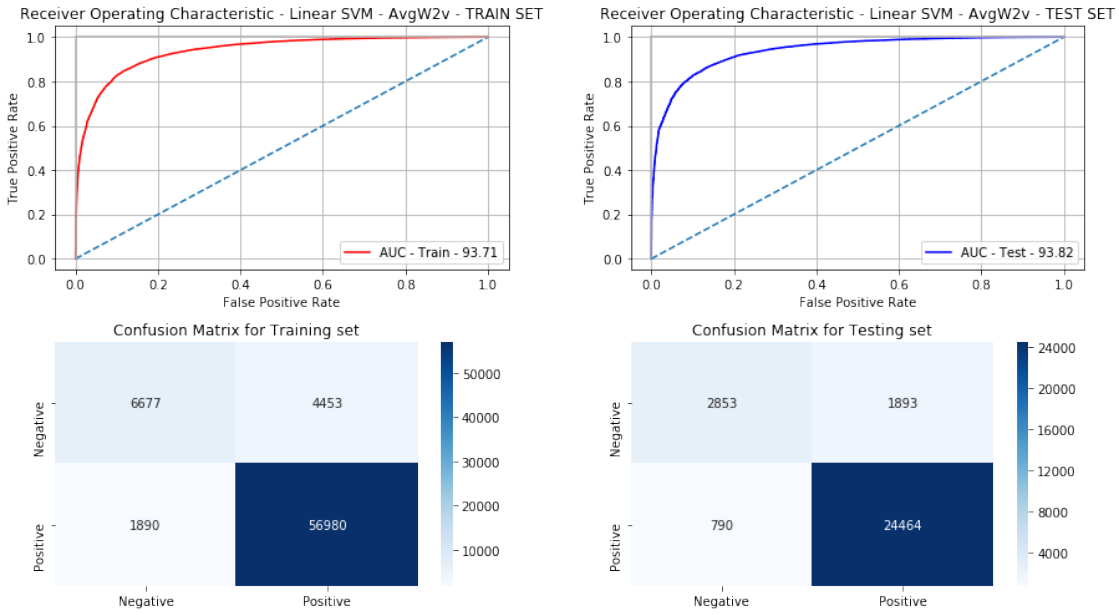
```
def returnScoresForHyperparameters(scores, params):
    i = 0
    score_l1 = []
    score_l2 = []
    train_scores = scores
    for paramsObj in params:
        value = train_scores[i]
        if paramsObj['penalty'] == 'l1':
            score_l1.append(value)
        elif paramsObj['penalty'] == 'l2':
            score_l2.append(value)
        i+=1
    return score_l1, score_l2

mean_train_score_l1, mean_train_score_l2 = returnScoresForHyperparameters(clf.cv_result
                                                                          clf.cv_result
mean_test_score_l1, mean_test_score_l2 = returnScoresForHyperparameters(clf.cv_results_
                                                                          clf.cv_result


plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(np.log(alpha_range), mean_train_score_l1, label='Training Score - L1', color='
plt.plot(np.log(alpha_range), mean_test_score_l1, label='Validation Score - L1', color=
plt.plot(np.log(alpha_range), mean_train_score_l2, label='Training Score - L2', color='
plt.plot(np.log(alpha_range), mean_test_score_l2, label='Validation Score - L2', color=
plt.xticks(np.log(alpha_range), alpha_range, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Linear SVM - AvgW2v Vect
plt.xlabel("Range of Alpha values (used log for plotting)")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")
plt.show()
```



In [49]:
```
optimal_alpha = clf.best_params_['alpha']
optimal_penalty = clf.best_params_['penalty']

sgd = SGDClassifier(loss = 'hinge', alpha = optimal_alpha, penalty=optimal_penalty)
ccv_clf = CalibratedClassifierCV(sgd, cv=10)
ccv_clf.fit(avgw2v_train, y_train)

# Get predicted values for test data
pred_train = ccv_clf.predict(avgw2v_train)
pred_test = ccv_clf.predict(avgw2v_test)
pred_proba_train = ccv_clf.predict_proba(avgw2v_train)[:,1]
pred_proba_test = ccv_clf.predict_proba(avgw2v_test)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Alpha: {} with Penalty: {} with AUC: {:.2f}%".format(optimal_alpha, opti
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'Avg-W2V',
                                      'MODEL': 'LINEAR-SVM',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': optimal_penalty,
                                      'HYPERPARAMETER': optimal_alpha,
                                      'F1_SCORE': f1_sc, 'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Linear SVM - AvgW2v - TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

# Plot ROC curve for test set
```

```
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Linear SVM - AvgW2v - TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
plt.title('Confusion Matrix for Testing set')
df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

plt.tight_layout()
plt.show()
```

```
Optimal Alpha: 0.001 with Penalty: l2 with AUC: 93.82%
```



7.1.6 [5.1.4] Applying Linear SVM on TFIDF W2V, SET 4

```
In [50]: model = TfidfVectorizer()
         model.fit(x_train)
```

```
Out[50]: TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
                dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
                lowercase=True, max_df=1.0, max_features=None, min_df=1,
                ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,
                stop_words=None, strip_accents=None, sublinear_tf=False,
                token_pattern='(?u)\\b\\w\\w+\\b', tokenizer=None, use_idf=True,
                vocabulary=None)
```

```
In [51]: #Creating the TFIDF W2V Training Set
         # 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_)))

         # 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

         tfidfw2v_train = []; # the tfidf-w2v for each sentence/review is stored in this list
         row=0;
         for sent in tqdm(list_of_sent_train): # for each review/sentence
             sent_vec = np.zeros(50) # as word vectors are of zero length
             weight_sum =0; # num of words with a valid vector in the sentence/review
             for word in sent: # for each word in a review/sentence
                 if word in w2v_words and word in tfidf_feat:
                     vec = w2v_model.wv[word]
                     tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                     sent_vec += (vec * tf_idf)
                     weight_sum += tf_idf
             if weight_sum != 0:
                 sent_vec /= weight_sum
             tfidfw2v_train.append(sent_vec)
             row += 1
```

```
100%|| 70000/70000 [1:24:51<00:00, 13.75it/s]
```

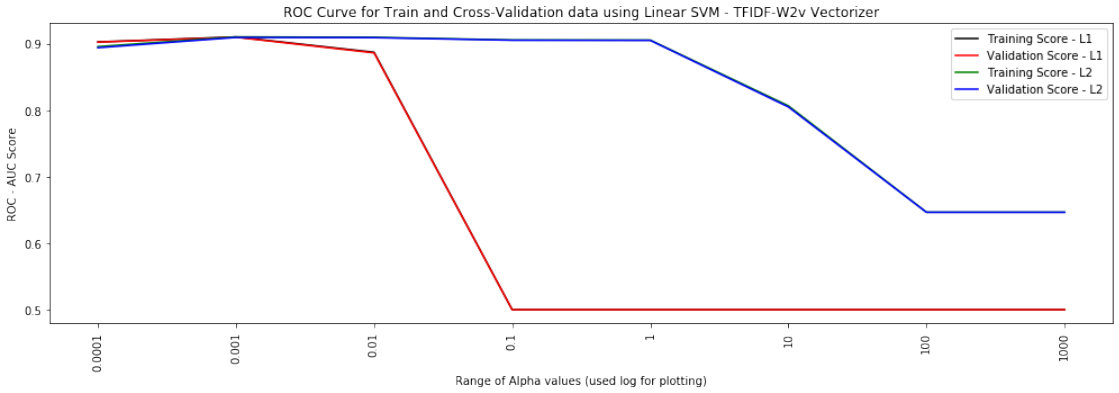
```
In [52]: #Creating the TFIDF W2V Testing Set

         # 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

         tfidfw2v_test = []; # the tfidf-w2v for each sentence/review is stored in this list
```

```
        row=0;
        for sent in tqdm(list_of_sent_test): # for each review/sentence
            sent_vec = np.zeros(50) # as word vectors are of zero length
            weight_sum =0; # num of words with a valid vector in the sentence/review
            for word in sent: # for each word in a review/sentence
                if word in w2v_words and word in tfidf_feat:
                    vec = w2v_model.wv[word]
                    tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                    sent_vec += (vec * tf_idf)
                    weight_sum += tf_idf
            if weight_sum != 0:
                sent_vec /= weight_sum
            tfidfw2v_test.append(sent_vec)
            row += 1
```

```
100%|| 30000/30000 [30:38<00:00, 26.48it/s]
```

```
In [53]: # Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
         sgd = SGDClassifier()
         parameters = {'alpha': alpha_range, 'penalty': penalty_range}
         clf = GridSearchCV(sgd, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
         clf.fit(tfidfw2v_train, y_train)

         def returnScoresForHyperparameters(scores, params):
             i = 0
             score_l1 = []
             score_l2 = []
             train_scores = scores
             for paramsObj in params:
                 value = train_scores[i]
                 if paramsObj['penalty'] == 'l1':
                     score_l1.append(value)
                 elif paramsObj['penalty'] == 'l2':
                     score_l2.append(value)
                 i+=1
             return score_l1, score_l2

         mean_train_score_l1, mean_train_score_l2 = returnScoresForHyperparameters(clf.cv_result
                                                                                   clf.cv_result
         mean_test_score_l1, mean_test_score_l2 = returnScoresForHyperparameters(clf.cv_results_
                                                                                 clf.cv_result

         plt.figure(figsize=(14, 5))
         #Plot mean accuracy for train and cv set scores
         plt.plot(np.log(alpha_range), mean_train_score_l1, label='Training Score - L1', color='
         plt.plot(np.log(alpha_range), mean_test_score_l1, label='Validation Score - L1', color=
         plt.plot(np.log(alpha_range), mean_train_score_l2, label='Training Score - L2', color='
```

```
plt.plot(np.log(alpha_range), mean_test_score_l2, label='Validation Score - L2', color=
plt.xticks(np.log(alpha_range), alpha_range, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Linear SVM - TFIDF-W2v V
plt.xlabel("Range of Alpha values (used log for plotting)")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")
plt.show()
```

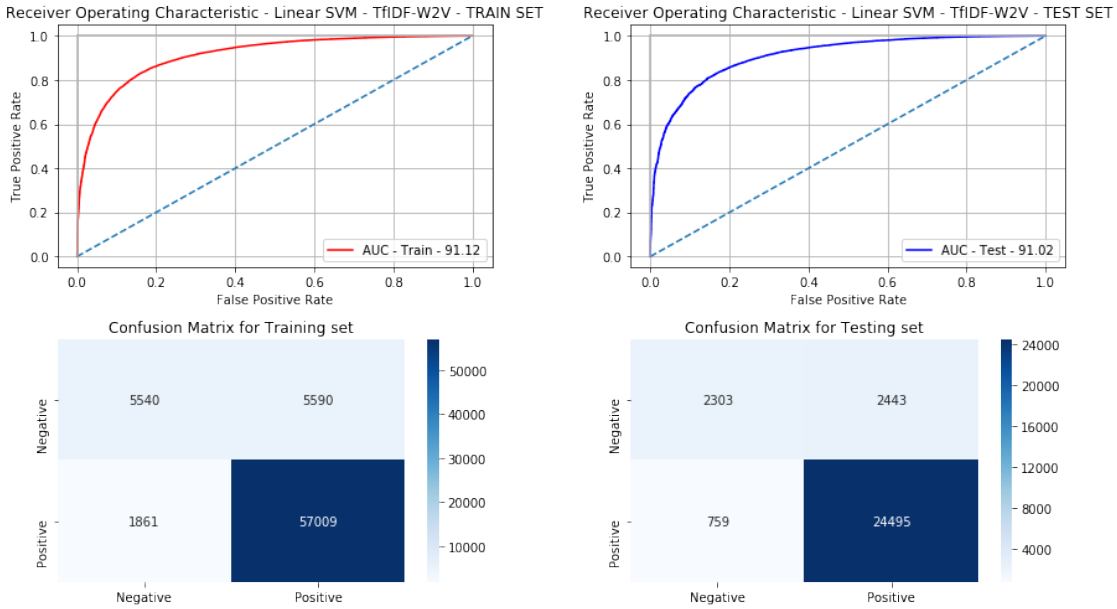


In [54]:
```
optimal_alpha = clf.best_params_['alpha']
optimal_penalty = clf.best_params_['penalty']

sgd = SGDClassifier(loss = 'hinge', alpha = optimal_alpha, penalty=optimal_penalty)
ccv_clf = CalibratedClassifierCV(sgd, cv=10)
ccv_clf.fit(tfidfw2v_train, y_train)

# Get predicted values for test data
pred_train = ccv_clf.predict(tfidfw2v_train)
pred_test = ccv_clf.predict(tfidfw2v_test)
pred_proba_train = ccv_clf.predict_proba(tfidfw2v_train)[:,1]
pred_proba_test = ccv_clf.predict_proba(tfidfw2v_test)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Alpha: {} with Penalty: {} with AUC: {:.2f}%".format(optimal_alpha, opti
```

```
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'TFIDF-W2V',
                                      'MODEL': 'LINEAR-SVM',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': optimal_penalty,
                                      'HYPERPARAMETER': optimal_alpha,
                                      'F1_SCORE': f1_sc, 'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Linear SVM - TfIDF-W2V - TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Linear SVM - TfIDF-W2V - TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
plt.title('Confusion Matrix for Testing set')
df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

plt.tight_layout()
```

```
        plt.show()
```

```
Optimal Alpha: 0.001 with Penalty: l1 with AUC: 91.02%
```



7.2 [5.2] RBF SVM

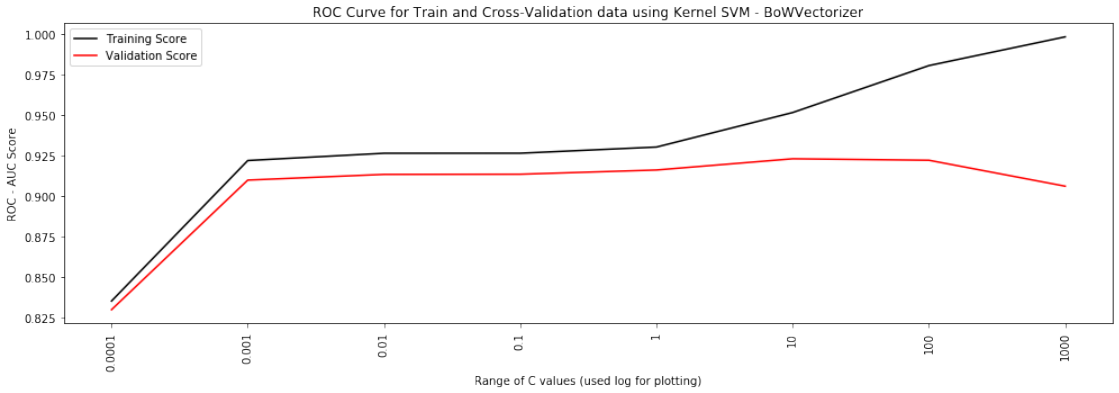
```
In [55]: #Using only 30k points for Kernel SVM (RBF Kernel)
         min_final = final.sample(n=30000)
         x_train, x_test, y_train, y_test = train_test_split(min_final['CleanedText'], min_final

         c_range = list([10 ** i for i in range(-4, 4, 1)])
```

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

```
In [56]: # Applying BOW Vectorizer
         bow_model = CountVectorizer(min_df = 5, max_features=500)
         bow_model.fit(x_train)

         x_train_bow = bow_model.transform(x_train)
         x_test_bow = bow_model.transform(x_test)
```

```
In [57]: # Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
         svc = SVC(kernel='rbf')

         parameters = {'C': c_range}
         clf = GridSearchCV(svc, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
         clf.fit(x_train_bow, y_train)
```

```
mean_train_score = clf.cv_results_['mean_train_score']
mean_test_score = clf.cv_results_['mean_test_score']

plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(np.log(c_range), mean_train_score, label='Training Score', color='black')
plt.plot(np.log(c_range), mean_test_score, label='Validation Score', color='red')

plt.xticks(np.log(c_range), c_range, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Kernel SVM - BoWVectoriz
plt.xlabel("Range of C values (used log for plotting)")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")
plt.show()
```

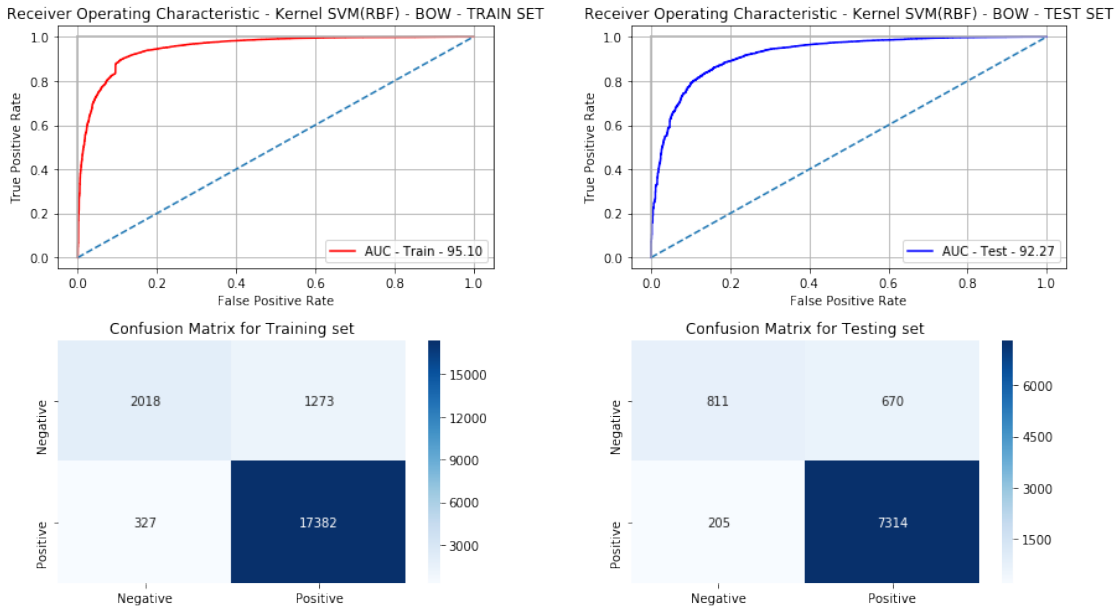


In [58]:
```
optimal_c = clf.best_params_['C']

clf = SVC(kernel='rbf',C=optimal_c, probability=True)
clf.fit(x_train_bow, y_train)

# Get predicted values for test data
pred_train = clf.predict(x_train_bow)
pred_test = clf.predict(x_test_bow)
pred_proba_train = clf.predict_proba(x_train_bow)[:,1]
pred_proba_test = clf.predict_proba(x_test_bow)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
```

```
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal C: {}  with AUC: {:.2f}%".format(optimal_c, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'Bag of Words(BoW)',
                                      'MODEL': 'KERNEL-SVM(RBF)',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': '-',
                                      'HYPERPARAMETER': optimal_c,
                                      'F1_SCORE': f1_sc, 'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - BOW - TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - BOW - TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
```

```
        plt.title('Confusion Matrix for Testing set')
        df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        plt.tight_layout()
        plt.show()
```

```
Optimal C: 10  with AUC: 92.27%
```

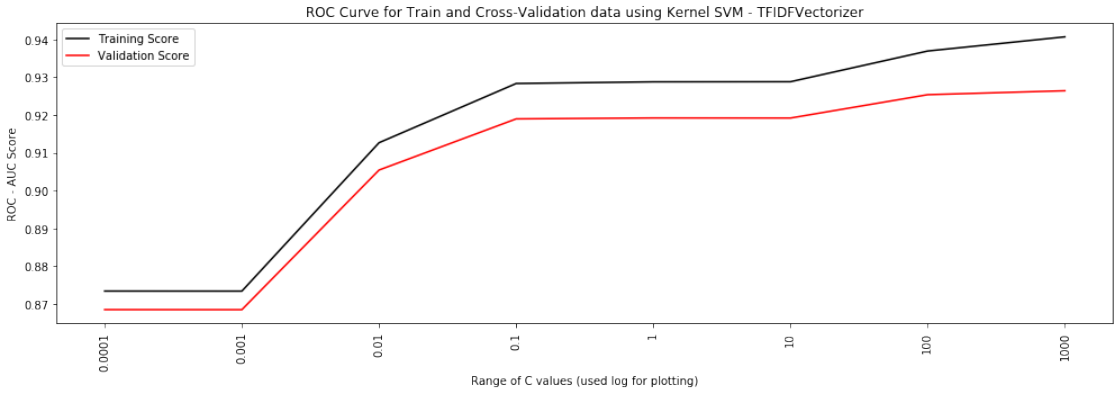


7.2.2 [5.2.2] Applying RBF SVM on TFIDF, SET 2

```
In [59]: # Applying TFIDF Vectorizer
         tfidf_model = TfidfVectorizer(min_df = 5, max_features=500)
         tfidf_model.fit(x_train)

         x_train_tfidf = tfidf_model.transform(x_train)
         x_test_tfidf = tfidf_model.transform(x_test)
```

```
In [60]: # Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
         svc = SVC(kernel='rbf')

         parameters = {'C': c_range}
         clf = GridSearchCV(svc, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
         clf.fit(x_train_tfidf, y_train)

         mean_train_score = clf.cv_results_['mean_train_score']
```

```
mean_test_score = clf.cv_results_['mean_test_score']

plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(np.log(c_range), mean_train_score, label='Training Score', color='black')
plt.plot(np.log(c_range), mean_test_score, label='Validation Score', color='red')

plt.xticks(np.log(c_range), c_range, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Kernel SVM - TFIDFVector
plt.xlabel("Range of C values (used log for plotting)")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")
plt.show()
```

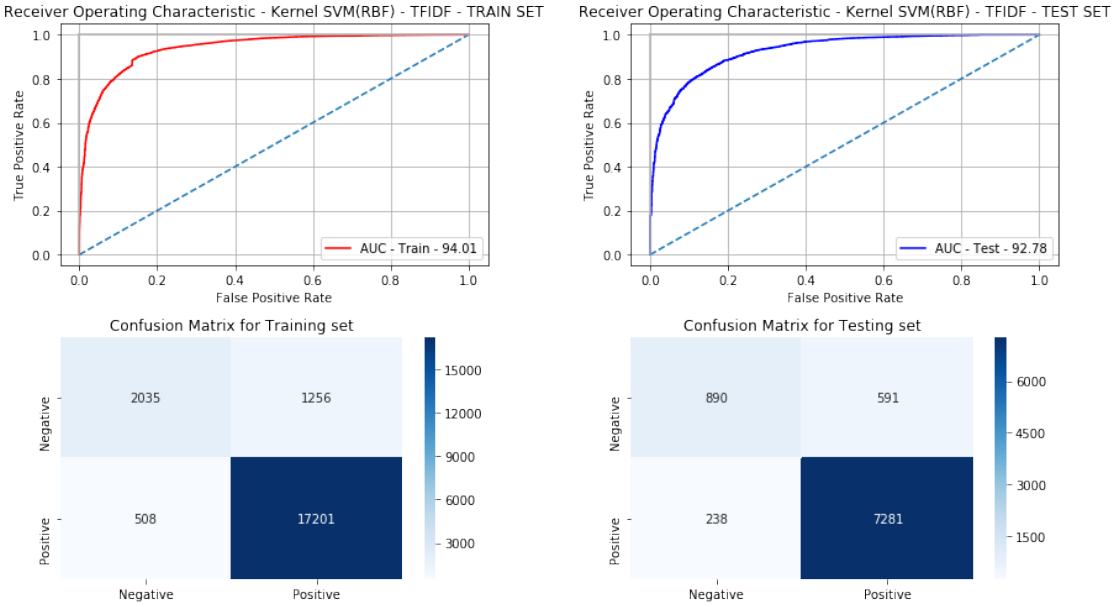


In [61]:
```
optimal_c = clf.best_params_['C']

clf = SVC(kernel='rbf',C=optimal_c, probability=True)
clf.fit(x_train_tfidf, y_train)

# Get predicted values for test data
pred_train = clf.predict(x_train_tfidf)
pred_test = clf.predict(x_test_tfidf)
pred_proba_train = clf.predict_proba(x_train_tfidf)[:,1]
pred_proba_test = clf.predict_proba(x_test_tfidf)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
```

```
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal C: {}  with AUC: {:.2f}%".format(optimal_c, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'TF-IDF',
                                      'MODEL': 'KERNEL-SVM(RBF)',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': '-',
                                      'HYPERPARAMETER': optimal_c,
                                      'F1_SCORE': f1_sc, 'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - TFIDF - TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - TFIDF - TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
plt.title('Confusion Matrix for Testing set')
df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
```

```
                           columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        plt.tight_layout()
        plt.show()
```

```
Optimal C: 1000  with AUC: 92.78%
```



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

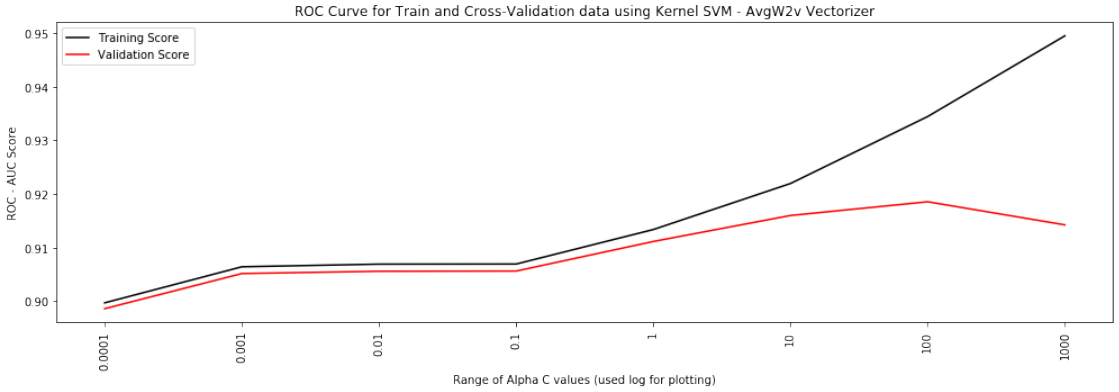
```
In [62]: list_of_sent_train = []
         list_of_sent_test = []

         for sent in x_train:
             list_of_sent_train.append(sent.split())
         for sent in x_test:
             list_of_sent_test.append(sent.split())

         w2v_model=Word2Vec(list_of_sent_train,min_count=5,size=50, workers=8)
         w2v_words = list(w2v_model.wv.vocab)


         # compute average word2vec for each review for train data
         avgw2v_train = [] # the avg-w2v for each sentence/review is stored in this list
         for sent in tqdm(list_of_sent_train): # for each review/sentence
             sent_vec = np.zeros(50)
             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
            avgw2v_train.append(sent_vec)


        # compute average word2vec for each review for test data
        avgw2v_test = [] # the avg-w2v for each sentence/review is stored in this list
        for sent in tqdm(list_of_sent_test): # for each review/sentence
            sent_vec = np.zeros(50)
            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
            avgw2v_test.append(sent_vec)
```

```
100%|| 21000/21000 [02:30<00:00, 139.60it/s]
100%|| 9000/9000 [01:03<00:00, 130.88it/s]
```

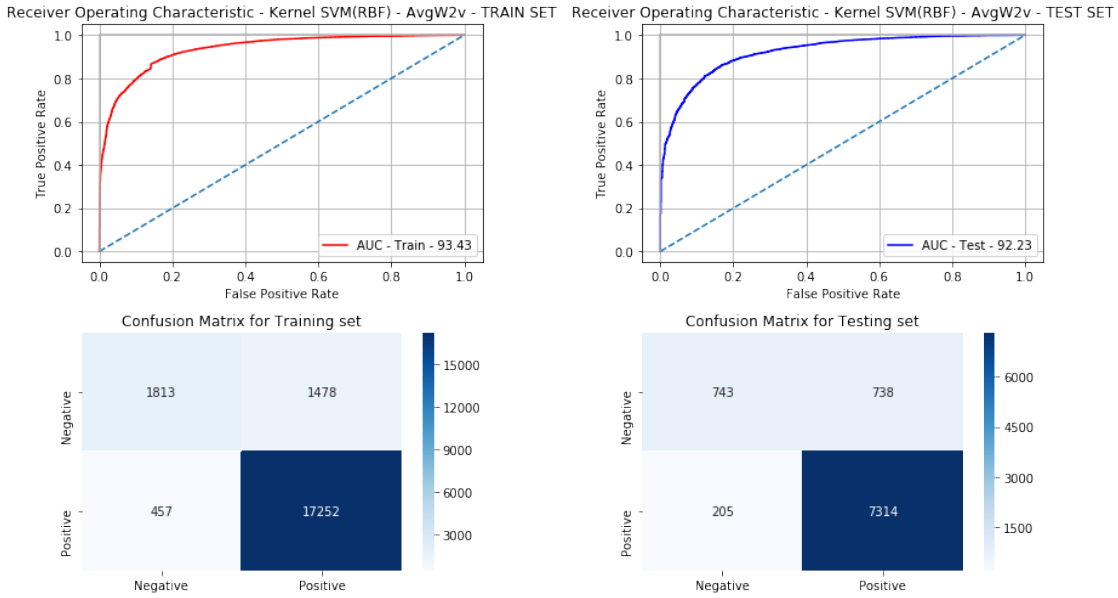
In [63]:
```
        # Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
        svc = SVC(kernel='rbf')

        parameters = {'C': c_range}
        clf = GridSearchCV(svc, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
        clf.fit(avgw2v_train, y_train)

        mean_train_score = clf.cv_results_['mean_train_score']
        mean_test_score = clf.cv_results_['mean_test_score']

        plt.figure(figsize=(14, 5))
        #Plot mean accuracy for train and cv set scores
        plt.plot(np.log(c_range), mean_train_score, label='Training Score', color='black')
        plt.plot(np.log(c_range), mean_test_score, label='Validation Score', color='red')

        plt.xticks(np.log(c_range), c_range, rotation='vertical')

        # Create plot
        plt.title("ROC Curve for Train and Cross-Validation data using Kernel SVM - AvgW2v Vect
        plt.xlabel("Range of Alpha C values (used log for plotting)")
```

```
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")
plt.show()
```



In [64]:
```
optimal_c = clf.best_params_['C']

clf = SVC(kernel='rbf',C=optimal_c, probability=True)
clf.fit(avgw2v_train, y_train)

# Get predicted values for test data
pred_train = clf.predict(avgw2v_train)
pred_test = clf.predict(avgw2v_test)
pred_proba_train = clf.predict_proba(avgw2v_train)[:,1]
pred_proba_test = clf.predict_proba(avgw2v_test)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal C: {}  with AUC: {:.2f}%".format(optimal_c, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'Avg-W2V',
                                      'MODEL': 'KERNEL-SVM(RBF)',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': '-',
                                      'HYPERPARAMETER': optimal_c,
                                      'F1_SCORE': f1_sc, 'AUC': auc_sc
                                     }, ignore_index=True)
```

```
        plt.figure(figsize=(13,7))
        # Plot ROC curve for training set
        plt.subplot(2, 2, 1)
        plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - AvgW2v - TRAIN SET')
        plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
        plt.plot([0, 1], ls="--")
        plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.grid()
        plt.legend(loc='best')

        # Plot ROC curve for test set
        plt.subplot(2, 2, 2)
        plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - AvgW2v - TEST SET')
        plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
        plt.plot([0, 1], ls="--")
        plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.grid()
        plt.legend(loc='best')

        #Plotting the confusion matrix for train
        plt.subplot(2, 2, 3)
        plt.title('Confusion Matrix for Training set')
        df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        #Plotting the confusion matrix for test
        plt.subplot(2, 2, 4)
        plt.title('Confusion Matrix for Testing set')
        df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        plt.tight_layout()
        plt.show()

Optimal C: 100  with AUC: 92.23%
```



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

In [65]:
```
model = TfidfVectorizer()
model.fit(x_train)
```

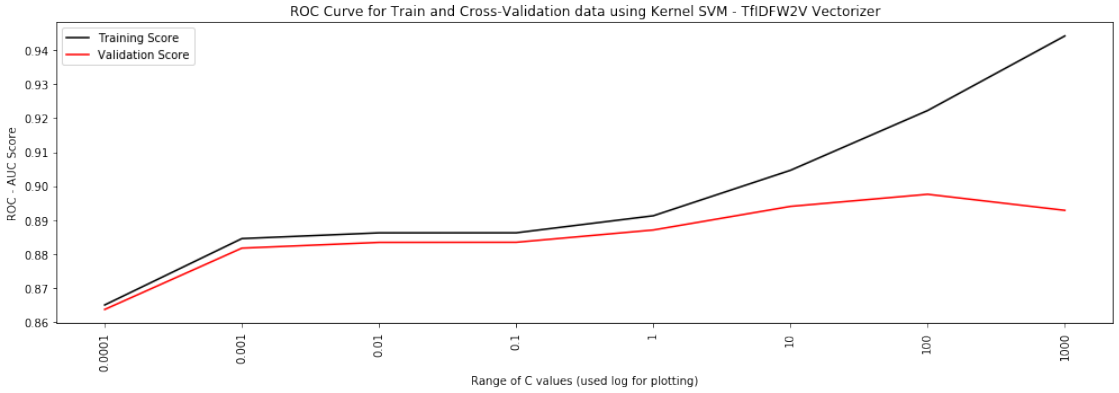
```
#Creating the TFIDF W2V Training Set
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))

# 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

tfidfw2v_train = []; # the tfidf-w2v for each sentence/review is stored in this list
row=0;
for sent in tqdm(list_of_sent_train): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
```

```
            tfidfw2v_train.append(sent_vec)
            row += 1



        #Creating the TFIDF W2V Testing Set

        # 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

        tfidfw2v_test = []; # the tfidf-w2v for each sentence/review is stored in this list
        row=0;
        for sent in tqdm(list_of_sent_test): # for each review/sentence
            sent_vec = np.zeros(50) # as word vectors are of zero length
            weight_sum =0; # num of words with a valid vector in the sentence/review
            for word in sent: # for each word in a review/sentence
                if word in w2v_words and word in tfidf_feat:
                    vec = w2v_model.wv[word]
                    tf_idf = dictionary[word]*(sent.count(word)/len(sent))
                    sent_vec += (vec * tf_idf)
                    weight_sum += tf_idf
            if weight_sum != 0:
                sent_vec /= weight_sum
            tfidfw2v_test.append(sent_vec)
            row += 1
```

```
100%|| 21000/21000 [11:51<00:00, 38.15it/s]
100%|| 9000/9000 [04:47<00:00, 31.28it/s]
```

```
In [66]: # Applying SGDClassifier to Alpha_ranges using GridSearch CV=10
         svc = SVC(kernel='rbf')

         parameters = {'C': c_range}
         clf = GridSearchCV(svc, parameters, cv=10, scoring = 'roc_auc', return_train_score=True
         clf.fit(tfidfw2v_train, y_train)

         mean_train_score = clf.cv_results_['mean_train_score']
         mean_test_score = clf.cv_results_['mean_test_score']

         plt.figure(figsize=(14, 5))
         #Plot mean accuracy for train and cv set scores
         plt.plot(np.log(c_range), mean_train_score, label='Training Score', color='black')
         plt.plot(np.log(c_range), mean_test_score, label='Validation Score', color='red')

         plt.xticks(np.log(c_range), c_range, rotation='vertical')
```

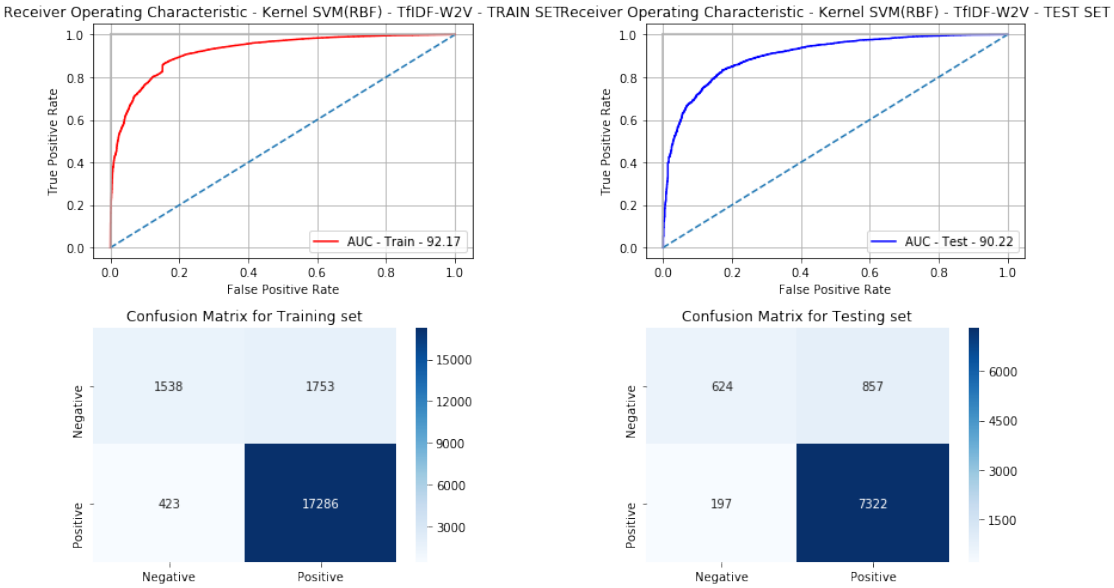
```
        # Create plot
        plt.title("ROC Curve for Train and Cross-Validation data using Kernel SVM - TfIDFW2V Ve
        plt.xlabel("Range of C values (used log for plotting)")
        plt.ylabel("ROC - AUC Score")
        plt.tight_layout()
        plt.legend(loc="best")
        plt.show()
```



In [67]:
```
optimal_c = clf.best_params_['C']

clf = SVC(kernel='rbf',C=optimal_c, probability=True)
clf.fit(tfidfw2v_train, y_train)

# Get predicted values for test data
pred_train = clf.predict(tfidfw2v_train)
pred_test = clf.predict(tfidfw2v_test)
pred_proba_train = clf.predict_proba(tfidfw2v_train)[:,1]
pred_proba_test = clf.predict_proba(tfidfw2v_test)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_train, pos_label
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal C: {}  with AUC: {:.2f}%".format(optimal_c, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'TFIDF-W2V',
                                      'MODEL': 'KERNEL-SVM(RBF)',
                                      'DATASET-SIZE': '{0:,.0f}'.format(int(min_final.s
                                      'PENALTY': '-',
```

```
                                            'HYPERPARAMETER': optimal_c,
                                            'F1_SCORE': f1_sc, 'AUC': auc_sc
                                           }, ignore_index=True)


        plt.figure(figsize=(13,7))
        # Plot ROC curve for training set
        plt.subplot(2, 2, 1)
        plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - TfIDF-W2V - TRAIN SET'
        plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}'.format(float(a
        plt.plot([0, 1], ls="--")
        plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.grid()
        plt.legend(loc='best')

        # Plot ROC curve for test set
        plt.subplot(2, 2, 2)
        plt.title('Receiver Operating Characteristic - Kernel SVM(RBF) - TfIDF-W2V - TEST SET')
        plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.format(float(auc
        plt.plot([0, 1], ls="--")
        plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
        plt.ylabel('True Positive Rate')
        plt.xlabel('False Positive Rate')
        plt.grid()
        plt.legend(loc='best')

        #Plotting the confusion matrix for train
        plt.subplot(2, 2, 3)
        plt.title('Confusion Matrix for Training set')
        df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        #Plotting the confusion matrix for test
        plt.subplot(2, 2, 4)
        plt.title('Confusion Matrix for Testing set')
        df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                             columns = ["Negative", "Positive"])
        sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

        plt.tight_layout()
        plt.show()
```

```
Optimal C: 100  with AUC: 90.22%
```



8 [6] Conclusions

In [68]: result_report

Out[68]:

	VECTORIZER	MODEL	DATASET-SIZE	HYPERPARAMETER	PENALTY	F1_SCORE	AUC
0	Bag of Words(BoW)	LINEAR-SVM	100,000	0.0010	l2	0.963602	0.963407
1	TF-IDF	LINEAR-SVM	100,000	0.0001	l2	0.963688	0.968203
2	Avg-W2V	LINEAR-SVM	100,000	0.0010	l2	0.948015	0.938168
3	TFIDF-W2V	LINEAR-SVM	100,000	0.0010	l1	0.938650	0.910219
4	Bag of Words(BoW)	KERNEL-SVM(RBF)	30,000	10.0000	-	0.943559	0.922702
5	TF-IDF	KERNEL-SVM(RBF)	30,000	1000.0000	-	0.946137	0.927810
6	Avg-W2V	KERNEL-SVM(RBF)	30,000	100.0000	-	0.939439	0.922257
7	TFIDF-W2V	KERNEL-SVM(RBF)	30,000	100.0000	-	0.932858	0.902246