```
%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
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
from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
```

READING DATA

```
dft = pd.read_csv('train_data.csv')
dfr = pd.read_csv('resources.csv')


print("Number of data points in train data", dft.shape)
print('-'*50)
```

```
print("The attributes of data :", dft.columns.values)
```

```
Number of data points in train data (109248, 17)
---------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

```
print("Number of data points in train data", dfr.shape)
print(dfr.columns.values)
dfr.head(2)
```

```
Number of data points in train data (1541272, 4)
['id' 'description' 'quantity' 'price']
```

	id	description	quantity	price
0	p233245	LC652 - Lakeshore Double-Space Mobile Drying Rack	1	149.00
1	p069063	Bouncy Bands for Desks (Blue support pipes)	3	14.95

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(dft.columns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
dft['Date'] = pd.to_datetime(dft['project_submitted_datetime'])
dft.drop('project_submitted_datetime', axis=1, inplace=True)
dft.sort_values(by=['Date'], inplace=True)


# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
dft = dft[cols]


dft.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT

TEXT PROCESSING

```
# merge two column text dataframe:
dft["essay"] = dft["project_essay_1"].map(str) +\
                        dft["project_essay_2"].map(str) + \
                        dft["project_essay_3"].map(str) + \
                        dft["project_essay_4"].map(str)
```

```
dft.head(2)
```

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT

```
# 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
```

```
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "yo
```

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

Preprocessing of project_subject_categories

```
catogories = list(dft['project_subject_categories'].values)

cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Ca
        if 'The' in j.split(): # this will split each of the catogory based on space "Math &
            j=j.replace('The','') # if we have the words "The" we are going to replace it wit
        j = j.replace(' ','') # we are placing all the ' '(space) with ''(empty) ex:"Math & S
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

dft['clean_categories'] = cat_list
dft.drop(['project_subject_categories'], axis=1, inplace=True)

from collections import Counter
my_counter = Counter()
for word in dft['clean_categories'].values:
    my_counter.update(word.split())

cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

Preprocessing of project_subject_subcategories

```
sub_catogories = list(dft['project_subject_subcategories'].values)
# remove special characters from list of strings python:
```

```
#https://stackoverflow.com/a/47301924/4084039

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Ca
        if 'The' in j.split(): # this will split each of the catogory based on space "Math &
            j=j.replace('The','') # if we have the words "The" we are going to replace it wit
        j = j.replace(' ','') # we are placing all the ' '(space) with ''(empty) ex:"Math & S
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

dft['clean_subcategories'] = sub_cat_list
dft.drop(['project_subject_subcategories'], axis=1, inplace=True)

# count of all the words in corpus python:
#https://stackoverflow.com/a/22898595/4084039
my_counter = Counter()
for word in dft['clean_subcategories'].values:
    my_counter.update(word.split())

sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))


# we have to remove the grades from every row
print(dft['project_grade_category'][:20])
```

```
55660     Grades PreK-2
76127        Grades 3-5
51140     Grades PreK-2
473       Grades PreK-2
41558        Grades 3-5
29891        Grades 3-5
81565        Grades 3-5
79026        Grades 3-5
23374     Grades PreK-2
86551        Grades 3-5
49228     Grades PreK-2
72638       Grades 9-12
7176      Grades PreK-2
70898        Grades 3-5
102755       Grades 3-5
72593     Grades PreK-2
35006        Grades 3-5
100222       Grades 3-5
5145         Grades 3-5
48237       Grades 9-12
Name: project_grade_category, dtype: object
```

```
d= list(dft['project_grade_category'].values)
# remove special characters from list of strings python:
```

```
# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/

grade_cat_list = []
for i in d:
# consider we have text like this:
    for j in i.split(' '): # # split by space
        j=j.replace('Grades','')# clean grades from the row
    grade_cat_list.append(j.strip())

dft['clean_grade'] = grade_cat_list
dft.drop(['project_grade_category'], axis=1, inplace=True)

my_counter = Counter()
for word in dft['clean_grade'].values:
     my_counter.update(word.split())
project_grade_category_dict= dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), key=lam
```

Preparing data for the models

Test - Train Split

```
# train test split

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(dft, dft['project_is_approved'],stratify
X_train,X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_t


X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, stratify= y_train,test_size


print(y_train.value_counts())
print(y_test.value_counts())
print(y_cv.value_counts())
```

```
1    27882
0     4975
Name: project_is_approved, dtype: int64
1    30593
0     5459
Name: project_is_approved, dtype: int64
1    13733
0     2451
Name: project_is_approved, dtype: int64
```

```
#droping the y labels
```

```
#https://stackoverflow.com/questions/13411544/delete-column-from-pandas-dataframe-by-column-n

X_train.drop(["project_is_approved"], axis = 1, inplace = True)

X_test.drop(["project_is_approved"], axis = 1, inplace = True)

X_cv.drop(["project_is_approved"], axis = 1, inplace = True)
```

Text preprocessing

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_essays_train = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_train.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 32857/3
```

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_essays_test = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_test.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 36052/3
```

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
```

```
from tqdm import tqdm
preprocessed_essays_cv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_cv.append(sent.lower().strip())
```

```
100%|██████████| 16184/1
```

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_titles_cv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles_cv.append(sent.lower().strip())
```

```
100%|██████████| 16184/16
```

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_titles_train = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles_train.append(sent.lower().strip())
```

```
100%|██████████| 32857/32
```

```
#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_titles_test = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_titles_test.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 36052/36
```

Encoding numerical, Categorical features

vectorize categorical data

```
#project_subject_categories convert categorical to vectors

# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer1 = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False,binary
vectorizer1.fit(X_train['clean_categories'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_cat = vectorizer1.transform(X_train['clean_categories'].values)
X_cv_cat = vectorizer1.transform(X_cv['clean_categories'].values)
X_test_cat = vectorizer1.transform(X_test['clean_categories'].values)
print(vectorizer1.get_feature_names())
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNee
```

```
print("After vectorizations")
print(X_train_cat.shape, y_train.shape)
print(X_cv_cat.shape, y_cv.shape)
print(X_test_cat.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 9) (32857,)
(16184, 9) (16184,)
(36052, 9) (36052,)
==================================================================================================
```

```
##project_subject_subcategories convert categorical to vectors
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer2 = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, b
vectorizer2.fit(X_train['clean_subcategories'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat = vectorizer2.transform(X_train['clean_subcategories'].values)
X_cv_subcat = vectorizer2.transform(X_cv['clean_subcategories'].values)
X_test_subcat = vectorizer2.transform(X_test['clean_subcategories'].values)
print(vectorizer2.get_feature_names())
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurric
```

```
print("After vectorizations")
print(X_train_subcat.shape, y_train.shape)
print(X_cv_subcat.shape, y_cv.shape)
print(X_test_subcat.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 30) (32857,)
(16184, 30) (16184,)
(36052, 30) (36052,)
==================================================================================================
```

```
# school_state convert categorical to vectors
# now time to cont the each words
from collections import Counter
my_counter = Counter()
for word in dft['school_state'].values:
    my_counter.update(word.split())# count the words
school_state_dict = dict(my_counter)# store in dicionary
sorted_school_state_dict = dict(sorted(school_state_dict.items(), key=lambda kv: kv[1]))
print(sorted_school_state_dict)
```

```
{'VT': 80, 'WY': 98, 'ND': 143, 'MT': 245, 'RI': 285, 'SD': 300, 'NE': 309, 'DE': 343, '
```

```
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
```

```
vectorizer3 = CountVectorizer(vocabulary=list(sorted_school_state_dict.keys()), lowercase=Fal
vectorizer3.fit(dft['school_state'].values)
# firstly convert fit the train data into the vector then it learn the vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_school_state = vectorizer3.transform(X_train['school_state'].values)
X_cv_school_state = vectorizer3.transform(X_cv['school_state'].values)
X_test_school_state = vectorizer3.transform(X_test['school_state'].values)
print(vectorizer3.get_feature_names())
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME', 'HI', 'DC', 'NM
```

```
print("After vectorizations")
print(X_train_school_state .shape, y_train.shape)
print(X_cv_school_state .shape, y_cv.shape)
print(X_test_school_state .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 51) (32857,)
(16184, 51) (16184,)
(36052, 51) (36052,)
====================================================================================================
```

```
#project_grade_category categorical to vectors
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-sp
dft['clean_grade']=dft['clean_grade'].fillna("")# fill the null values with space
# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer4 = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys()),lowe
vectorizer4.fit(dft['clean_grade'].values)
# firstly convert fit the train data into the vectoriaer then it learn hte vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_project_grade_category = vectorizer4.transform(X_train['clean_grade'].values)
X_cv_project_grade_category = vectorizer4.transform(X_cv['clean_grade'].values)
X_test_project_grade_category = vectorizer4.transform(X_test['clean_grade'].values)
print(vectorizer4.get_feature_names())
```

```
['9-12', '6-8', '3-5', 'PreK-2']
```

```
print("After vectorizations")
print(X_train_project_grade_category .shape, y_train.shape)
print(X_cv_project_grade_category .shape, y_cv.shape)
print(X_test_project_grade_category .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 4) (32857,)
(16184, 4) (16184,)
(36052, 4) (36052,)
==================================================================================================
```

```
#teacher_prefix categorical to vectors
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-sp
dft['teacher_prefix']=dft['teacher_prefix'].fillna(" ")# filll the null valueswith space
my_counter = Counter()
for word in dft['teacher_prefix'].values:
    my_counter.update(word.split())
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
teacher_cat_dict = dict(my_counter)
sorted_teacher_prefix_dict = dict(sorted(teacher_cat_dict.items(), key=lambda kv: kv[1]))


# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer5 = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowercase=F
vectorizer5.fit(dft['teacher_prefix'].values.astype('U'))
# firstly convert fit the train data into the vectorizer
# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_prefix = vectorizer5.transform(X_train['teacher_prefix'].values.astype('U'))
X_cv_teacher_prefix= vectorizer5.transform(X_cv['teacher_prefix'].values.astype('U'))
X_test_teacher_prefix = vectorizer5.transform(X_test['teacher_prefix'].values.astype('U'))
print(vectorizer5.get_feature_names())
```

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
```

```
print("After vectorizations")
print(X_train_teacher_prefix .shape, y_train.shape)
print(X_cv_teacher_prefix .shape, y_cv.shape)
print(X_test_teacher_prefix .shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 5) (32857,)
(16184, 5) (16184,)
(36052, 5) (36052,)
==================================================================================================
```

Encoding essay, and Project_title

```
#bow featurization essay

X_train_essay=preprocessed_essays_train
X_cv_essay=preprocessed_essays_cv
```

```
X_cv_essay=preprocessed_essays_cv
X_test_essay=preprocessed_essays_test

X_train_title=preprocessed_titles_train
X_cv_title=preprocessed_titles_cv
X_test_title=preprocessed_titles_test
# We are considering only the words which appeared in at least 10 documents(rows or projects)
vectorizer6 = CountVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer6.fit(X_train_essay)# that is learned from trained data

# we use the fitted CountVectorizer to convert the text to vector
X_train_bow = vectorizer6.transform(X_train_essay)
X_cv_bow = vectorizer6.transform(X_cv_essay)
X_test_bow = vectorizer6.transform(X_test_essay)



#bow featurization title
vectorizer7 = CountVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer7.fit(X_train_title)# that is learned from trainned data
# we use the fitted CountVectorizer to convert the text to vector
X_train_bow_title = vectorizer7.transform(X_train_title)
X_cv_bow_title= vectorizer7.transform(X_cv_title)
X_test_bow_title = vectorizer7.transform(X_test_title)
print("After vectorizations")
print(X_train_bow_title.shape, y_train.shape)
print(X_cv_bow_title.shape, y_cv.shape)
print(X_test_bow_title.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 2288) (32857,)
(16184, 2288) (16184,)
(36052, 2288) (36052,)
====================================================================================================
```

Tfidf featurization

```
#for titles
from sklearn.feature_extraction.text import TfidfVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or projects)
vectorizer8 = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer8.fit(X_train_title)# that is learned from trained data

# we use the fitted CountVectorizer to convert the text to vector
X_train_tf_title = vectorizer8.transform(X_train_title)
X_cv_tf_title= vectorizer8.transform(X_cv_title)
X_test_tf_title = vectorizer8.transform(X_test_title)
print("After vectorizations")
print(X_train_tf_title.shape, y_train.shape)
```

```
print(X_train_tf_title.shape, y_train.shape)
print(X_cv_tf_title.shape, y_cv.shape)
print(X_test_tf_title.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 2288) (32857,)
(16184, 2288) (16184,)
(36052, 2288) (36052,)
====================================================================================================
```

```
#for essay
from sklearn.feature_extraction.text import TfidfVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or projects)
vectorizer9 = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer9.fit(X_train_essay)# that is learned from trained data
# we use the fitted CountVectorizer to convert the text to vector
X_train_tf_essay = vectorizer9.transform(X_train_essay)
X_cv_tf_essay= vectorizer9.transform(X_cv_essay)
X_test_tf_essay = vectorizer9.transform(X_test_essay)
print("After vectorizations")
print(X_train_tf_essay.shape, y_train.shape)
print(X_cv_tf_essay.shape, y_cv.shape)
print(X_test_tf_essay.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(32857, 5000) (32857,)
(16184, 5000) (16184,)
(36052, 5000) (36052,)
====================================================================================================
```

Using Pretrained Models : AVG W2V

```
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039

def loadGloveModel(gloveFile):

    print ("Loading Glove Model")

    f = open(gloveFile,'r', encoding = 'utf8')

    model = {}

    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
```

```
    print ("Done.",len(model)," words loaded!")

    return model


model = loadGloveModel('glove.42B.300d.txt')
```

```
Loading Glove Model
1917495it [04:53, 6540.17it/s]
Done. 1917495  words loaded!
```

```
glove_words = set(model.keys())


#for essay
# average Word2Vec
# compute average word2vec for each review.
def func(wordlist):

  train_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
  for sentence in tqdm(wordlist): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length # we are taking the 300dimens
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_avg_w2v_vectors.append(vector)

  print(len(train_avg_w2v_vectors))
  print(len(train_avg_w2v_vectors[0]))
  return train_avg_w2v_vectors


train_avg_w2v_vectors=func(preprocessed_essays_train)
test_avg_w2v_vectors=func(preprocessed_essays_test)
cv_avg_w2v_vectors=func(preprocessed_essays_cv)
#for titles
cv_avg_w2v_vectors_title=func(preprocessed_titles_cv)
test_avg_w2v_vectors_title=func(preprocessed_titles_test)
train_avg_w2v_vectors_title=func(preprocessed_titles_train)
```

```
100%|██████████████████████████████████████████████████████████████████████| 32857/3
32857
300
100%|██████████████████████████████████████████████████████████████████████| 36052/3
36052
300
100%|██████████████████████████████████████████████████████████████████████| 16184/1
16184
300
100%|██████████████████████████████████████████████████████████████████████| 16184/16
16184
300
100%|██████████████████████████████████████████████████████████████████████| 36052/36
36052
300
100%|██████████████████████████████████████████████████████████████████████| 32857/32
32857
300
```

Using Pretrained Models: TFIDF weighted W2V

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())


# average Word2Vec
# compute average word2vec for each review.
def tf_idf_done(word_list):
    train_title_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in t
    for sentence in tqdm(word_list): # for each review/sentence
        vector = np.zeros(300) # as word vectors are of zero length
        tf_idf_weight =0; # num of words with a valid vector in the sentence/review
        for word in sentence.split():#.split(): # for each word in a review/sentence
            if (word in glove_words) and (word in tfidf_words):
              #vec = model.wv[word]
              vec = model[word] # getting the vector for each word
# here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/
              tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
              vector += (vec * tf_idf) # calculating tfidf weighted w2v
              tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        train_title_tfidf_w2v_vectors.append(vector)
    print(len(train_title_tfidf_w2v_vectors))
    print(len(train_title_tfidf_w2v_vectors[0]))
    return train_title_tfidf_w2v_vectors
```

```
#train_title_tfidf_w2v_vectors=tf_idf_done(tf_idf_train_title)
#train_title_tfidf_w2v_vector
train_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_train)
test_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_test)
cv_tfidf_w2v_vectors=tf_idf_done(preprocessed_essays_cv)
```

```
100%|██████████| 32857/32857
300
100%|██████████| 36052/36052
300
100%|██████████| 16184/16184
300
```

```
#train_title_tfidf_w2v_vectors=tf_idf_done(tf_idf_train_title)
#train_title_tfidf_w2v_vector
train_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_train)
test_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_test)
cv_title_tfidf_w2v_vectors=tf_idf_done(preprocessed_titles_cv)
```

```
100%|██████████| 32857/32857
300
100%|██████████| 36052/36052
300
100%|██████████| 16184/16184
300
```

Vectorizing Numerical features

4 cells hidden

merging

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_train = hstack((X_train_bow_title,X_train_bow,# all bows
                       X_train_teacher_prefix,X_train_cat,X_train_subcat
                      ,X_train_project_grade_category,X_train_school_state,
                       train_qnty_standar,train_price_standar,train_prev_proj_standar))
print(X_set1_train.shape, y_train.shape)
```

(32857, 7390) (32857,)

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_cv = hstack((X_cv_bow_title,X_cv_bow,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state,
                    cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))
print(X_set1_cv.shape, y_cv.shape)
```

(16184, 7390) (16184,)

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set1_test = hstack((X_test_bow_title,X_test_bow,
                      X_test_teacher_prefix,X_test_cat,X_test_subcat,
                      X_test_project_grade_category,X_test_school_state,
                      test_qnty_standar,test_price_standar,test_prev_proj_standar))
print(X_set1_test.shape, y_test.shape)
```

(36052, 7390) (36052,)

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set2_train = hstack((X_train_tf_essay,X_train_tf_title,
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state,
                       train_qnty_standar,train_price_standar,train_prev_proj_standar))
print(X_set2_train.shape, y_train.shape)
```

(32857, 7390) (32857,)

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set2_cv = hstack((X_cv_tf_essay,X_cv_tf_title,
                    X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                    X_cv_project_grade_category,X_cv_school_state,
                    cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))
print(X_set2_cv.shape, y_cv.shape)
```

(16184, 7390) (16184,)

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set2_test = hstack((X_test_tf_essay,X_test_tf_title,
                      X_test_teacher_prefix,X_test_cat,X_test_subcat,
                      X_test_project_grade_category,X_test_school_state,
                      test_qnty_standar,test_price_standar,test_prev_proj_standar))
print(X_set2_test.shape, y_test.shape)
```

```
print(X_set2_test.shape, y_test.shape)
```

```
(36052, 7390) (36052,)
```

```
import numpy
s=numpy.array(train_avg_w2v_vectors)
print(X_train_project_grade_category.shape)
print(s.shape)
```

```
(32857, 4)
(32857, 300)
```

```
from scipy.sparse import hstack
import numpy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set3_train = hstack((numpy.array(train_avg_w2v_vectors),numpy.array(train_avg_w2v_vectors_t
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state))
print(X_set3_train.shape, y_train.shape)
```

```
(32857, 702) (32857,)
```

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set3_cv =hstack((cv_avg_w2v_vectors,cv_avg_w2v_vectors_title,cv_prev_proj_standar,cv_price_
                   X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                   X_cv_project_grade_category,X_cv_school_state))
print(X_set3_cv.shape, y_cv.shape)
```

```
(16184, 702) (16184,)
```

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set3_test =hstack((test_avg_w2v_vectors,test_avg_w2v_vectors_title,test_prev_proj_standar,t
                     test_qnty_standar,
                     X_test_teacher_prefix,X_test_cat,X_test_subcat,
                     X_test_project_grade_category,X_test_school_state))
print(X_set3_test.shape, y_test.shape)
```

```
(36052, 702) (36052,)
```

```
import numpy
s=numpy.array(train_tfidf_w2v_vectors)
print(X_train_project_grade_category.shape)
print(s.shape)
```

```
(32857, 4)
(32857, 300)
```

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set4_train =hstack((train_tfidf_w2v_vectors, train_title_tfidf_w2v_vectors,train_prev_proj_
                      train_price_standar,train_qnty_standar,
                       X_train_teacher_prefix,X_train_cat,X_train_subcat,
                       X_train_project_grade_category,X_train_school_state))

print(X_set4_train.shape, y_train.shape)
```

```
(32857, 702) (32857,)
```

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set4_cv =hstack((cv_tfidf_w2v_vectors,cv_title_tfidf_w2v_vectors,cv_prev_proj_standar,
                   cv_price_standar,cv_qnty_standar,
                   X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,
                   X_cv_project_grade_category,X_cv_school_state))


print(X_set4_cv.shape, y_cv.shape)
```

```
(16184, 702) (16184,)
```

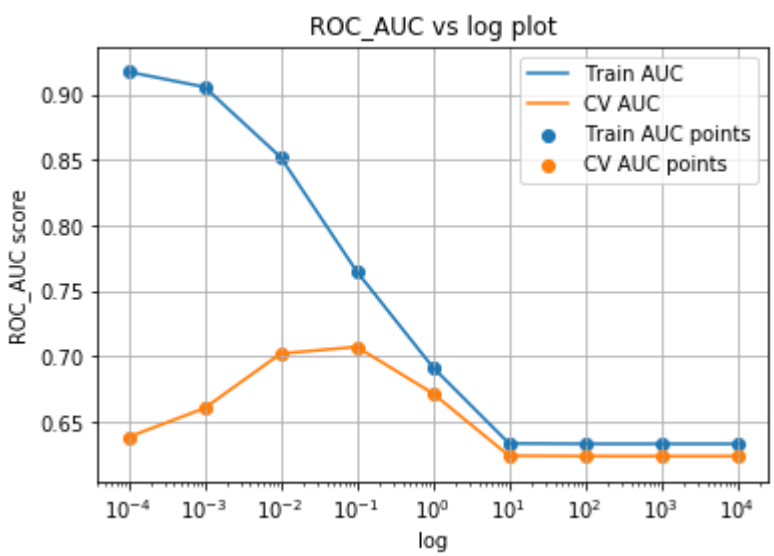
```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_set4_test = hstack((test_title_tfidf_w2v_vectors,test_tfidf_w2v_vectors,test_prev_proj_stan
                       X_test_project_grade_category,X_test_school_state))
print(X_set4_test.shape, y_test.shape)
```

```
(36052, 702) (36052,)
```

Applying SVM on BOW

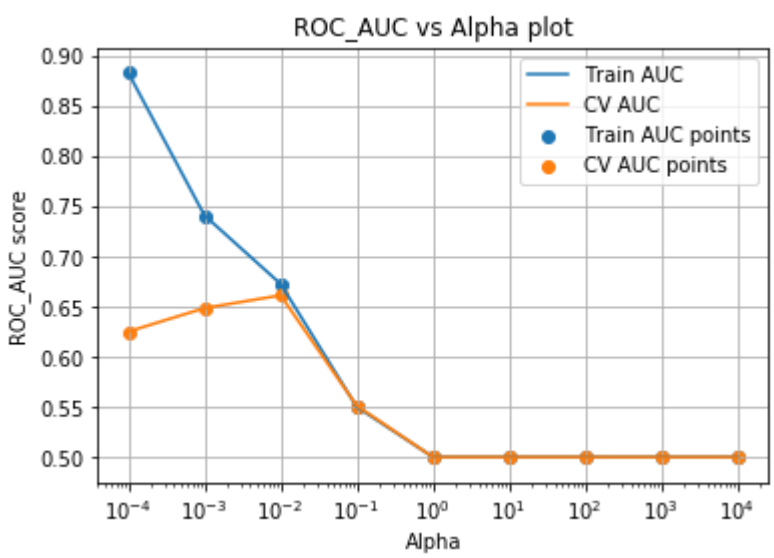
```
## By using "l2" Regulrizer
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
#from sklearn.datasets import *
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
# hyperparameter tuning with l2 reg
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set1_train, y_train)
```

```
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log")
plt.xscale('log')
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```




```
#By using  "l1" Regularization

# hyperparameter tuning with l1 reg
#parameters = {'alpha':[0.007,0.009,0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,1.2,1.4,1
import warnings
warnings.filterwarnings("ignore")

parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set1_train, y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')

plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
```

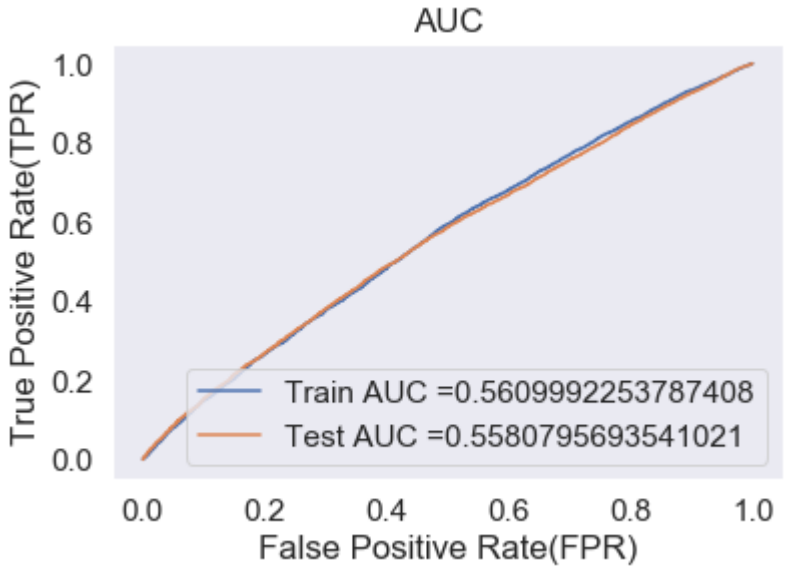
```
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Alpha")
plt.xscale('log')
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```



Observation: l2 regularizatin works better than l1 and best alpha is 10.

Fitting Model to Hyper-Parameter Curve

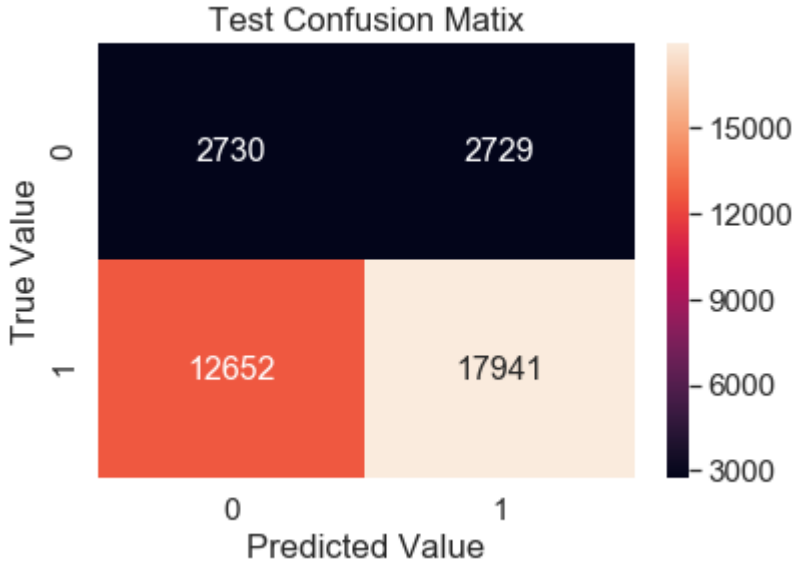
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.met
from sklearn.metrics import roc_curve, auc
Classifier_bow = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 10)
Classifier_bow.fit(X_set1_train ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#skl
y_train_pred = Classifier_bow.decision_function(X_set1_train)
y_test_pred = Classifier_bow.decision_function(X_set1_test)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```




```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", np.round(max(tpr*(1-fpr)),2) , "for threshold",
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

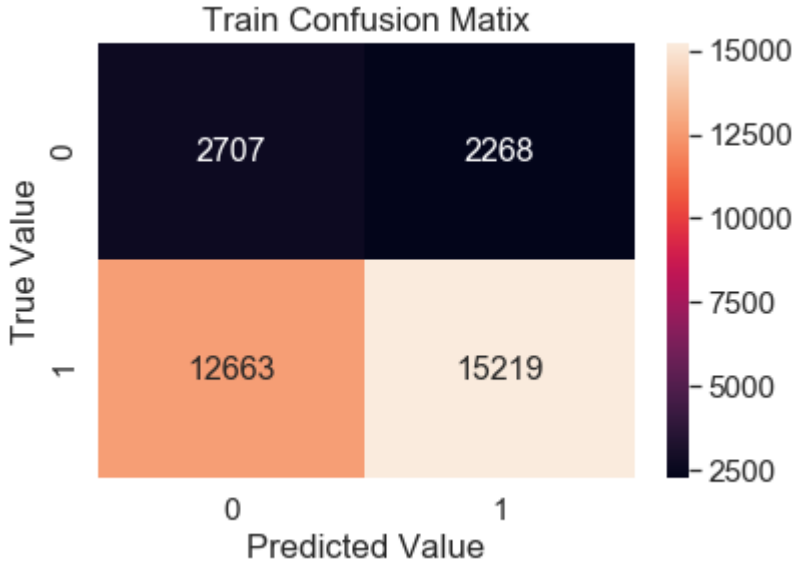
```
import seaborn as sea
test_confusion_matrix = pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred, te_threshol
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.99
Text(0.5, 1.0, 'Test Confusion Matix')
```




```
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred, te_thres
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

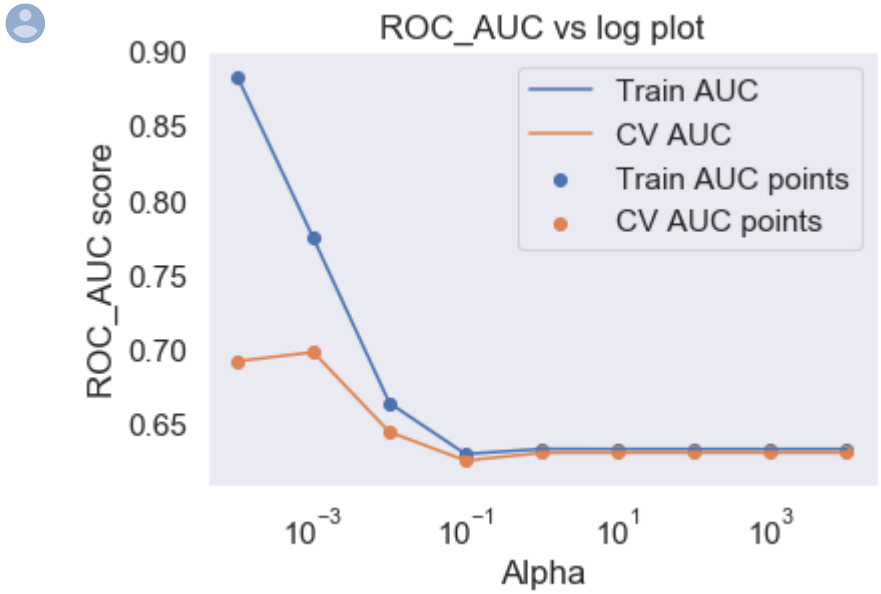
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.02
Text(0.5, 1.0, 'Train Confusion Matix')
```



Applying SVM on TFIDF

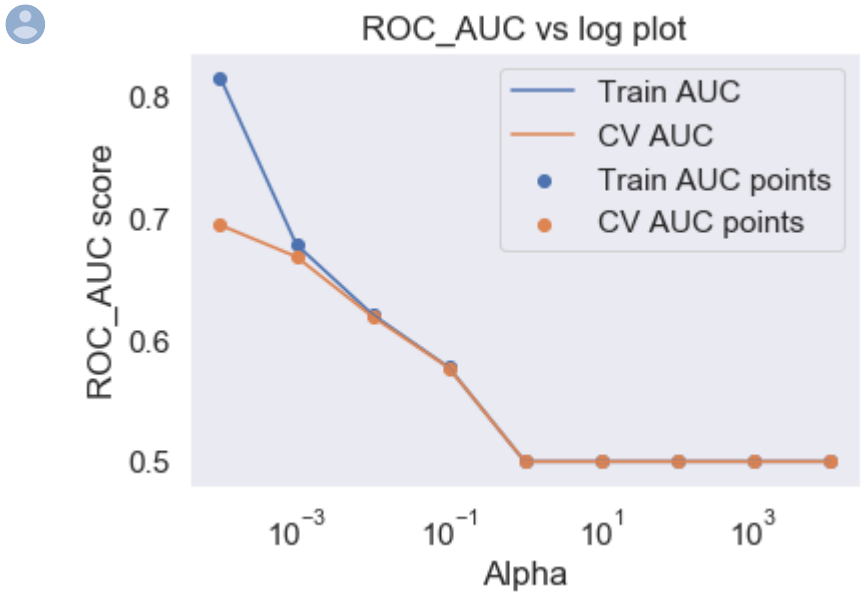
```
#BY USING L2 REGULARISER
```

```
# hyperparameter tuning with l2 reg
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set2_train, y_train)

train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')

plt.legend()
plt.xscale('log')
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```




```
#BY USING "L1" REGULARISER
# hyperparameter tuning with l2 reg reduce the alpha values in list
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set2_train, y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
```

```
plt.legend()
plt.xscale('log')
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```

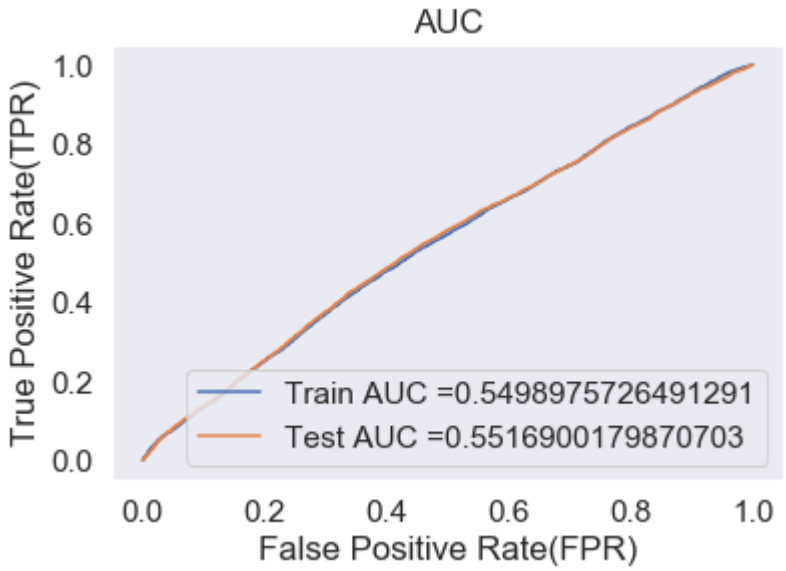



```
Observation:
l2 regularizatiOn works better than l1 and best alpha is 1.
```

Fit the best hyperparameter

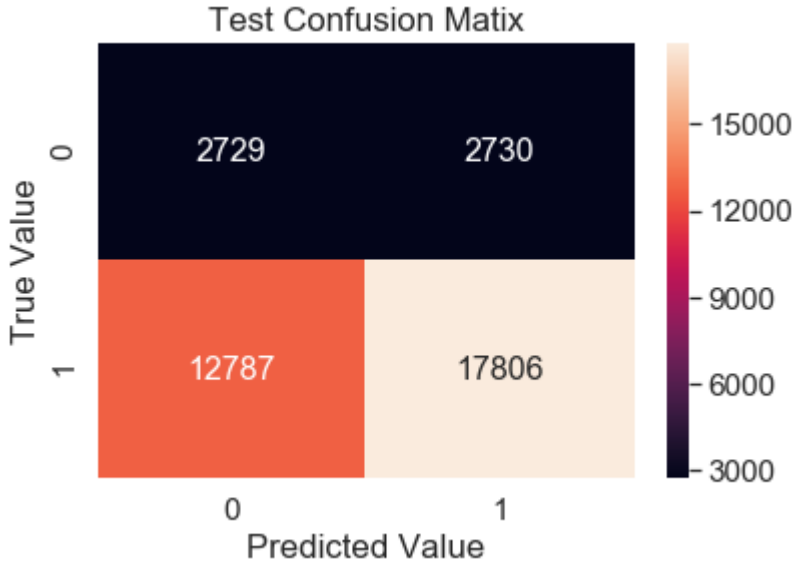
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.met
from sklearn.metrics import roc_curve, auc
Classifier_bow = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 1)
Classifier_bow.fit(X_set2_train ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#skl
y_train_pred = Classifier_bow.decision_function(X_set2_train)
y_test_pred = Classifier_bow.decision_function(X_set2_test)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
```

```
plt.title("AUC")
plt.grid()
plt.show()
```




```
#CONFUSION MATRIX
import seaborn as sea
test_confusion_matrix = pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_threshold
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

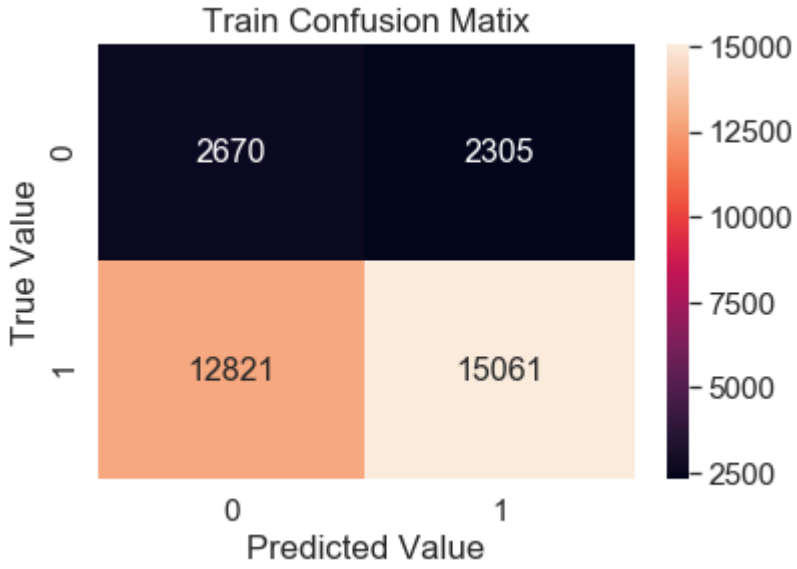
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.53
Text(0.5, 1.0, 'Test Confusion Matix')
```




```
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresh
```

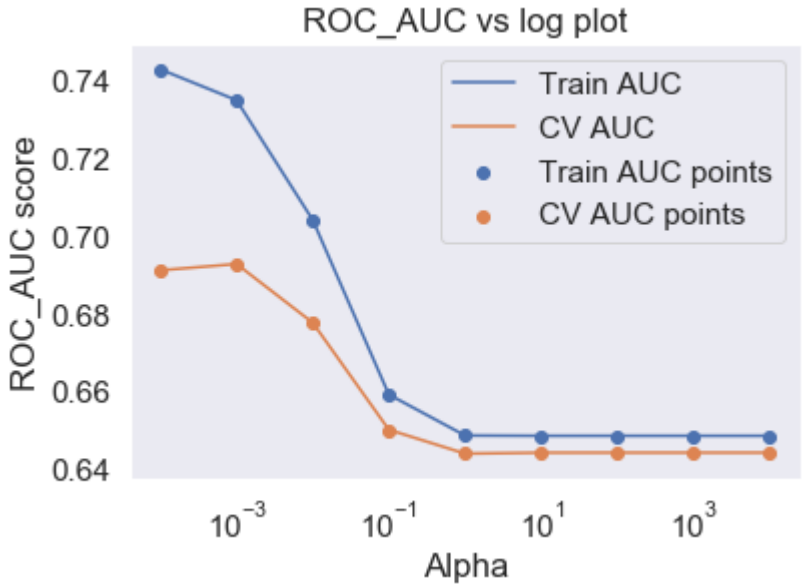
```
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.57
Text(0.5, 1.0, 'Train Confusion Matix')
```

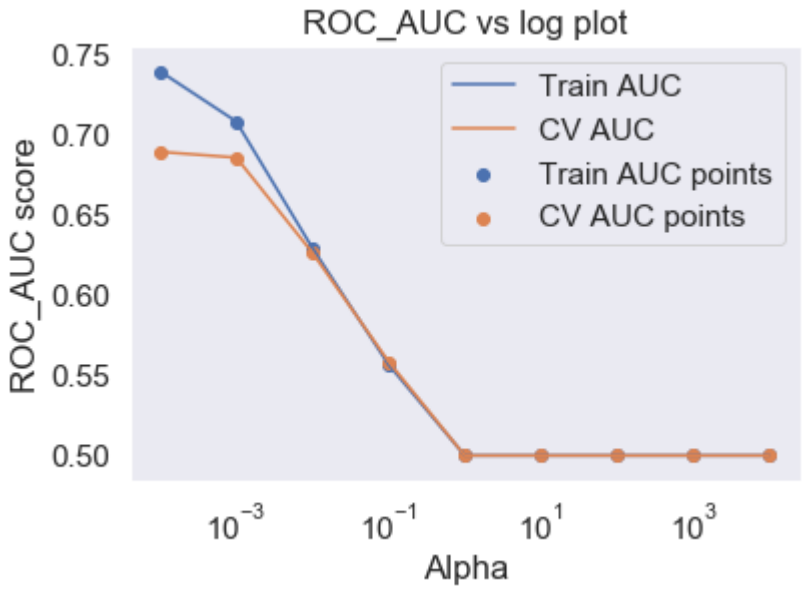


Applying SVM on AVG W2V

```
#BY USING "L2" REGULARISER
# hyperparameter tuning with l2 reg
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')

classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set3_train, y_train)

train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xscale('log')
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```



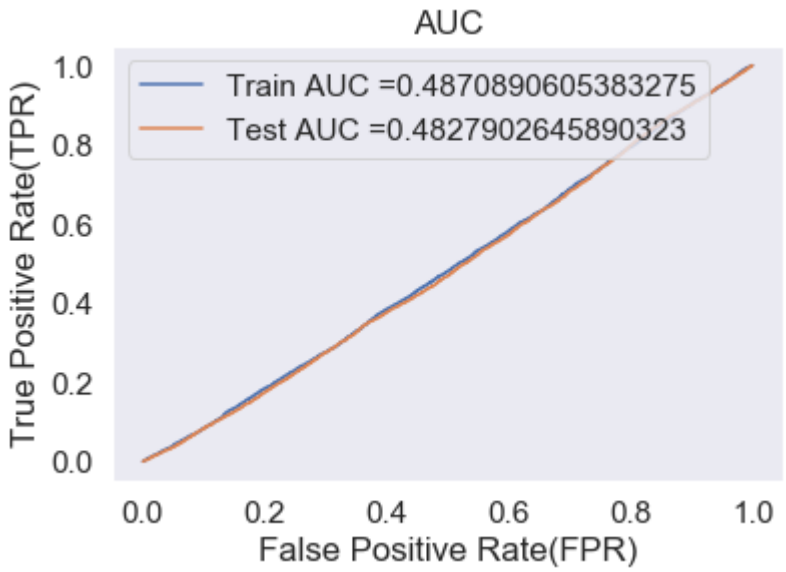

```
#BY USING "L1" REGULARISER
# hyperparameter tuning with l2 reg
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')

classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set3_train, y_train)

train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xscale('log')
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```



Observation: l2 regularizatiOn works better than l1 and best alpha is 1

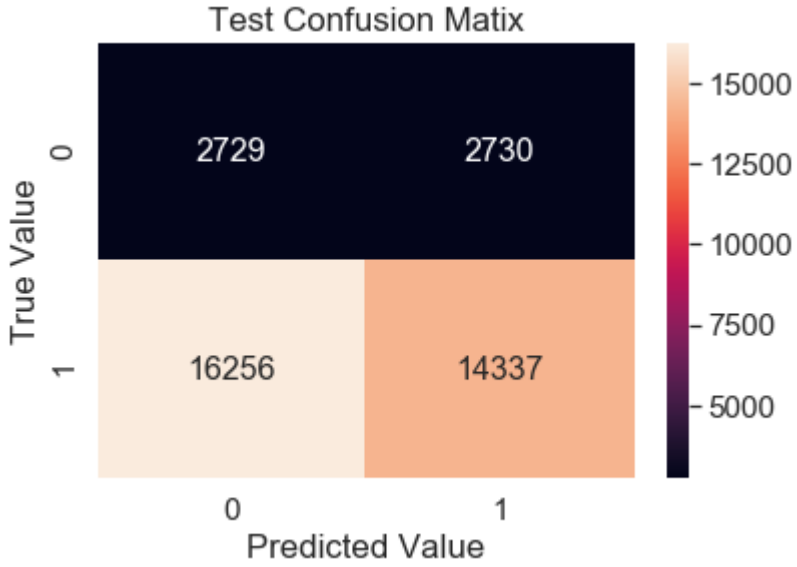
Fitting Model to Hyper-Parameter Curve:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve

from sklearn.metrics import roc_curve, auc
Classifier_bow = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 1)
Classifier_bow.fit(X_set3_train ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#skl
y_train_pred = Classifier_bow.decision_function(X_set3_train)
y_test_pred = Classifier_bow.decision_function(X_set3_test)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```




```
#CONFUSION MATRIX
import seaborn as sea
test_confusion_matrix = pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_threshold
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

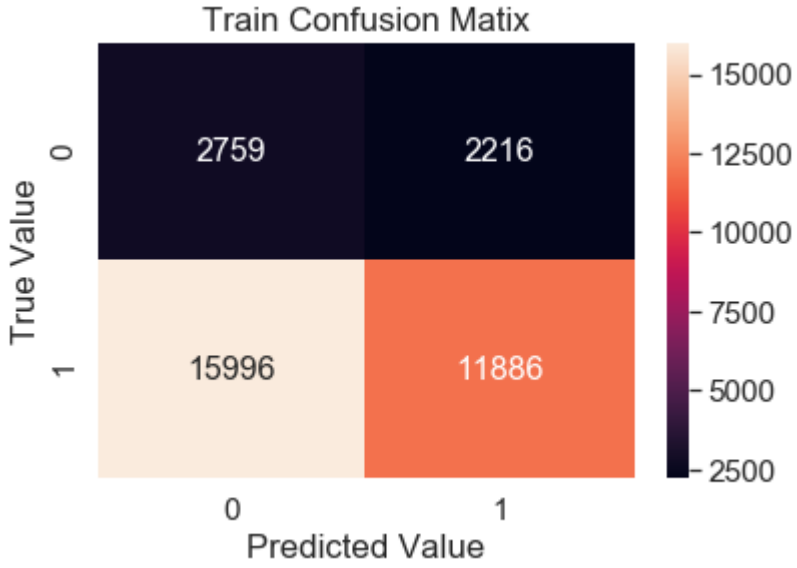
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.03
Text(0.5, 1.0, 'Test Confusion Matix')
```




```
#CONFUSION MATRIX
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresh
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
```

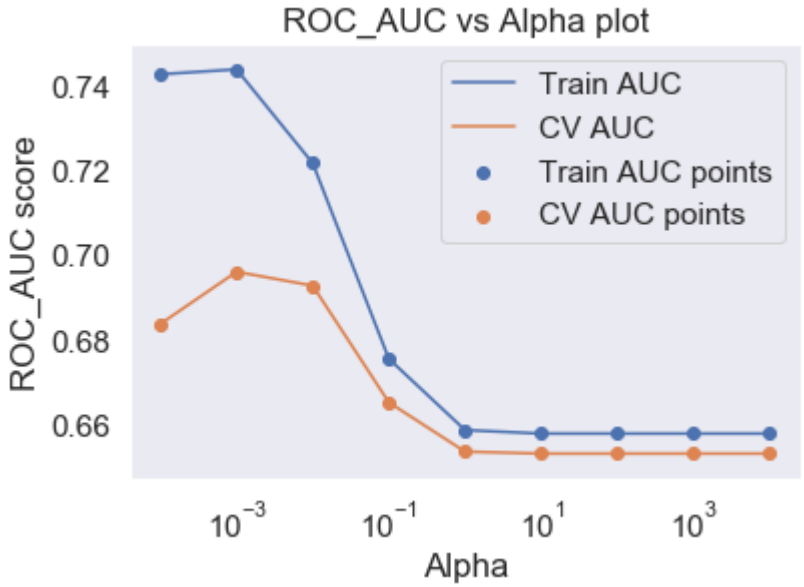
```
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.04
Text(0.5, 1.0, 'Train Confusion Matix')
```

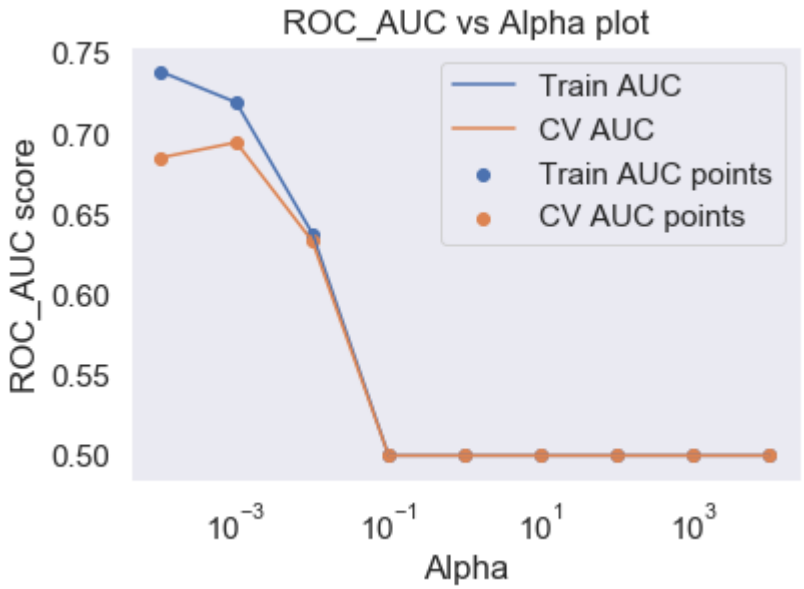


Applying SVM on td_idf W2V

```
#BY USING "l2" REGULARISER

parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
SV = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced',)

classifier = GridSearchCV(SV, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set4_train, y_train)

train_auc= classifier.cv_results_['mean_train_score']
cv_auc = classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xscale('log')
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```




```
""#BY USING "L1" REGULARIZER

parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
SV = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')

classifier = GridSearchCV(SV, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set4_train, y_train)

train_auc= classifier.cv_results_['mean_train_score']
cv_auc = classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xscale('log')
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```



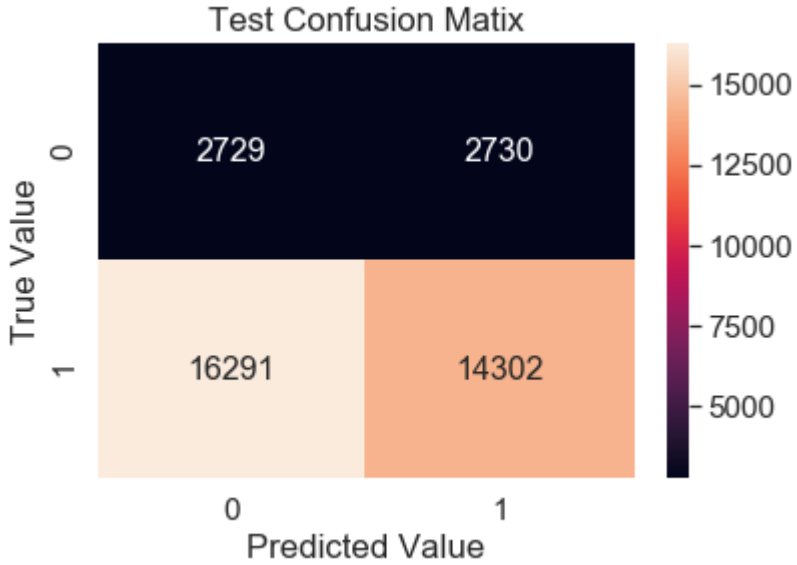
Observation: l2 regularizatiOn works better than l1 and best alpha is 1

Fitting Model to Hyper-Parameter Curve:

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.met
from sklearn.metrics import roc_curve, auc
Classifier_bow = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 1)
Classifier_bow.fit(X_set4_train ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#skl
y_train_pred = Classifier_bow.decision_function(X_set4_train)
y_test_pred = Classifier_bow.decision_function(X_set4_test)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```


```
#CONFUSION MATRIX
import seaborn as sea
test_confusion_matrix = pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_threshold
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

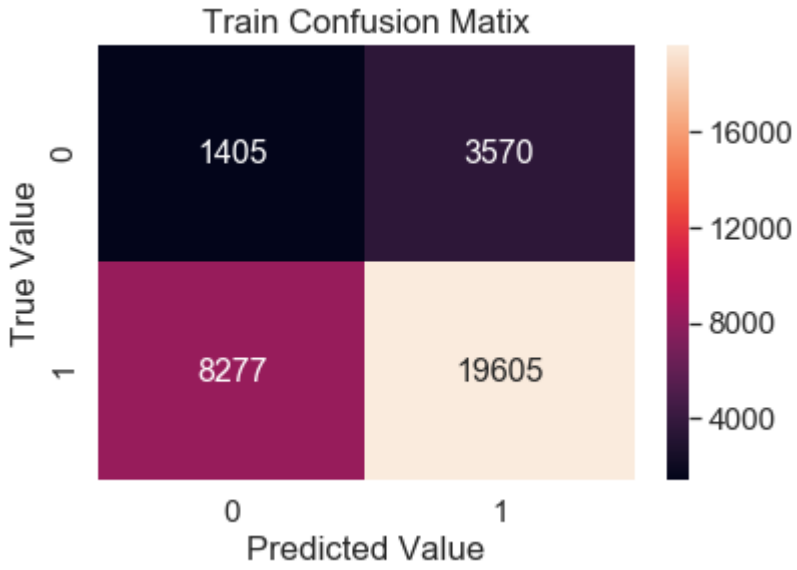
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.0
Text(0.5, 1.0, 'Test Confusion Matix')
```




```
#CONFUSION MATRIX
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresh
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
```

```
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.01
Text(0.5, 1.0, 'Train Confusion Matix')
```



Now instead of bow,tf-df ,wordtovec and tfwor2v featurizers i use three new features 1.Sentiment sco titles 3.Number of words in combined esssays then after apply logistic regression and by taking best

New feature(No. of words in title)

```
X_cv.shape
```

```
(16184, 19)
```

```
# For train data
title_length_train=[]
for i in range(0,32857):
  title_length_train.append(len(X_train["project_title"][i].split()))

title_length_train=np.array(title_length_train)

#for test data titles
title_length_test=[]
for i in range(0,36052):
  title_length_test.append(len(X_test["project_title"][i].split()))

title_length_test=np.array(title_length_test)
#for cv data titles
title_length_cv=[]
for i in range(0,16184):
```

```
for i in range(0,16184):
  title_length_cv.append(len(X_cv["project_title"][i].split()))

title_length_cv=np.array(title_length_cv)
```

New feature(No. of words in combined essays)

```
#for test data esssay
essay_length_test=[]
for i in range(0,36052):
  essay_length_test.append(len(X_test["essay"][i].split()))
essay_length_test=np.array(essay_length_test)
#for cv data essay
essay_length_cv=[]
for i in range(0,16184):
  essay_length_cv.append(len(X_cv["essay"][i].split()))
essay_length_cv=np.array(essay_length_cv)
#for train data essay
essay_length_train=[]
for i in range(0,32857):
  essay_length_train.append(len(X_train["essay"][i].split()))
essay_length_train=np.array(essay_length_train)
```

New feature(Sentiment scores of each combined essay's)

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
nltk.download('vader_lexicon')
#https://www.programcreek.com/python/example/100005/nltk.sentiment.vader.SentimentIntensityAn
def analyze_sentiment(df):
    sentiments = []
    sid = SentimentIntensityAnalyzer()
    for i in tqdm(range(df.shape[0])):
        line = df['essay'][i]  # take one essay
        sentiment = sid.polarity_scores(line)# calculate the sentiment
        sentiments.append([sentiment['neg'], sentiment['pos'],
        sentiment['neu'], sentiment['compound']])# list of lists
    df[['neg', 'pos', 'neu', 'compound']] = pd.DataFrame(sentiments)
    df['Negative'] = df['compound'] < -0.1
    df['Positive'] = df['compound'] > 0.1
    return df
```

```
[nltk_data] Downloading package vader_lexicon to
[nltk_data]     C:\Users\Hp\AppData\Roaming\nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
```

```
X_train=analyze_sentiment(X_train)
X_test=analyze_sentiment(X_test)
X_cv=analyze_sentiment(X_cv)
```

```
100%|██████████| 32857/
100%|██████████| 36052/
100%|██████████| 16184/
```

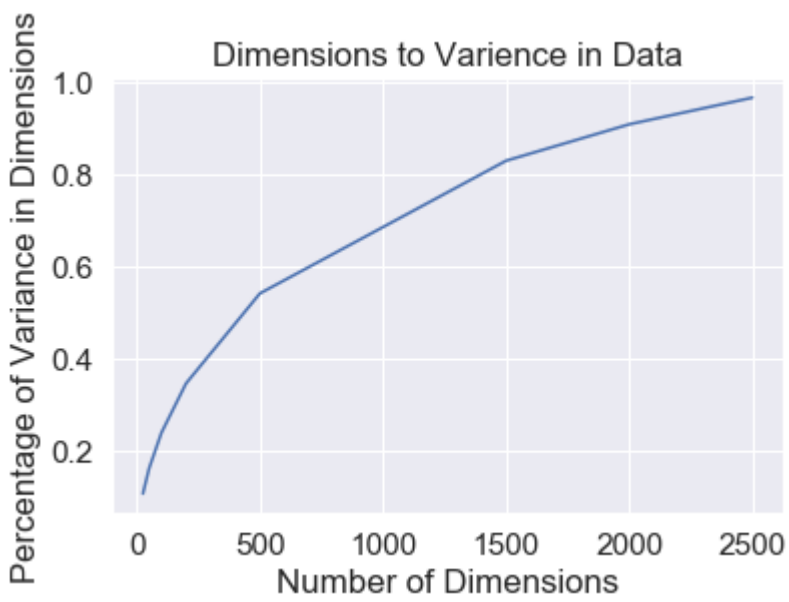
Apply TruncatedSVD on TfidfVectorizer of essay text, choose t components (n_components) using elbow method :numerica

```
#Dimensions are very large so thats why i take less here.
X_train_tf_essay=X_train_tf_essay[:,0:4000]
X_cv_tf_essay=X_cv_tf_essay[:,0:4000]
X_test_tf_essay=X_test_tf_essay[:,0:4000]
from sklearn.decomposition import TruncatedSVD
#https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html
#declaring index as Dimensions in train_text_tfidf
Di = [25,50,100,200,500,1500,2000,2500]
Varience_sum = []
for i in tqdm(Di):
    svd = TruncatedSVD(n_components = i, random_state = 42)
    svd.fit(X_train_tf_essay)
    Varience_sum.append(svd.explained_variance_ratio_.sum())
```

```
  0%|
 12%|██████████
 25%|████████████████████
 38%|████████████████████████████████
 50%|████████████████████████████████████████
 62%|██████████████████████████████████████████████████
 75%|████████████████████████████████████████████████████████████
 88%|██████████████████████████████████████████████████████████████████████
100%|████████████████████████████████████████████████████████████████████████████████
```

```
plt.xlabel("Number of Dimensions")
plt.ylabel("Percentage of Variance in Dimensions")
plt.title("Dimensions to Varience in Data")
plt.plot(Di,Varience_sum)
```

```
plt.show()
```



OBSERVATION: At 2000 dimensions we have Accuracy of greater than 90% so considering 2000 dime

```
svd = TruncatedSVD(n_components= 2000)
svd.fit(X_train_tf_essay)
#Transforms:
#Train SVD
X_train_tf_essay= svd.transform(X_train_tf_essay )
#Test SVD
X_test_tf_essay = svd.transform(X_test_tf_essay )
#CV SVD
X_cv_tf_essay =  svd.transform(X_cv_tf_essay )
```

Combine all features:

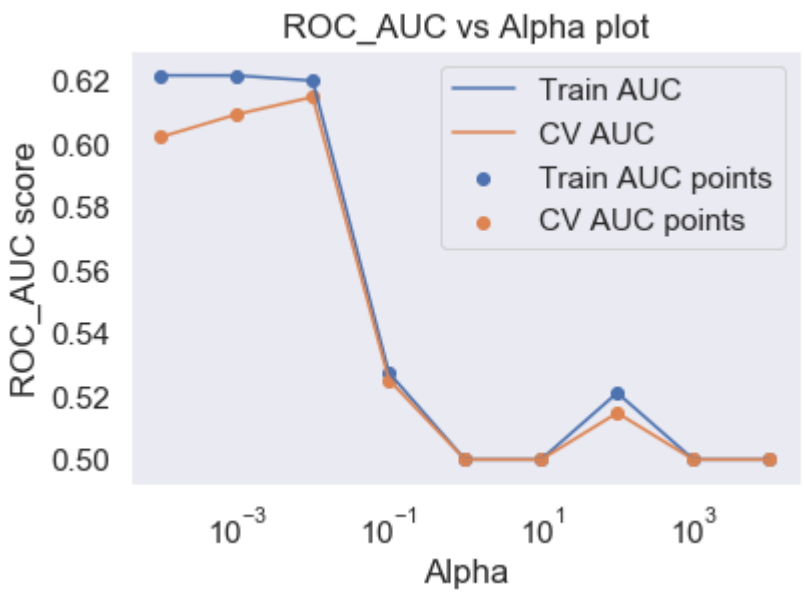
```
#for train
pos=list(X_train['pos'])
pos=np.array(pos)
neg=list(X_train['neg'])
neg=np.array(neg)
com=list(X_train['compound'])
com=np.array(com)
# combine all
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set5_train = hstack((X_train_teacher_prefix,X_train_cat,X_train_subcat,X_train_project_grad
                       essay_length_train.reshape(-1,1),title_length_train.reshape(-1,1),
                       pos.reshape(-1,1),neg.reshape(-1,1),com.reshape(-1,1)))
```

```
#for test
pos=list(X_test['pos'])
pos=np.array(pos)
neg=list(X_test['neg'])
neg=np.array(neg)
com=list(X_test['compound'])
com=np.array(com)
# combine all
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_set5_test = hstack((X_test_teacher_prefix,X_test_cat,X_test_subcat ,X_test_project_grade_ca
                      test_qnty_standar,test_price_standar,test_prev_proj_standar,
                      essay_length_test.reshape(-1,1),title_length_test.reshape(-1,1),
                      pos.reshape(-1,1),neg.reshape(-1,1),com.reshape(-1,1),))
```

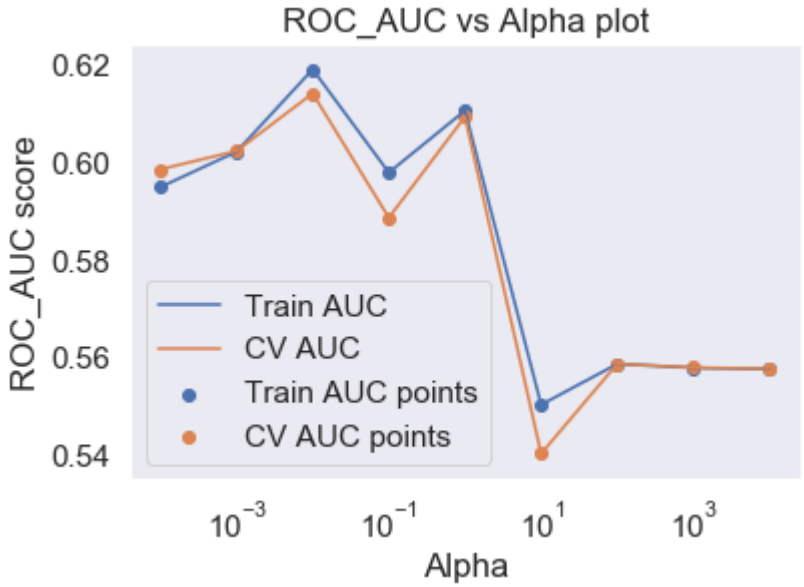
Applying SVM on SET 5

```
#BY USING L1 RGULARISER
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
#from sklearn.datasets import *
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
# hyperparameter tuning with l2 reg
""#we are using L1 Regularizer
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
SV = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced',)
classifier = GridSearchCV(SV, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set5_train, y_train)

train_auc= classifier.cv_results_['mean_train_score']
cv_auc = classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')

plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xscale("log")
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```

```
plt.show()
```



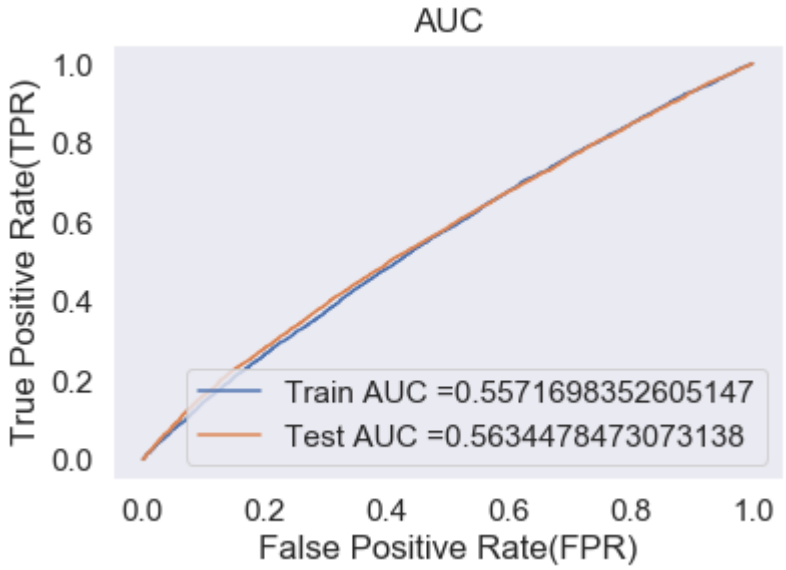

```
#BY USING L2 REGULARISER

parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
SV = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced',)
classifier = GridSearchCV(SV, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_set5_train, y_train)

train_auc= classifier.cv_results_['mean_train_score']
cv_auc = classifier.cv_results_['mean_test_score']

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xscale("log")
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```



Observation: l2 regularizatiOn works better than l1 and best alpha is 10**3

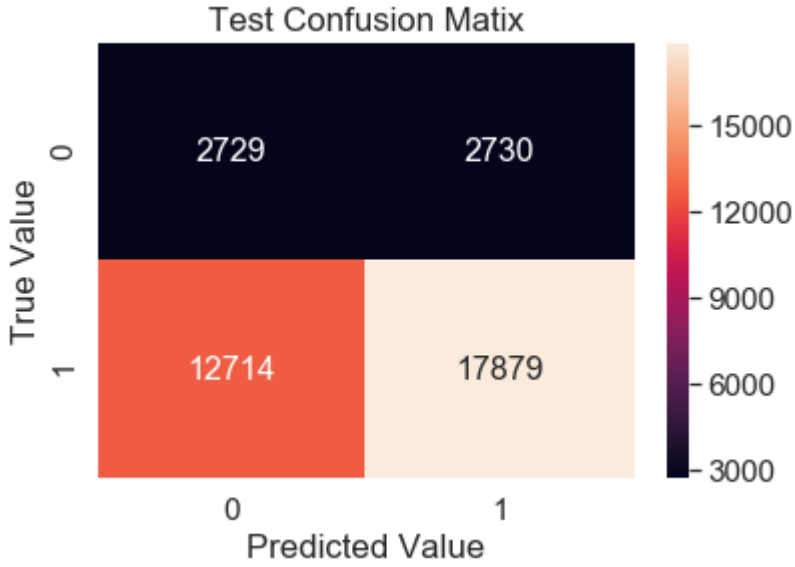
Fitting Model to Hyper-Parameter Curve

```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.met
from sklearn.metrics import roc_curve, auc
Classifier_bow = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 10**3)
Classifier_bow.fit(X_set5_train ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the pos
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#skl
y_train_pred = Classifier_bow.decision_function(X_set5_train)
y_test_pred = Classifier_bow.decision_function(X_set5_test)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```




```
#CONFUSION MATRIX
import seaborn as sea
test_confusion_matrix = pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_threshold
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

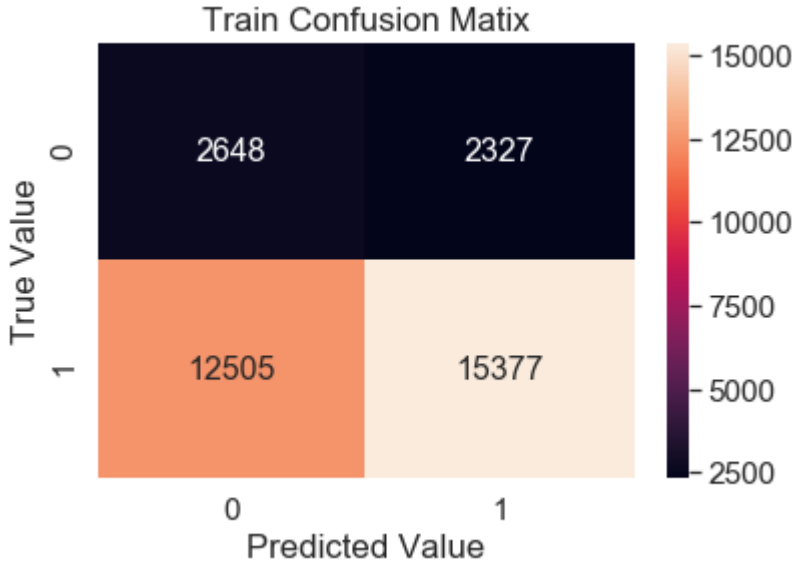
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.09
Text(0.5, 1.0, 'Test Confusion Matix')
```




```
#CONFUSION MATRIX
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresh
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
```

```
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.12
Text(0.5, 1.0, 'Train Confusion Matix')
```



Conclusions

```
# Please compare all your models using Prettytable library
#how to use pretty table http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
tb = PrettyTable()
tb.field_names= ("Vectorizer", " Alpha ", " AUC ")
tb.add_row(["BOW ", 10, 55])
tb.add_row(["Tf - Idf ", 1, 55])
tb.add_row(["AVG - W2V", 1, 48])
tb.add_row(["AVG - Tf - Idf", 1, 47])
tb.add_row(["SVD-Top 2000 Features", 10**3, 56])
print(tb.get_string(titles = "SVM- Observations"))
```

```
+-----------------------+---------+-------+
|       Vectorizer      |  Alpha  |  AUC  |
+-----------------------+---------+-------+
|          BOW          |    10   |   55  |
|       Tf - Idf        |    1    |   55  |
|       AVG - W2V       |    1    |   48  |
|     AVG - Tf - Idf    |    1    |   47  |
| SVD-Top 2000 Features |   1000  |   56  |
+-----------------------+---------+-------+
```