ASSIGNMENT - SUPPORT VECTOR MACHINE(SVM)

[1] READING DATA ¶

In [1]:
```
import pandas as pd

project_data=pd.read_csv("Donor_choose/train_data.csv")
resource_data=pd.read_csv("Donor_choose/resources.csv")
```

[2] Sorting data according to time [TBS]

In [2]:
```
# 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(project_data.columns)]

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

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

print(cols)
project_data.head(2)
```

```
['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state', 'Date', '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_approve
d']
```

Out[2]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_subject_catego
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Math & Scie
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Special Ne

In [3]:
```
print(project_data.shape)
print("="*100)
print(project_data.columns.values)
print("="*100)
print(resource_data.shape)
print("="*100)
print(resource_data.columns.values)
```

```
(109248, 17)
====================================================================================================
['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state' 'Date'
 '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']
====================================================================================================
(1541272, 4)
====================================================================================================
['id' 'description' 'quantity' 'price']
```

[3] Preproccesing Steps

In [4]:
```
categories=list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039
cat_list = []
for i in categories:
    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", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&",
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The'
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science
        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())
```

In [5]:
```
project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)
project_data.head(2)
```

Out[5]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_subject_subcat
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Applied Sciences, Healt
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Specia

In [6]:
```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
from collections import Counter
my_counter = Counter()
for word in project_data['clean_categories'].values:
    my_counter.update(word.split())
```

In [7]:
```
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
cat_dict = dict(my_counter)
sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
sorted_cat_dict
```

Out[7]:
```
{'Warmth': 1388,
 'Care_Hunger': 1388,
 'History_Civics': 5914,
 'Music_Arts': 10293,
 'AppliedLearning': 12135,
 'SpecialNeeds': 13642,
 'Health_Sports': 14223,
 'Math_Science': 41421,
 'Literacy_Language': 52239}
```

In [8]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python

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", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&",
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The'
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())
```

In [9]:
```
project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
project_data.head(2)
```

Out[9]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_e
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Engineering STEAM into the Primary Classroom	I hav fortunate to use th
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Sensory Tools for Focus	Imagine b 9 ye You're

In [10]:
```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
from collections import Counter
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())
```

In [11]:
```
# dict sort by value python: https://stackoverflow.com/a/613218/4084039
sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
sorted_sub_cat_dict
```

Out[11]:
```
{'Economics': 269,
 'CommunityService': 441,
 'FinancialLiteracy': 568,
 'ParentInvolvement': 677,
 'Extracurricular': 810,
 'Civics_Government': 815,
 'ForeignLanguages': 890,
 'NutritionEducation': 1355,
 'Warmth': 1388,
 'Care_Hunger': 1388,
 'SocialSciences': 1920,
 'PerformingArts': 1961,
 'CharacterEducation': 2065,
 'TeamSports': 2192,
 'Other': 2372,
 'College_CareerPrep': 2568,
 'Music': 3145,
 'History_Geography': 3171,
 'Health_LifeScience': 4235,
 'EarlyDevelopment': 4254,
 'ESL': 4367,
 'Gym_Fitness': 4509,
 'EnvironmentalScience': 5591,
 'VisualArts': 6278,
 'Health_Wellness': 10234,
 'AppliedSciences': 10816,
 'SpecialNeeds': 13642,
 'Literature_Writing': 22179,
 'Mathematics': 28074,
 'Literacy': 33700}
```

In [12]:
```
# merge two column text dataframe:
project_data["essay"] = project_data["project_essay_1"].map(str) +\
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
print(project_data["essay"].value_counts)
project_data.head(2)

```

```
<bound method IndexOpsMixin.value_counts of 55660     I have been fortunate enough to use the Fairy ...
76127     Imagine being 8-9 years old. You're in your th...
51140     Having a class of 24 students comes with diver...
473       I recently read an article about giving studen...
41558     My students crave challenge, they eat obstacle...
29891     It's the end of the school year. Routines have...
81565     \"Sitting still is overrated. It makes sense f...
79026     It’s not enough to read a book and write an es...
23374     Never has society so rapidly changed. Technolo...
86551     Do you remember the first time you saw Star Wa...
49228     My students yearn for a classroom environment ...
72638     Media and cinematography has been an extremely...
7176      Computer coding and robotics, my second grader...
70898     I teach 4th grade math, writing, social studie...
102755    In my classroom we explore and delve into real...
72593     A typical day in my classroom starts 30 minute...
35006     We LOVE technology! In our classroom, technolo...
100222    \"Teachers who love teaching teach children to...
5145      Do you remember the book you read that made yo...
48237     My students are learning to become lovers of r...
64637     Throughout this school year, I hope to enable ...
98973     Children spend much too much time connected to...
52282     Education is about nurturing justice, engaging...
46375     Everyday my students interact with each other ...
83528     I teach six amazing children with autism. Each...
36468     Everyday students are so excited to come to me...
36358     I am half day pre-k. I have two sets of studen...
39438     Our school is an urban public school that serv...
72117     Each day I teach a class from every grade. I'm...
2521      My students are all struggling readers. I supp...
                                ...
65527     I work in a school of approximately 800 studen...
24226     As a new teacher working in a high poverty dis...
35609     Love to sing, create, move and learn? You've c...
57692     Our school is 95 percent free and reduced lunc...
96905     My students live in Oklahoma City.  Oklahoma g...
27437     My 6th period class consist of 36 students wit...
86437     I work with a wonderful group of second grader...
64442     As a teacher-librarian, I get to share my love...
60130     I am so incredibly lucky to spend my days with...
61773     I teach fifth graders in a low income, high po...
83452     \"Every child deserves a champion: an adult wh...
78852     My students are from low income families aroun...
62763     Our school encountered a great loss due to a d...
98383     Motivated to learn, my students never cease to...
108896    Although physical education is mandated for on...
5403      My students are excited, happy, frustrated, sa...
18892     My first graders are creative, innovative, and...
56589     My classroom is a revolving door. They are eag...
21335     My school will work with Microsoft's TEALS pro...
41604     Each day my students eagerly anticipate our re...
11368     I teach 17 amazing students in a Title One sch...
32881     My students often have to worry about things o...
84022     Our students come from multiple different back...
106793    My students this year love science and enginee...
27376     I teach first grade in a Title I school. Altho...
87154     Our day starts with about 100 students athlete...
14678     My students range from age four to five years ...
39096     We are a Title 1 school  650 total students. O...
87881     I teach many different types of students.  My ...
78306     My first graders are eager to learn about the ...
Name: essay, Length: 109248, dtype: object>
```

Out[12]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_e
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Engineering STEAM into the Primary Classroom	I hav fortunate to use th
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Sensory Tools for Focus	Imagine b 9 ye You're

In [13]:
```
# we get the cost of the project using resource.csv file
resource_data.head(2)
```

Out[13]:

	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

In [14]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(2)
```

Out[14]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [15]:
```
# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [16]:
```
approved_price = project_data[project_data['project_is_approved']==1]['price'].values

rejected_price = project_data[project_data['project_is_approved']==0]['price'].values
```

In [17]:
```
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
import numpy as np


t = PrettyTable()
t.field_names = ["Percentile", "Approved Projects", "Not Approved Projects"]

for i in range(0,101,5):
    t.add_row([i,np.round(np.percentile(approved_price,i), 3), np.round(np.percentile(rejected_price,i), 3)])
print(t)
```

```
+------------+------------------+-----------------------+
| Percentile | Approved Projects | Not Approved Projects |
+------------+------------------+-----------------------+
|     0      |       0.66       |          1.97         |
|     5      |      13.59       |          41.9         |
|     10     |      33.88       |         73.67         |
|     15     |       58.0       |         99.109        |
|     20     |      77.38       |         118.56        |
|     25     |      99.95       |        140.892        |
|     30     |      116.68      |         162.23        |
|     35     |     137.232      |        184.014        |
|     40     |      157.0       |        208.632        |
|     45     |     178.265      |        235.106        |
|     50     |      198.99      |        263.145        |
|     55     |      223.99      |         292.61        |
|     60     |      255.63      |        325.144        |
|     65     |     285.412      |         362.39        |
|     70     |     321.225      |         399.99        |
|     75     |     366.075      |        449.945        |
|     80     |      411.67      |        519.282        |
|     85     |      479.0       |        618.276        |
|     90     |      593.11      |        739.356        |
|     95     |     801.598      |        992.486        |
|    100     |      9999.0      |         9999.0        |
+------------+------------------+-----------------------+
```

In [18]:
```
project_data.head(2)
```

Out[18]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_essay
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Engineering STEAM into the Primary Classroom	I have be fortunate enou to use the Fa
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Sensory Tools for Focus	Imagine being 9 years o You're in yo th

In [19]:
```
# 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 [20]:
```
import nltk
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer
stopWords = set(stopwords.words('english'))
print(stopWords)

sno=nltk.stem.SnowballStemmer('english')
print(sno.stem('amazing'))

```

```
{'hasn', 'there', 'weren', 'between', 'then', 'if', 'wouldn', "that'll", 'as', 'ours', 'is', 'theirs', 'it', 'until',
'again', 'no', 'didn', 'do', 'over', 'a', 'up', 'myself', 'having', "should've", 'will', 'i', 'its', "you're", 'yours',
'm', 'couldn', 'both', 'which', 'has', 'his', 'because', 'was', 'them', 'who', 'we', 'he', 'what', 've', 'on', 'durin
g', 'the', 'were', 'very', 's', 'some', 'y', 'can', 'won', "isn't", 're', 'she', 'all', 'once', 'to', 'him', 'being',
'off', 'out', 'your', 'with', 'whom', 'o', 'don', 'other', 'more', "haven't", "weren't", 'those', 'such', 'while', "mig
htn't", 'here', 'hadn', 'of', 'needn', "hasn't", 'this', 'about', 'they', 'further', 't', "you'll", 'doing', 'just', 't
hat', 'aren', 'after', 'me', "won't", 'above', 'most', "hadn't", 'haven', 'ourselves', 'yourself', 'at', 'themselves',
'why', 'own', 'how', 'herself', 'where', 'doesn', 'shouldn', "couldn't", 'be', 'by', 'had', 'each', 'd', 'does', 'did',
'before', "you've", 'mustn', 'been', 'nor', 'against', 'through', 'than', 'ma', "it's", 'now', 'these', 'and', "are
n't", 'yourselves', 'you', 'wasn', 'below', "shouldn't", 'not', 'for', 'an', 'so', 'should', "doesn't", "wouldn't", 'l
l', 'mightn', "you'd", "didn't", "mustn't", 'himself', 'same', 'their', 'our', "wasn't", 'hers', 'but', 'are', 'down',
'too', 'few', 'ain', 'her', "she's", 'am', 'have', 'any', 'in', 'only', 'my', 'itself', 'or', 'under', "don't", 'shan',
'when', "needn't", "shan't", 'into', 'isn', 'from'}
amaz
```

In [21]:
```
# PREPROCESSING FOR ESSAYS
from tqdm import tqdm
import re
import string
from bs4 import BeautifulSoup
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    sent = re.sub("\S*\d\S*", "", sent).strip()
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopWords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109248 [00:29<00:00, 3686.82it/s]
```

In [22]:
```
# After preprocessing
preprocessed_essays[2000]
```

Out[22]:
```
'creativity intelligence fun albert einstein our elementary library greenville elementary anything quiet hushed space i
t place collaboration research it place incorporating technology it place innovation and place creating our school serv
es third fourth graders primarily live rural poverty stricken areas community being title i school approximately receiv
e free reduced lunch but inquisitive creative eager learn they love visiting library check books hear stories create di
gital stories use computer lab learning fun we want build library makerspace activities revolving around art literacy p
rovide engaging hands activities we want begin makerspace fridays our school recently received grant books arts integra
ted makerspace we received titles origami everyone how make stuff ducktape cool engineering activities girls we need su
pplies correlate new informational texts by adding art craft supplies students able design create masterpieces related
coursework for example studying native americans students use looms yarn recreate navajo pueblo weaving weaving also in
tegrated literacy greek mythology story arachne creating art perler beads many possibilities students design animals st
udying characteristics they use symmetry patterning create one kind originals origami reinforces geometry thinking skil
ls fractions problem solving fun science our students need able apply read learn if read book apply reading hands art a
ctivity actually create product this crucial skill real world by creating designing masterpieces using many critical th
inking skills students become analytical thinkers'
```

In [23]:
```
project_data = pd.DataFrame(project_data)
```

In [24]:
```
project_data['cleaned_essays'] = preprocessed_essays
```

In [25]:
```
project_data.head(2)
```

Out[25]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_essay
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Engineering STEAM into the Primary Classroom	I have be fortunate enou to use the Fa
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Sensory Tools for Focus	Imagine being 9 years o You're in yc th

2 rows × 21 columns

In [26]:
```
# Data preprocessing on title text
from tqdm import tqdm
import re
import string
from bs4 import BeautifulSoup
preprocessed_title_text = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['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)
    sent = re.sub("\S*\d\S*", "", sent).strip()
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopWords)
    preprocessed_title_text.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [00:01<00:00, 60943.23it/s]
```

In [27]:
```
project_data = pd.DataFrame(project_data)
project_data['cleaned_title_text'] = preprocessed_title_text

```

In [28]:
```
project_data.head(2)
```

Out[28]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_essay
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Engineering STEAM into the Primary Classroom	I have be fortunate enou to use the Fa
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Sensory Tools for Focus	Imagine being 9 years o You're in yc th

2 rows × 22 columns

In [29]:
```
print(project_data.shape)
print(project_data.columns)
```

```
(109248, 22)
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', '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',
       'clean_categories', 'clean_subcategories', 'essay', 'price', 'quantity',
       'cleaned_essays', 'cleaned_title_text'],
      dtype='object')
```

In [30]:
```
# Fill blank spaces of teacher_prefix with nan

#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-split
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna('null')

project_data.head(2)

```

Out[30]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_essay
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2	Engineering STEAM into the Primary Classroom	I have be fortunate enou to use the Fa
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5	Sensory Tools for Focus	Imagine being 9 years o You're in yc th

2 rows × 22 columns

In [31]:
```
# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
from collections import Counter
my_counter = Counter()
for word in project_data['project_grade_category'].values:
    my_counter.update(word.split())
```

In [32]:
```
project_grade_category_dict = dict(my_counter)
project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), key=lambda kv: kv[1]))

```

Train Test split

In [33]:
```
project_data.shape
```

Out[33]: (109248, 22)

In [34]:
```
project_data["project_is_approved"].value_counts()
```

Out[34]:
```
1    92706
0    16542
Name: project_is_approved, dtype: int64
```

In [35]:
```
# Randomly sample 50k points

project_data = project_data.sample(n=50000)
project_data.shape
```

Out[35]: (50000, 22)

In [36]:
```
# Define x & y for splitting

y=project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)      # drop project is approved columns
x=project_data
```

In [37]:
```
print(y.shape)
print(x.shape)
```

```
(50000,)
(50000, 21)
```

In [38]:
```
1 x.head(2)
```

Out[38]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_e
77625	83475	p210432	02925c70cfaaf02c50a818333a0e0c72	Mrs.	KY	2016-12-24 15:26:02	Grades PreK-2	\"Ear-Resistible\" Listening Center!	future. stude simply a
20897	17991	p052636	cb2410db949de9b02e1ec55ab98cf0d7	Mrs.	CA	2016-08-01 22:59:39	Grades 3-5	Rug to the Rescue	My fourt stude curious b

2 rows × 21 columns

In [39]:
```
1 # break in train test
2
3 from sklearn.model_selection import train_test_split
4
5 x_train,x_test,y_train,y_test= train_test_split(x,y,test_size=0.3,random_state=2,shuffle=False)
6
7 # now break trainig data further in train and cv
8 #x_train,x_cv,y_train,y_cv= train_test_split(x_train, y_train, test_size=0.3 ,random_state=2,stratify=y_train)
```

In [40]:
```
1 print(x_train.shape, y_train.shape)
2 #print(x_cv.shape, y_cv.shape)
3 print(x_test.shape, y_test.shape)
4
5 print("="*100)
```

```
(35000, 21) (35000,)
(15000, 21) (15000,)
====================================================================================================
```

In [41]:
```
1 x=np.count_nonzero(y_test)
2 # count no. of project app or not on test data set
3 print(len(y_test)-x)
4 print(x)
5
```

```
2303
12697
```

In [42]:
```
1 x_train.head(2)
2
```

Out[42]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_title	project_e
77625	83475	p210432	02925c70cfaaf02c50a818333a0e0c72	Mrs.	KY	2016-12-24 15:26:02	Grades PreK-2	\"Ear-Resistible\" Listening Center!	future. stude simply a
20897	17991	p052636	cb2410db949de9b02e1ec55ab98cf0d7	Mrs.	CA	2016-08-01 22:59:39	Grades 3-5	Rug to the Rescue	My fourt stude curious b

2 rows × 21 columns

Apply BOW and OHE

In [43]:
```
from sklearn.feature_extraction.text import CountVectorizer
# Vectorizing text data
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2))
vectorizer.fit_transform(x_train["cleaned_essays"].values)

x_train_essay_bow = vectorizer.transform(x_train['cleaned_essays'].values)
#x_cv_essay_bow = vectorizer.transform(x_cv['cleaned_essays'].values)
x_test_essay_bow = vectorizer.transform(x_test['cleaned_essays'].values)

print("After vectorizations")
print(x_train_essay_bow.shape, y_train.shape)
#print(x_cv_essay_bow.shape, y_cv.shape)
print(x_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(35000, 74447) (35000,)
(15000, 74447) (15000,)
====================================================================================================
```

In [44]:
```
# BOW on clean_titles

from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2))
vectorizer.fit(x_train['cleaned_title_text'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
x_train_titles_bow = vectorizer.transform(x_train['cleaned_title_text'].values)
#x_cv_titles_bow = vectorizer.transform(x_cv['cleaned_title_text'].values)
x_test_titles_bow = vectorizer.transform(x_test['cleaned_title_text'].values)

print("After vectorizations")
print(x_train_titles_bow.shape, y_train.shape)
#print(x_cv_titles_bow.shape, y_cv.shape)
print(x_test_titles_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(35000, 2786) (35000,)
(15000, 2786) (15000,)
====================================================================================================
```

In [45]:
```
# ONE of subject category
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer()
vectorizer.fit(x_train['clean_categories'].values) # fit has to happen only on train data


# we use the fitted CountVectorizer to convert the text to vector
x_train_clean_cat_ohe = vectorizer.transform(x_train['clean_categories'].values)
#x_cv_clean_cat_ohe = vectorizer.transform(x_cv['clean_categories'].values)
x_test_clean_cat_ohe = vectorizer.transform(x_test['clean_categories'].values)

print("After vectorizations")
print(x_train_clean_cat_ohe.shape, y_train.shape)
#print(x_cv_clean_cat_ohe.shape, y_cv.shape)
print(x_test_clean_cat_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(35000, 9) (35000,)
(15000, 9) (15000,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language', 'math_science', 'music_art
s', 'specialneeds', 'warmth']
====================================================================================================
```

In [46]:
```
# ONE of subject subcategory

vectorizer = CountVectorizer()
vectorizer.fit(x_train['clean_subcategories'].values) # fit has to happen only on train data


# we use the fitted CountVectorizer to convert the text to vector
x_train_clean_subcat_ohe = vectorizer.transform(x_train['clean_subcategories'].values)
#x_cv_clean_subcat_ohe = vectorizer.transform(x_cv['clean_subcategories'].values)
x_test_clean_subcat_ohe = vectorizer.transform(x_test['clean_subcategories'].values)

print("After vectorizations")
print(x_train_clean_cat_ohe.shape, y_train.shape)
#print(x_cv_clean_cat_ohe.shape, y_cv.shape)
print(x_test_clean_cat_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(35000, 9) (35000,)
(15000, 9) (15000,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government', 'college_careerprep', 'communityservice',
'earlydevelopment', 'economics', 'environmentalscience', 'esl', 'extracurricular', 'financialliteracy', 'foreignlanguag
es', 'gym_fitness', 'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'ma
thematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socialsciences', 'specialne
eds', 'teamsports', 'visualarts', 'warmth']
====================================================================================================
```

In [47]:
```
# one hot encoding the catogorical features: categorical_categories
# teacher_prefix

vectorizer = CountVectorizer()
vectorizer.fit(x_train['teacher_prefix'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
x_train_teacher_pre = vectorizer.transform(x_train['teacher_prefix'].values)
#x_cv_teacher_pre = vectorizer.transform(x_cv['teacher_prefix'].values)
x_test_teacher_pre = vectorizer.transform(x_test['teacher_prefix'].values)

print("After vectorizations")
print(x_train_teacher_pre.shape, y_train.shape)
#print(x_cv_teacher_pre.shape, y_cv.shape)
print(x_test_teacher_pre.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)

```

```
After vectorizations
(35000, 6) (35000,)
(15000, 6) (15000,)
['dr', 'mr', 'mrs', 'ms', 'null', 'teacher']
====================================================================================================
```

In [48]:
```
# school_state

vectorizer = CountVectorizer()
vectorizer.fit(x_train['school_state'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
x_train_state_ohe = vectorizer.transform(x_train['school_state'].values)
#x_cv_state_ohe = vectorizer.transform(x_cv['school_state'].values)
x_test_state_ohe = vectorizer.transform(x_test['school_state'].values)

print("After vectorizations")
print(x_train_state_ohe.shape, y_train.shape)
#print(x_cv_state_ohe.shape, y_cv.shape)
print(x_test_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(35000, 51) (35000,)
(15000, 51) (15000,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'ks', 'ky', 'la', 'm
a', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'ok', 'or', 'pa',
'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
====================================================================================================
```

In [49]:
```
project_grade_category= x_train['project_grade_category'].unique()
```

In [50]:
```
vectorizer5 = CountVectorizer(vocabulary=list(project_grade_category), lowercase=False, binary=True)
vectorizer5.fit(x_train['project_grade_category'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
x_train_grade_ohe = vectorizer5.transform(x_train['project_grade_category'].values)
#x_cv_grade_ohe = vectorizer.transform(x_cv['project_grade_category'].values)
x_test_grade_ohe = vectorizer5.transform(x_test['project_grade_category'].values)

print("After vectorizations")
print(x_train_grade_ohe.shape, y_train.shape)
#print(x_cv_grade_ohe.shape, y_cv.shape)
print(x_test_grade_ohe.shape, y_test.shape)
print(vectorizer5.get_feature_names())
print("="*100)

```

```
After vectorizations
(35000, 4) (35000,)
(15000, 4) (15000,)
['Grades PreK-2', 'Grades 3-5', 'Grades 6-8', 'Grades 9-12']
====================================================================================================
```

In [51]:
```
# Standarized the numerical features: Price

from sklearn.preprocessing import StandardScaler
price_scalar = StandardScaler()
price_scalar.fit(x_train['price'].values.reshape(-1,1)) # finding the mean and standard deviation of this data

x_train_price_std = price_scalar.transform(x_train['price'].values.reshape(-1,1))
#x_cv_price_std = price_scalar.transform(x_cv['price'].values.reshape(-1,1))
x_test_price_std = price_scalar.transform(x_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(x_train_price_std.shape, y_train.shape)
#print(x_cv_price_std.shape, y_cv.shape)
print(x_test_price_std.shape, y_test.shape)
print("="*100)
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
```

```
After vectorizations
(35000, 1) (35000,)
(15000, 1) (15000,)
====================================================================================================
Mean : 297.5980302857143, Standard deviation : 356.70522540667776
```

In [52]:
```
x_train_price_std
```

Out[52]:
```
array([[-0.13049439],
       [ 0.30367363],
       [ 0.78042582],
       ...,
       [-0.29794358],
       [-0.75622113],
       [-0.53603933]])
```

In [53]:

```
# Standarized the numerical features: teacher_previously

from sklearn.preprocessing import StandardScaler
teacher_previously_scalar = StandardScaler()
teacher_previously_scalar.fit(x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # findin

x_train_teacher_previously_std = teacher_previously_scalar.transform(x_train['teacher_number_of_previously_posted_pr
#x_cv_teacher_previously_std = teacher_previously_scalar.transform(x_cv['teacher_number_of_previously_posted_project
x_test_teacher_previously_std = teacher_previously_scalar.transform(x_test['teacher_number_of_previously_posted_proj

print("After vectorizations")
print(x_train_teacher_previously_std.shape, y_train.shape)
#print(x_cv_teacher_previously_std.shape, y_cv.shape)
print(x_test_teacher_previously_std.shape, y_test.shape)
print("="*100)
print(f"Mean : {teacher_previously_scalar.mean_[0]}, Standard deviation : {np.sqrt(teacher_previously_scalar.var_[0]
```

```
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConversionWarning: Data with inp
ut dtype int64 was converted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConversionWarning: Data with inp
ut dtype int64 was converted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConversionWarning: Data with inp
ut dtype int64 was converted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)

After vectorizations
(35000, 1) (35000,)
(15000, 1) (15000,)
====================================================================================================
Mean : 11.310028571428571, Standard deviation : 28.152185847624402
```

In [54]:

```
# Standarized the numerical features:quantity

from sklearn.preprocessing import StandardScaler
quantity_scalar = StandardScaler()
quantity_scalar.fit(x_train['quantity'].values.reshape(-1,1)) # finding the mean and standard deviation of this data

x_train_quantity_std = quantity_scalar.transform(x_train['quantity'].values.reshape(-1,1))
#x_cv_teacher_previously_std = teacher_previously_scalar.transform(x_cv['teacher_number_of_previously_posted_project
x_test_quantity_std = quantity_scalar.transform(x_test['quantity'].values.reshape(-1,1))

print("After vectorizations")
print(x_train_quantity_std.shape, y_train.shape)
#print(x_cv_teacher_previously_std.shape, y_cv.shape)
print(x_test_quantity_std.shape, y_test.shape)
print("="*100)
print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation : {np.sqrt(quantity_scalar.var_[0])}")
```

```
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConversionWarning: Data with inp
ut dtype int64 was converted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConversionWarning: Data with inp
ut dtype int64 was converted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\sklearn\utils\validation.py:595: DataConversionWarning: Data with inp
ut dtype int64 was converted to float64 by StandardScaler.
  warnings.warn(msg, DataConversionWarning)

After vectorizations
(35000, 1) (35000,)
(15000, 1) (15000,)
====================================================================================================
Mean : 17.0862, Standard deviation : 26.59960307684523
```

In [55]:
```
# CONCATINATE all features

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_train = hstack((x_train_essay_bow,x_train_titles_bow,x_train_clean_cat_ohe,x_train_clean_subcat_ohe, x_train_state
#X_cv = hstack((x_cv_essay_bow,x_cv_titles_bow,x_cv_clean_cat_ohe,x_cv_clean_subcat_ohe, x_cv_state_ohe, x_cv_teache
X_test = hstack((x_test_essay_bow,x_test_titles_bow,x_test_clean_cat_ohe,x_test_clean_subcat_ohe, x_test_state_ohe,

print("Final Data matrix")
print(X_train.shape, y_train.shape)
#print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(35000, 77335) (35000,)
(15000, 77335) (15000,)
====================================================================================================
```

In [56]:
```
type(X_train)
```

Out[56]:
```
scipy.sparse.csr.csr_matrix
```

In [ ]:
```

```

SET : 1 [BOW}

In [57]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier



clf_param_grid = {
    'alpha' : [10**-x for x in range(-4,5)],
    'penalty' : ['l1','l2']
}
SGD1 = SGDClassifier(class_weight='balanced')

estimator = GridSearchCV(SGD1, param_grid=clf_param_grid ,cv=10, verbose=1, scoring="roc_auc",n_jobs=-1)
estimator.fit(X_train,y_train)

print(estimator.best_params_)



```

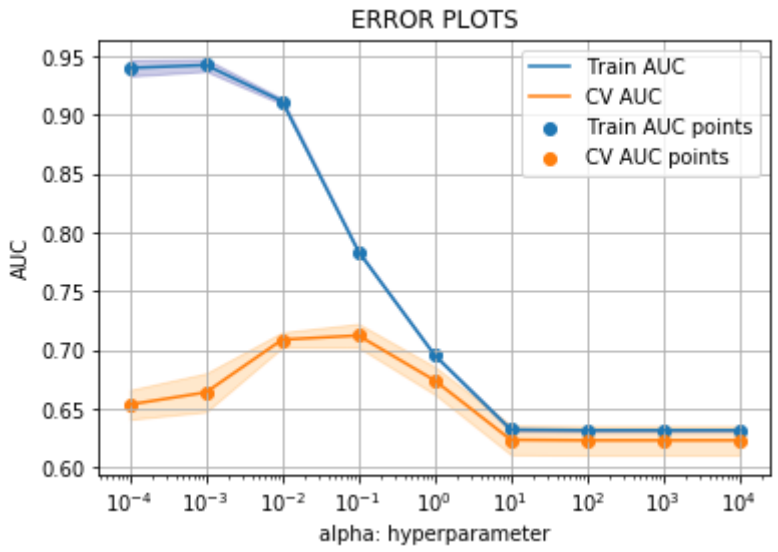
```
Fitting 10 folds for each of 18 candidates, totalling 180 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed:   10.7s
[Parallel(n_jobs=-1)]: Done 180 out of 180 | elapsed:   49.6s finished
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\sklearn\linear_model\stochastic_gradient.py:166: FutureWarning: max_i
ter and tol parameters have been added in SGDClassifier in 0.19. If both are left unset, they default to max_iter=5 and
tol=None. If tol is not None, max_iter defaults to max_iter=1000. From 0.21, default max_iter will be 1000, and default
tol will be 1e-3.
  FutureWarning)

{'alpha': 0.1, 'penalty': 'l2'}
```

In [58]:
```
import warnings
warnings.filterwarnings("ignore")
```

In [59]:
```
b1=estimator.best_params_["alpha"]
p1=estimator.best_params_["penalty"]
```

In [60]:
```
import matplotlib.pyplot as plt
import math
```

In [61]:
```
train_auc1= estimator.cv_results_['mean_train_score'][estimator.cv_results_['param_penalty']==p1]
train_auc_std1= estimator.cv_results_['std_train_score'][estimator.cv_results_['param_penalty']==p1]
cv_auc1 = estimator.cv_results_['mean_test_score'][estimator.cv_results_['param_penalty']==p1]
cv_auc_std1= estimator.cv_results_['std_test_score'][estimator.cv_results_['param_penalty']==p1]

ax=plt.subplot()
plt.plot(clf_param_grid['alpha'], train_auc1, label='Train AUC')

# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(clf_param_grid['alpha'],train_auc1 - train_auc_std1,train_auc1 + train_auc_std1,alpha=0.2,col
# create a shaded area between [mean - std, mean + std]

plt.plot(clf_param_grid['alpha'], cv_auc1, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(clf_param_grid['alpha'],cv_auc1 - cv_auc_std1,cv_auc1 + cv_auc_std1,alpha=0.2,color='darkorar

plt.scatter(clf_param_grid['alpha'], train_auc1, label='Train AUC points')
plt.scatter(clf_param_grid['alpha'], cv_auc1, label='CV AUC points')

plt.xscale('log')
plt.axis('tight')
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



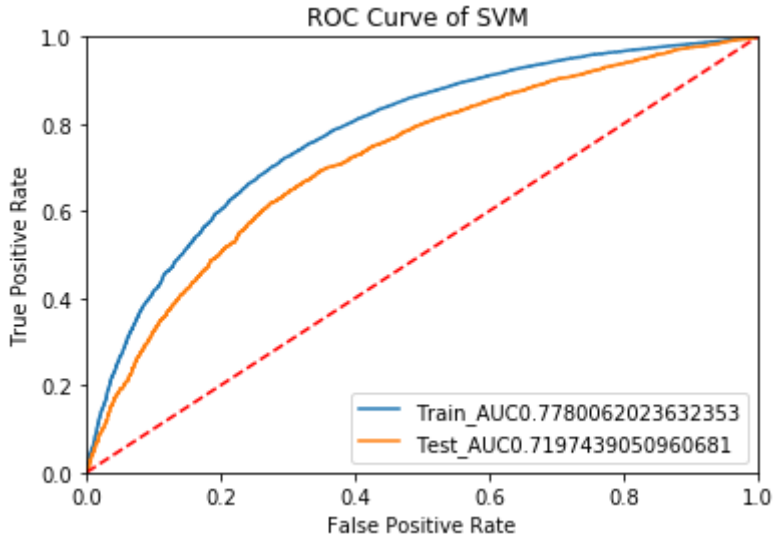
In [62]:
```
model_new1=SGDClassifier(penalty=p1, alpha= b1,class_weight='balanced',random_state=1)
model_new1.fit(X_train,y_train)
```

Out[62]:
```
SGDClassifier(alpha=0.1, average=False, class_weight='balanced',
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=None,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l2',
       power_t=0.5, random_state=1, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
```

In [169]:
```
import numpy as np
import math

# custom function
def sigmoid(x):
    return 1 / (1 + math.exp(-x))

# define vectorized sigmoid
sigmoid_v = np.vectorize(sigmoid)

# test
scores = np.array([ -0.54761371,  17.04850603,   4.86054302])
print (sigmoid_v(scores))
```

```
[0.36641822 0.99999996 0.99231327]
```

In [170]:
```
from  sklearn.metrics import roc_curve
from sklearn.metrics import auc
import matplotlib.pyplot as plt


score_roc_train = model_new1.decision_function(X_train)
fpr_train, tpr_train, threshold_train = roc_curve(y_train, sigmoid_v(score_roc_train))
roc_auc_train = auc(fpr_train, tpr_train)

score_roc_test = model_new1.decision_function(X_test)
fpr_test, tpr_test, threshold_test = roc_curve(y_test,sigmoid_v( score_roc_test))
roc_auc_test = auc(fpr_test, tpr_test)


plt.plot(fpr_train, tpr_train, label = "Train_AUC"+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test, tpr_test, label = "Test_AUC"+str(auc(fpr_test, tpr_test)))
plt.legend(loc = 'lower right')

plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])

plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('ROC Curve of SVM ')
plt.show()
```



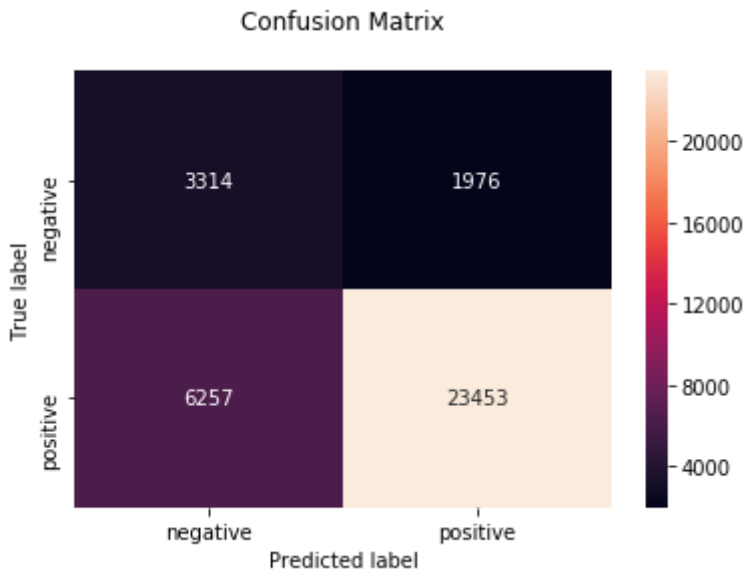
In [171]:
```
y_train_pred = model_new1.predict(X_train)
y_test_pred = model_new1.predict(X_test)
```

In [172]:
```
# we are defining are own function for use probabilities to plot confusion matrix
# we have to plot confusion matrix at least fpr and high tpr values

def predict(proba,threshold,fpr,tpr):

    t = threshold[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))


    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions

```

In [173]:
```
from sklearn.metrics import confusion_matrix

import seaborn as sns
ax = plt.subplot()

print("Train confusion matrix")
cnn_train = confusion_matrix(y_train, predict(y_train_pred, threshold_train, fpr_train, tpr_train))
sns.heatmap(cnn_train,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.5088269083815256 for threshold 0.536
```

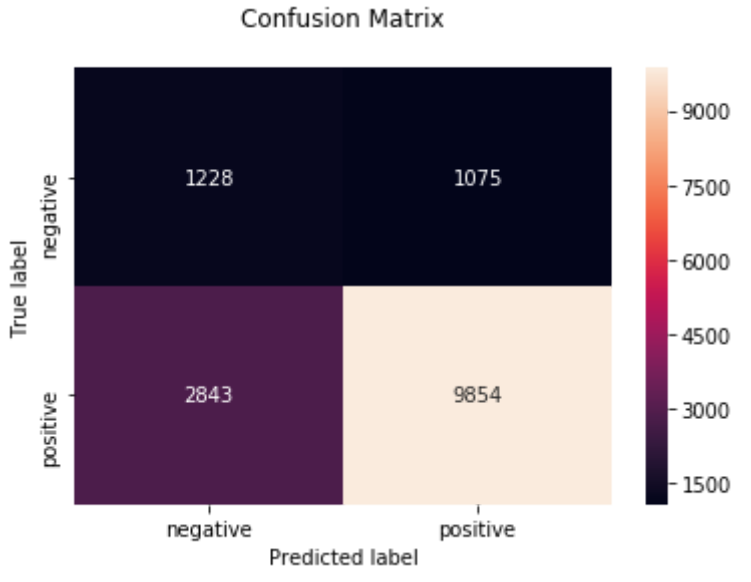
Out[173]:
```
Text(0.5, 1.0, 'Confusion Matrix\n')
```



In [174]:
```
ax = plt.subplot()

print("Test confusion matrix")
cnn_test = confusion_matrix(y_test, predict(y_test_pred, threshold_test, fpr_test, tpr_test))
sns.heatmap(cnn_test,annot = True,ax=ax,fmt='d')

ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.4515797595248429 for threshold 0.557
```

Out[174]:
```
Text(0.5, 1.0, 'Confusion Matrix\n')
```



In [68]:
```
from sklearn.metrics import classification_report
print("_" * 101)
print("Classification Report: \n")
print(classification_report(y_test,y_test_pred))
print("_" * 101)

```

```
_____________________________________________________________________________________________________
Classification Report:

              precision    recall  f1-score   support

           0       0.30      0.53      0.39      2303
           1       0.90      0.78      0.83     12697

   micro avg       0.74      0.74      0.74     15000
   macro avg       0.60      0.65      0.61     15000
weighted avg       0.81      0.74      0.77     15000

_____________________________________________________________________________________________________
```

SET : 2 ()tf-idf

TFIDF VECTORIZER

In [69]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer8 = TfidfVectorizer(min_df=10)
preprocessed_essays_xtr_tfidf = vectorizer8.fit_transform(x_train['cleaned_essays'])
print("Shape of matrix after one hot encodig ",preprocessed_essays_xtr_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (35000, 10483)
```

In [70]:
```
preprocessed_essays_xtest_tfidf = vectorizer8.transform(x_test['cleaned_essays'])
print("Shape of matrix after one hot encodig ",preprocessed_essays_xtest_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (15000, 10483)
```

In [71]:
```
vectorizer9 = TfidfVectorizer(min_df=10)
preprocessed_title_xtr_tfidf = vectorizer9.fit_transform(x_train['cleaned_title_text'])
print("Shape of matrix after one hot encodig ",preprocessed_title_xtr_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (35000, 1680)
```

In [72]:
```
preprocessed_title_xtest_tfidf = vectorizer9.transform(x_test['cleaned_title_text'])
print("Shape of matrix after one hot encodig ",preprocessed_title_xtest_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (15000, 1680)
```

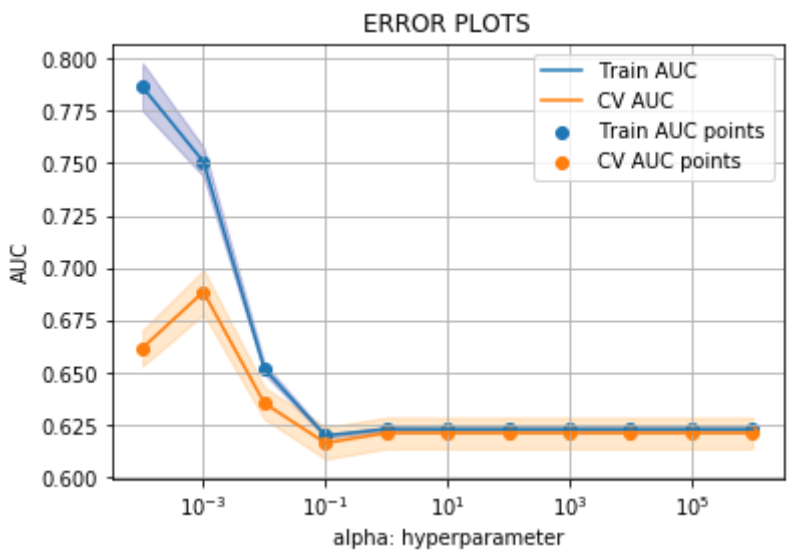
In [73]:
```
X_train_tfidf=hstack((preprocessed_essays_xtr_tfidf,preprocessed_title_xtr_tfidf,x_train_clean_cat_ohe,x_train_clear
                      ,x_train_quantity_std ))
#X_cv_tfidf=hstack((preprocessed_essays_xcv_tfidf,preprocessed_title_xcv_tfidf,x_cv_clean_cat_ohe,x_cv_clean_subcat_

X_test_tfidf=hstack((preprocessed_essays_xtest_tfidf,preprocessed_title_xtest_tfidf,x_test_clean_cat_ohe,x_test_clea
                     ,x_test_quantity_std ))
```

In [74]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier


clf_param_grid = {
    'alpha' : [10**-x for x in range(-6,5)],
    'penalty' : ['l1','l2']
}
SGD2 = SGDClassifier(class_weight='balanced')

estimator2 = GridSearchCV(SGD2, param_grid=clf_param_grid ,cv=10, verbose=2, scoring="roc_auc",n_jobs=-1)
estimator2.fit(X_train_tfidf,y_train)

print(estimator2.best_params_)
```

```
Fitting 10 folds for each of 22 candidates, totalling 220 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  17 tasks      | elapsed:    1.5s
[Parallel(n_jobs=-1)]: Done 138 tasks      | elapsed:    9.8s
[Parallel(n_jobs=-1)]: Done 220 out of 220 | elapsed:   15.0s finished

{'alpha': 0.001, 'penalty': 'l2'}
```

In [75]:
```
b2=estimator2.best_params_["alpha"]
p2=estimator2.best_params_["penalty"]
```

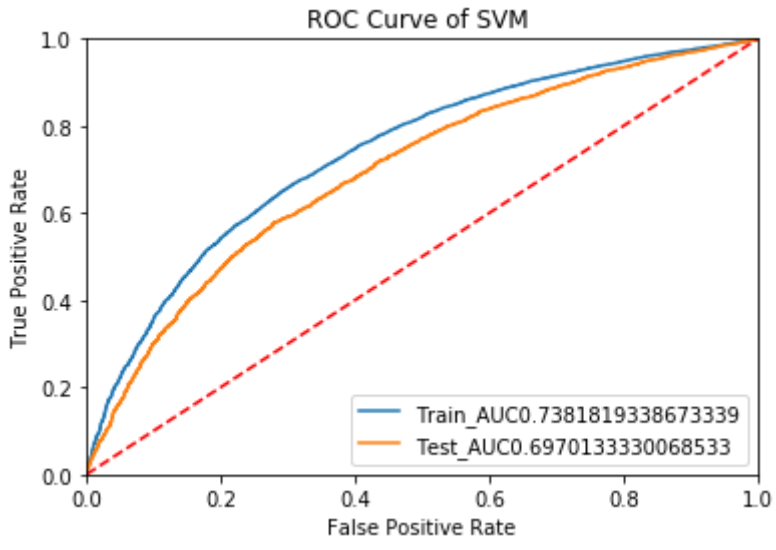
In [76]:
```
train_auc2= estimator2.cv_results_['mean_train_score'][estimator2.cv_results_['param_penalty']==p2]
train_auc_std2= estimator2.cv_results_['std_train_score'][estimator2.cv_results_['param_penalty']==p2]
cv_auc2 = estimator2.cv_results_['mean_test_score'][estimator2.cv_results_['param_penalty']==p2]
cv_auc_std2= estimator2.cv_results_['std_test_score'][estimator2.cv_results_['param_penalty']==p2]

ax=plt.subplot()
plt.plot(clf_param_grid['alpha'], train_auc2, label='Train AUC')

# this code is copied from here: https://stackoverflow.com/a/48803362/4084039
plt.gca().fill_between(clf_param_grid['alpha'],train_auc2 - train_auc_std2,train_auc2 + train_auc_std2,alpha=0.2,col
# create a shaded area between [mean - std, mean + std]

plt.plot(clf_param_grid['alpha'], cv_auc2, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803362/4084039
plt.gca().fill_between(clf_param_grid['alpha'],cv_auc2 - cv_auc_std2,cv_auc2 + cv_auc_std2,alpha=0.2,color='darkoran

plt.scatter(clf_param_grid['alpha'], train_auc2, label='Train AUC points')
plt.scatter(clf_param_grid['alpha'], cv_auc2, label='CV AUC points')

plt.xscale('log')
plt.axis('tight')
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [77]:
```
model_new2=SGDClassifier( penalty=p2, alpha= b2,class_weight='balanced')
model_new2.fit(X_train_tfidf,y_train)
```

Out[77]:
```
SGDClassifier(alpha=0.001, average=False, class_weight='balanced',
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=None,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l2',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
```

In [166]:
```
score_roc_train = model_new2.decision_function(X_train_tfidf)
fpr_train, tpr_train, threshold_train = roc_curve(y_train, sigmoid_v(score_roc_train))
roc_auc_train = auc(fpr_train, tpr_train)

score_roc_test = model_new2.decision_function(X_test_tfidf)
fpr_test, tpr_test, threshold_test = roc_curve(y_test,sigmoid_v (score_roc_test))
roc_auc_test = auc(fpr_test, tpr_test)


plt.plot(fpr_train, tpr_train, label = "Train_AUC"+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test, tpr_test, label = "Test_AUC"+str(auc(fpr_test, tpr_test)))
plt.legend(loc = 'lower right')

plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])

plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('ROC Curve of SVM ')
plt.show()
```

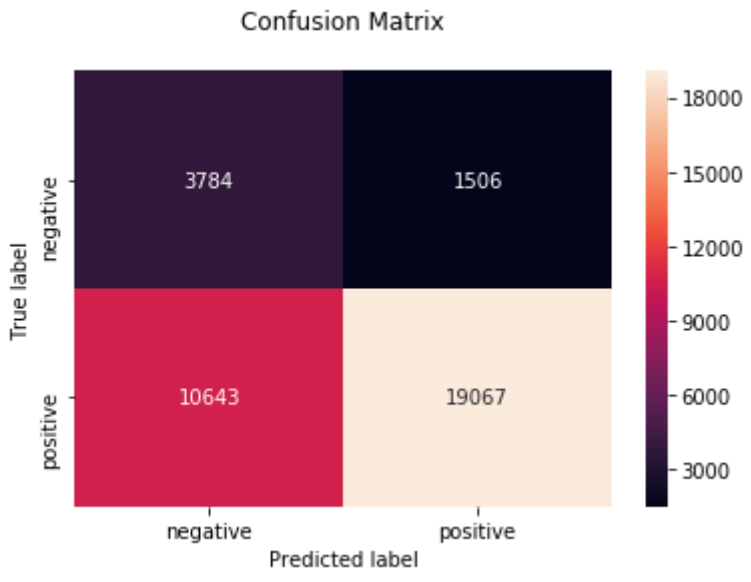


In [167]:
```
y_train_pred = model_new2.predict(X_train_tfidf)
y_test_pred = model_new2.predict(X_test_tfidf)
```

In [168]:
```
from sklearn.metrics import confusion_matrix

ax = plt.subplot()

print("Train confusion matrix")
cnn_train = confusion_matrix(y_train, predict(y_train_pred, threshold_train, fpr_train, tpr_train))
sns.heatmap(cnn_train,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4614392180492079 for threshold 0.486
```

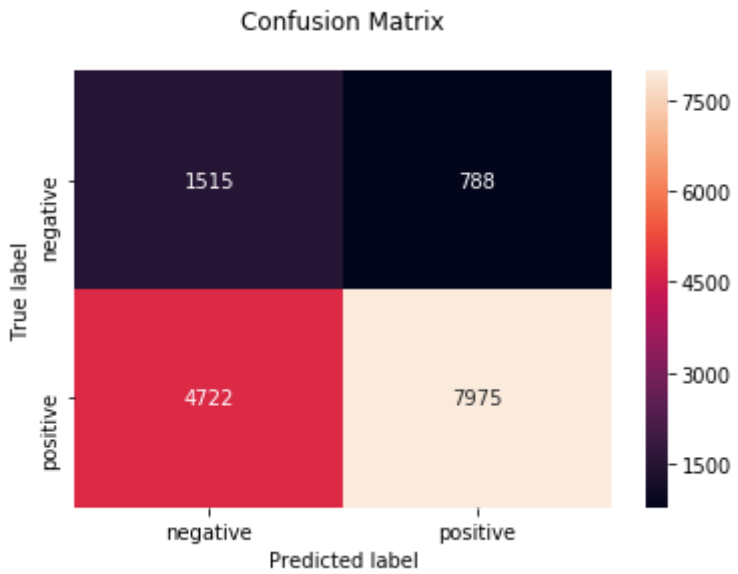
Out[168]: Text(0.5, 1.0, 'Confusion Matrix\n')



In [81]:
```
from sklearn.metrics import confusion_matrix

ax = plt.subplot()

print("test confusion matrix")
cnn_test = confusion_matrix(y_test, predict(y_test_pred, threshold_test, fpr_test, tpr_test))
sns.heatmap(cnn_test,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
test confusion matrix
the maximum value of tpr*(1-fpr) 0.41708355860060553 for threshold 0.103
```

Out[81]:
```
Text(0.5, 1.0, 'Confusion Matrix\n')
```



In [82]:
```
from sklearn.metrics import classification_report
print("_" * 101)
print("Classification Report: \n")
print(classification_report(y_test,y_test_pred))
print("_" * 101)

```

```
_____________________________________________________________________________________________________
Classification Report:

              precision    recall  f1-score   support

           0       0.24      0.66      0.35      2303
           1       0.91      0.63      0.74     12697

   micro avg       0.63      0.63      0.63     15000
   macro avg       0.58      0.64      0.55     15000
weighted avg       0.81      0.63      0.68     15000

_____________________________________________________________________________________________________
```

SET 3 [AVG-W2V]

In [83]:
```
list_preprocessed_essays_xtr = []
for e in x_train['cleaned_essays'].values:
    list_preprocessed_essays_xtr.append(e.split())
```

In [84]:
```
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
preprocessed_essays_xtr_w2v=Word2Vec(list_preprocessed_essays_xtr,min_count=10,size=100,workers =12 )
```

```
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\smart_open\ssh.py:34: UserWarning: paramiko missing, opening SSH/SCP/
SFTP paths will be disabled.  `pip install paramiko` to suppress
  warnings.warn('paramiko missing, opening SSH/SCP/SFTP paths will be disabled.  `pip install paramiko` to suppress')
C:\Users\Tarun Makkar\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: detected Windows; aliasing chunkiz
e to chunkize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

In [85]:
```
# average Word2Vec
# compute average word2vec for each review.
preprocessed_essays_xtr_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['cleaned_essays']): # for each review/sentence
    vector = np.zeros(100) # as word vectors are of zero length
    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 preprocessed_essays_xtr_w2v.wv.vocab:
            vector += preprocessed_essays_xtr_w2v[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    preprocessed_essays_xtr_avg_w2v_vectors.append(vector)

print(len(preprocessed_essays_xtr_avg_w2v_vectors))
print(len(preprocessed_essays_xtr_avg_w2v_vectors[0]))
```

```
100%|██████████| 35000/35000 [00:31<00:00, 1127.99it/s]

35000
100
```

In [86]:
```
preprocessed_essays_xtest_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['cleaned_essays']): # for each review/sentence
    vector = np.zeros(100) # as word vectors are of zero length
    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 preprocessed_essays_xtr_w2v.wv.vocab:
            vector += preprocessed_essays_xtr_w2v[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    preprocessed_essays_xtest_avg_w2v_vectors.append(vector)

print(len(preprocessed_essays_xtest_avg_w2v_vectors))
print(len(preprocessed_essays_xtest_avg_w2v_vectors[0]))
```

```
100%|██████████| 15000/15000 [00:13<00:00, 1076.57it/s]

15000
100
```

In [87]:
```
list_preprocessed_title_xtr = []
for e in x_train['cleaned_title_text'].values:
    list_preprocessed_title_xtr.append(e.split())
```

In [88]:
```
preprocessed_title_xtr_w2v=Word2Vec(list_preprocessed_title_xtr,min_count=10,size=100,workers = 8)
```

In [89]:
```
preprocessed_title_xtr_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['cleaned_title_text']): # for each review/sentence
    vector = np.zeros(100) # as word vectors are of zero length
    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 preprocessed_title_xtr_w2v.wv.vocab:
            vector += preprocessed_title_xtr_w2v[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    preprocessed_title_xtr_avg_w2v_vectors.append(vector)

print(len(preprocessed_title_xtr_avg_w2v_vectors))
print(len(preprocessed_title_xtr_avg_w2v_vectors[0]))
```

```
100%|██████████| 35000/35000 [00:01<00:00, 31160.73it/s]

35000
100
```

In [90]:
```
preprocessed_title_xtest_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['cleaned_title_text']): # for each review/sentence
    vector = np.zeros(100) # as word vectors are of zero length
    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 preprocessed_title_xtr_w2v.wv.vocab:
            vector += preprocessed_title_xtr_w2v[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    preprocessed_title_xtest_avg_w2v_vectors.append(vector)

print(len(preprocessed_title_xtest_avg_w2v_vectors))
print(len(preprocessed_title_xtest_avg_w2v_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 15000/15000 [00:00<00:00, 31998.27it/s]

15000
100
```

In [91]:
```
from scipy.sparse import hstack
X_train_w2v=hstack((preprocessed_essays_xtr_avg_w2v_vectors,preprocessed_title_xtr_avg_w2v_vectors,x_train_clean_cat
                    ,x_train_quantity_std))
#X_cv_tfidf=hstack((preprocessed_essays_xcv_tfidf,preprocessed_title_xcv_tfidf,x_cv_clean_cat_ohe,x_cv_clean_subcat_

X_test_w2v=hstack((preprocessed_essays_xtest_avg_w2v_vectors,preprocessed_essays_xtest_avg_w2v_vectors,x_test_clean_

                   ,x_test_quantity_std))
```

In [92]:
```
print(X_train_w2v.shape)
print(X_test_w2v.shape)
```

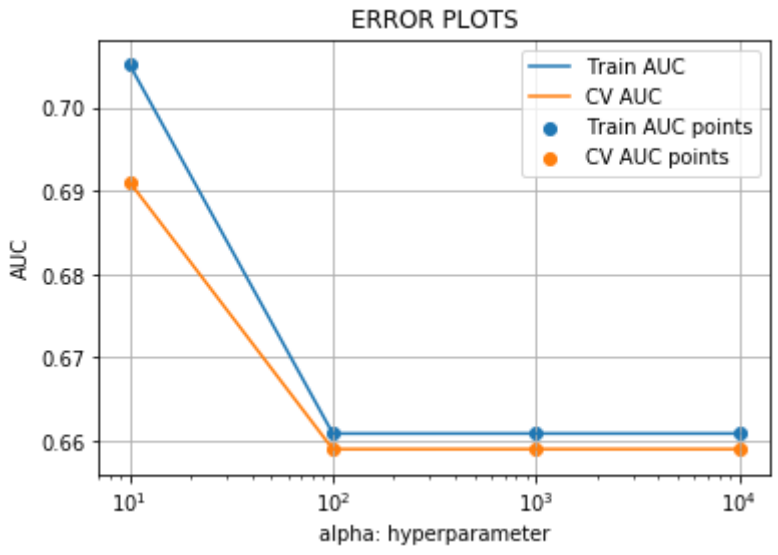
```
(35000, 303)
(15000, 303)
```

In [93]:
```
from sklearn.model_selection import RandomizedSearchCV
from sklearn.linear_model import SGDClassifier


clf_param_grid = {
    'alpha' : [10**-x for x in range(-6,5)],
    'penalty' : ['l1','l2']
}
SGD3 = SGDClassifier(class_weight='balanced')

estimator3 = RandomizedSearchCV(SGD3, param_distributions=clf_param_grid ,cv=10, verbose=2,scoring="roc_auc",n_jobs=
estimator3.fit(X_train_w2v,y_train)

print(estimator3.best_params_)
```

```
Fitting 10 folds for each of 10 candidates, totalling 100 fits

[Parallel(n_jobs=6)]: Using backend LokyBackend with 6 concurrent workers.
[Parallel(n_jobs=6)]: Done  29 tasks      | elapsed:    3.3s
[Parallel(n_jobs=6)]: Done 100 out of 100 | elapsed:   10.3s finished

{'penalty': 'l2', 'alpha': 0.001}
```

In [94]:
```
b3=estimator3.best_params_["alpha"]
p3=estimator3.best_params_["penalty"]
```

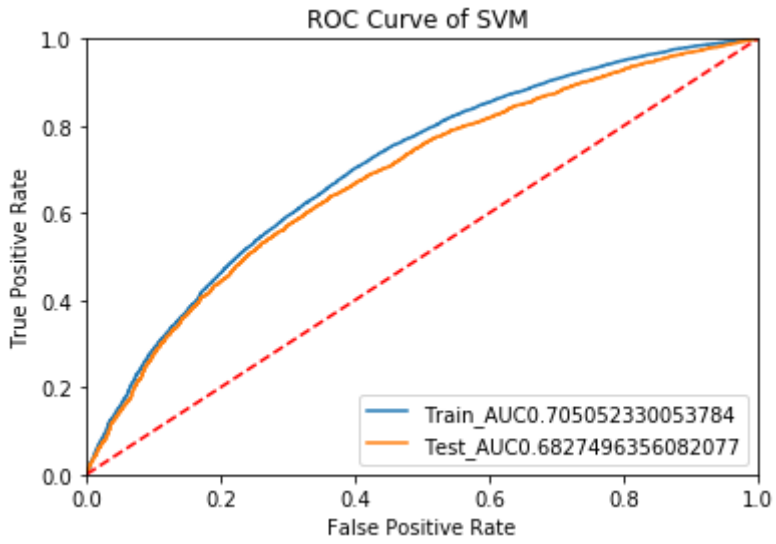
In [188]:
```
train_auc3= estimator3.cv_results_['mean_train_score'][estimator3.cv_results_['param_penalty']==p3]
train_auc_std3= estimator3.cv_results_['std_train_score'][estimator3.cv_results_['param_penalty']==p3]
cv_auc3 = estimator3.cv_results_['mean_test_score'][estimator3.cv_results_['param_penalty']==p3]
cv_auc_std3= estimator3.cv_results_['std_test_score'][estimator3.cv_results_['param_penalty']==p3]

plt.plot(clf_param_grid['alpha'][:4], train_auc3, label='Train AUC')

# this code is copied from here: https://stackoverflow.com/a/48803363/4084039
#plt.gca().fill_between(clf_param_grid['alpha'][:4],train_auc3 - train_auc_std3,train_auc3 + train_auc_std3,alpha=0.
# create a shaded area between [mean - std, mean + std]

plt.plot(clf_param_grid['alpha'][:4], cv_auc3, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803363/4084039
#plt.gca().fill_between(clf_param_grid['alpha'][:4],cv_auc3 - cv_auc_std3,cv_auc3 + cv_auc_std3,alpha=0.3,color='dar

plt.scatter(clf_param_grid['alpha'][:4], train_auc3, label='Train AUC points')
plt.scatter(clf_param_grid['alpha'][:4], cv_auc3, label='CV AUC points')
plt.xscale('log')
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [97]:
```
model_new3=SGDClassifier( penalty=p3, alpha= b3,class_weight='balanced')
model_new3.fit(X_train_w2v,y_train)
```

Out[97]:
```
SGDClassifier(alpha=0.001, average=False, class_weight='balanced',
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=None,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l2',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
```

In [175]:
```
score_roc_train = model_new3.decision_function(X_train_w2v)
fpr_train, tpr_train, threshold_train = roc_curve(y_train, sigmoid_v(score_roc_train))
roc_auc_train = auc(fpr_train, tpr_train)

score_roc_test = model_new3.decision_function(X_test_w2v)
fpr_test, tpr_test, threshold_test = roc_curve(y_test, sigmoid_v(score_roc_test))
roc_auc_test = auc(fpr_test, tpr_test)


plt.plot(fpr_train, tpr_train, label = "Train_AUC"+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test, tpr_test, label = "Test_AUC"+str(auc(fpr_test, tpr_test)))
plt.legend(loc = 'lower right')

plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])

plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('ROC Curve of SVM ')
plt.show()
```

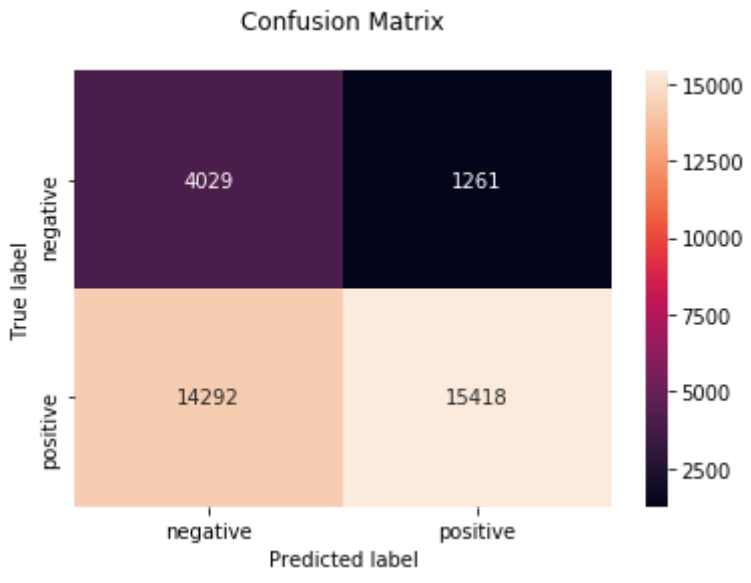


In [176]:
```
y_train_pred = model_new3.predict(X_train_w2v)
y_test_pred = model_new3.predict(X_test_w2v)
```

In [177]:
```
from sklearn.metrics import confusion_matrix

ax = plt.subplot()

print("Train confusion matrix")
cnn_train = confusion_matrix(y_train, predict(y_train_pred, threshold_train, fpr_train, tpr_train))
sns.heatmap(cnn_train,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.42251539297010354 for threshold 0.418
```

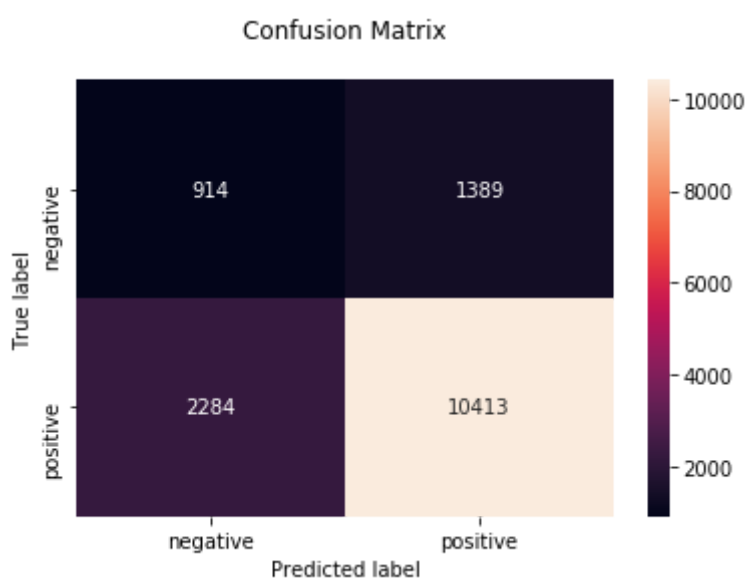
Out[177]: Text(0.5, 1.0, 'Confusion Matrix\n')



In [178]:
```
ax = plt.subplot()

print("test confusion matrix")
cnn_test = confusion_matrix(y_test, predict(y_test_pred, threshold_test, fpr_test, tpr_test))
sns.heatmap(cnn_test,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
test confusion matrix
the maximum value of tpr*(1-fpr) 0.4061383135864746 for threshold 0.628
```

Out[178]:
```
Text(0.5, 1.0, 'Confusion Matrix\n')
```



In [179]:
```
from sklearn.metrics import classification_report
print("_" * 101)
print("Classification Report: \n")
print(classification_report(y_test,y_test_pred))
print("_" * 101)
```

```
_____________________________________________________________________________________________________
Classification Report:

              precision    recall  f1-score   support

           0       0.29      0.40      0.33      2303
           1       0.88      0.82      0.85     12697

   micro avg       0.76      0.76      0.76     15000
   macro avg       0.58      0.61      0.59     15000
weighted avg       0.79      0.76      0.77     15000

_____________________________________________________________________________________________________
```

SET : 4 [TFIDF-W2V]

In [103]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

tfidf_model1 = TfidfVectorizer()
tfidf_model1.fit(x_train['cleaned_essays'])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model1.get_feature_names(), list(tfidf_model1.idf_)))
tfidf_words = set(tfidf_model1.get_feature_names())
```

In [104]:
```
# average Word2Vec
# compute average word2vec for each review.
preprocessed_essays_xtr_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['cleaned_essays']): # for each review/sentence
    vector = np.zeros(100) # 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(): # for each word in a review/sentence
        if (word in list(preprocessed_essays_xtr_w2v.wv.vocab)) and (word in tfidf_words):
            vec = preprocessed_essays_xtr_w2v[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for eac
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    preprocessed_essays_xtr_tfidf_w2v_vectors.append(vector)

print(len(preprocessed_essays_xtr_tfidf_w2v_vectors))
print(len(preprocessed_essays_xtr_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 35000/35000 [14:38<00:00, 39.86it/s]

35000
100
```

In [105]:
```
preprocessed_essays_xtest_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['cleaned_essays']): # for each review/sentence
    vector = np.zeros(100) # 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(): # for each word in a review/sentence
        if (word in list(preprocessed_essays_xtr_w2v.wv.vocab)) and (word in tfidf_words):
            vec = preprocessed_essays_xtr_w2v[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for eac
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    preprocessed_essays_xtest_tfidf_w2v_vectors.append(vector)

print(len(preprocessed_essays_xtest_tfidf_w2v_vectors))
print(len(preprocessed_essays_xtest_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 15000/15000 [06:15<00:00, 39.95it/s]

15000
100
```

In [106]:
```
# Similarly you can vectorize for title also
tfidf_model2 = TfidfVectorizer()
tfidf_model2.fit(x_train['cleaned_title_text'])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model2.get_feature_names(), list(tfidf_model1.idf_)))
tfidf_words = set(tfidf_model2.get_feature_names())
```

In [107]:
```
preprocessed_title_xtr_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['cleaned_title_text']): # for each review/sentence
    vector = np.zeros(100) # 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(): # for each word in a review/sentence
        if (word in list(preprocessed_title_xtr_w2v.wv.vocab)) and (word in tfidf_words):
            vec = preprocessed_title_xtr_w2v[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for eac
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    preprocessed_title_xtr_tfidf_w2v_vectors.append(vector)

print(len(preprocessed_title_xtr_tfidf_w2v_vectors))
print(len(preprocessed_title_xtr_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 35000/35000 [00:05<00:00, 6750.53it/s]

35000
100
```

In [108]:
```
preprocessed_title_xtest_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['cleaned_title_text']): # for each review/sentence
    vector = np.zeros(100) # 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(): # for each word in a review/sentence
        if (word in list(preprocessed_title_xtr_w2v.wv.vocab)) and (word in tfidf_words):
            vec = preprocessed_title_xtr_w2v[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for eac
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    preprocessed_title_xtest_tfidf_w2v_vectors.append(vector)

print(len(preprocessed_title_xtest_tfidf_w2v_vectors))
print(len(preprocessed_title_xtest_tfidf_w2v_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 15000/15000 [00:02<00:00, 6379.80it/s]

15000
100
```

In [109]:
```

X_train_tfidf_w2v=hstack((preprocessed_essays_xtr_tfidf_w2v_vectors,preprocessed_title_xtr_tfidf_w2v_vectors,x_train
                 ,x_train_quantity_std   ))
#X_cv_tfidf=hstack((preprocessed_essays_xcv_tfidf,preprocessed_title_xcv_tfidf,x_cv_clean_cat_ohe,x_cv_clean_subcat_

X_test_tfidf_w2v=hstack((preprocessed_essays_xtest_tfidf_w2v_vectors,preprocessed_essays_xtest_tfidf_w2v_vectors,x_t

                  ,x_test_quantity_std))
```

In [110]:
```
print(X_train_tfidf_w2v.shape)
print(X_test_tfidf_w2v.shape)
```

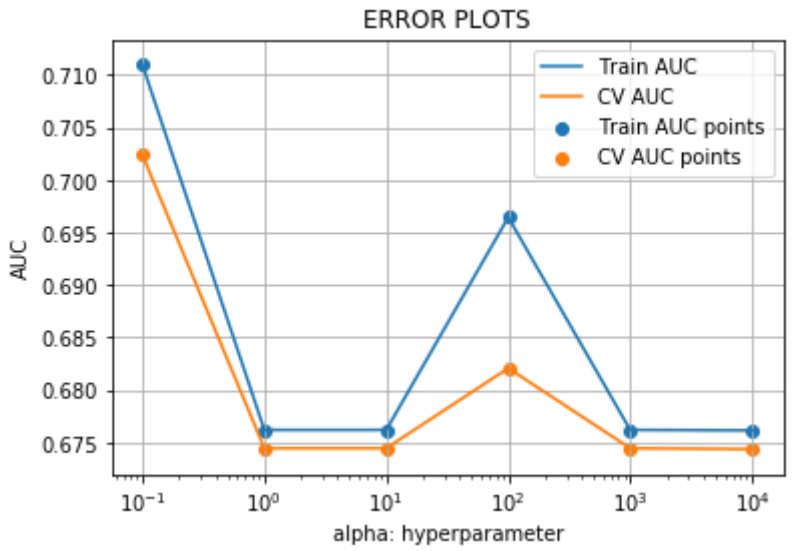
```
(35000, 303)
(15000, 303)
```

In [111]:
```
from sklearn.model_selection import RandomizedSearchCV
from sklearn.linear_model import SGDClassifier


clf_param_grid = {
    'alpha' : [10**-x for x in range(-6,6)],
    'penalty' : ['l1','l2']
}
SGD4 = SGDClassifier(class_weight='balanced')

estimator4 = RandomizedSearchCV(SGD4, param_distributions=clf_param_grid ,cv=10, verbose=2,scoring="roc_auc",n_jobs=
estimator4.fit(X_train_tfidf_w2v,y_train)

print(estimator4.best_params_)
```

```
Fitting 10 folds for each of 10 candidates, totalling 100 fits

[Parallel(n_jobs=4)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=4)]: Done  33 tasks      | elapsed:    6.0s
[Parallel(n_jobs=4)]: Done 100 out of 100 | elapsed:   13.8s finished

{'penalty': 'l2', 'alpha': 0.01}
```

In [112]:
```
b4=estimator4.best_params_["alpha"]
p4=estimator4.best_params_["penalty"]
```

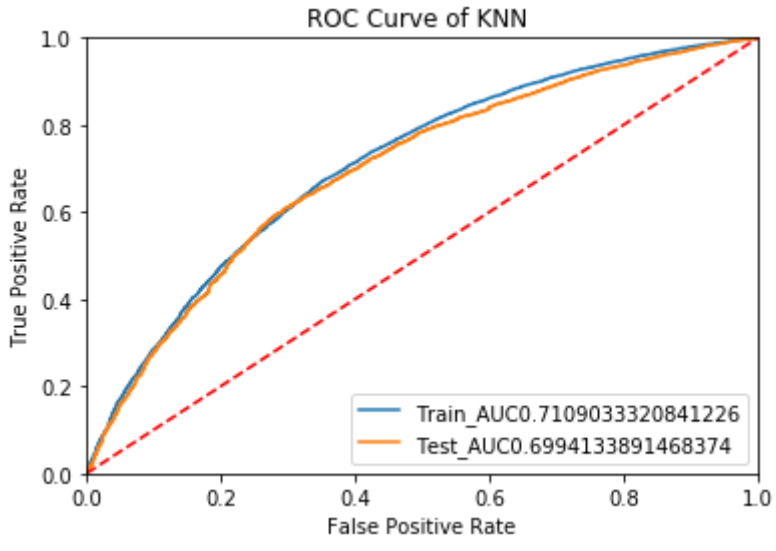
In [147]:
```
train_auc4= estimator4.cv_results_['mean_train_score'][estimator4.cv_results_['param_penalty']==p4]
train_auc_std4= estimator4.cv_results_['std_train_score'][estimator4.cv_results_['param_penalty']==p4]
cv_auc4 = estimator4.cv_results_['mean_test_score'][estimator4.cv_results_['param_penalty']==p4]
cv_auc_std4= estimator4.cv_results_['std_test_score'][estimator4.cv_results_['param_penalty']==p4]

ax=plt.subplot()
plt.plot(clf_param_grid['alpha'][:6], train_auc4, label='Train AUC')

# this code is copied from here: https://stackoverflow.com/a/48804464/4084049
#plt.gca().fill_between(clf_param_grid['alpha'][:6],train_auc4 - train_auc_std4,train_auc4 + train_auc_std4,alpha=0.
# create a shaded area between [mean - std, mean + std]

plt.plot(clf_param_grid['alpha'][:6], cv_auc4, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48804464/4084049
#plt.gca().fill_between(clf_param_grid['alpha'][:6],cv_auc4 - cv_auc_std4,cv_auc4 + cv_auc_std4,alpha=0.4,color='dar

plt.scatter(clf_param_grid['alpha'][:6], train_auc4, label='Train AUC points')
plt.scatter(clf_param_grid['alpha'][:6], cv_auc4, label='CV AUC points')
plt.axis([10**-1,10**5,0.675,0.710])
plt.xscale('log')
plt.axis('tight')
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [120]:
```
model_new4 = SGDClassifier( penalty=p4, alpha=b4,class_weight='balanced')
model_new4.fit(X_train_tfidf_w2v,y_train)
```

Out[120]:
```
SGDClassifier(alpha=0.01, average=False, class_weight='balanced',
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=None,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l2',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
```

In [180]:
```
score_roc_train = model_new4.decision_function(X_train_tfidf_w2v)
fpr_train, tpr_train, threshold_train = roc_curve(y_train, sigmoid_v(score_roc_train))
roc_auc_train = auc(fpr_train, tpr_train)

score_roc_test = model_new4.decision_function(X_test_tfidf_w2v)
fpr_test, tpr_test, threshold_test = roc_curve(y_test, sigmoid_v(score_roc_test))
roc_auc_test = auc(fpr_test, tpr_test)


plt.plot(fpr_train, tpr_train, label = "Train_AUC"+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test, tpr_test, label = "Test_AUC"+str(auc(fpr_test, tpr_test)))
plt.legend(loc = 'lower right')

plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])

plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('ROC Curve of KNN ')
plt.show()
```

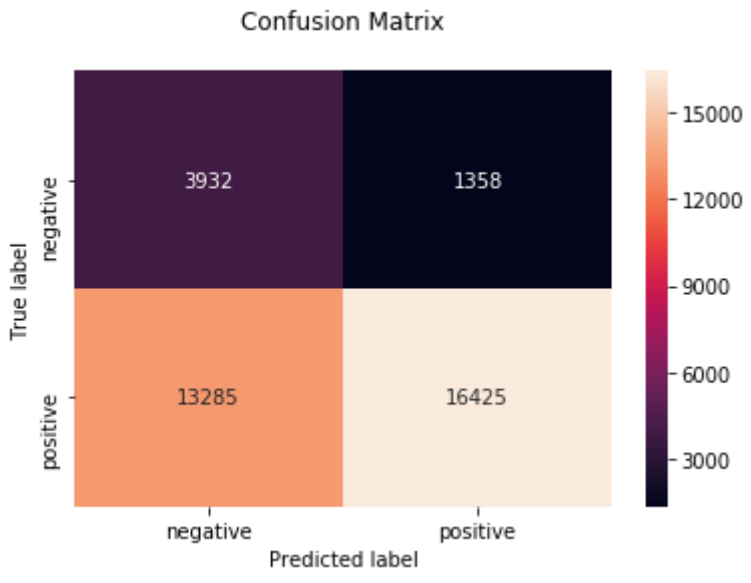


In [181]:
```
y_train_pred = model_new4.predict(X_train_tfidf_w2v)
y_test_pred = model_new4.predict(X_test_tfidf_w2v)
```

In [182]:
```
from sklearn.metrics import confusion_matrix

ax = plt.subplot()

print("Train confusion matrix")
cnn_train = confusion_matrix(y_train, predict(y_train_pred, threshold_train, fpr_train, tpr_train))
sns.heatmap(cnn_train,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.43533277892978056 for threshold 0.44
```

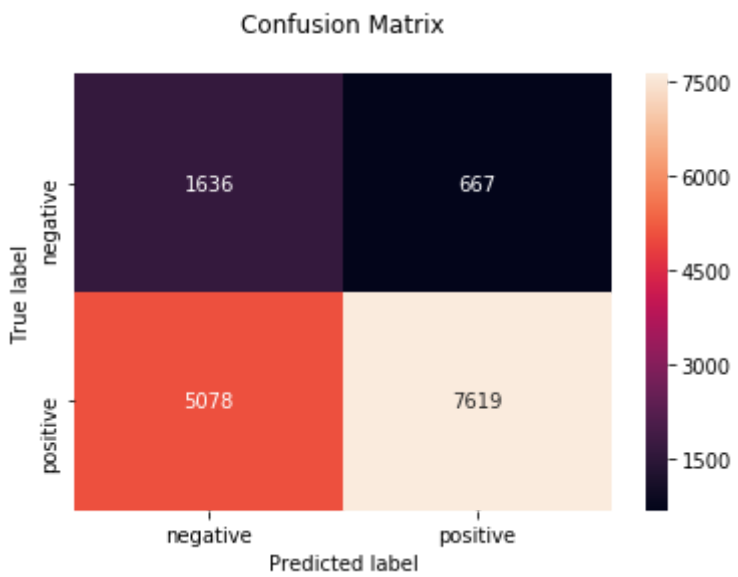
Out[182]: Text(0.5, 1.0, 'Confusion Matrix\n')



In [183]:
```
from sklearn.metrics import confusion_matrix

ax = plt.subplot()

print("test confusion matrix")
cnn_test = confusion_matrix(y_test, predict(y_test_pred, threshold_test, fpr_test, tpr_test))
sns.heatmap(cnn_test,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
test confusion matrix
the maximum value of tpr*(1-fpr) 0.4292029349967312 for threshold 0.481
```

Out[183]:
```
Text(0.5, 1.0, 'Confusion Matrix\n')
```



In [125]:
```
from sklearn.metrics import classification_report
print("_" * 101)
print("Classification Report: \n")
print(classification_report(y_test,y_test_pred))
print("_" * 101)
```

```
_____________________________________________________________________________________________________
Classification Report:

              precision    recall  f1-score   support

           0       0.24      0.71      0.36      2303
           1       0.92      0.60      0.73     12697

   micro avg       0.62      0.62      0.62     15000
   macro avg       0.58      0.66      0.54     15000
weighted avg       0.82      0.62      0.67     15000

_____________________________________________________________________________________________________
```

SET : 5 [Truncated SVD]

In [126]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer8 = TfidfVectorizer(min_df=10)
preprocessed_essays_xtr_tfidf = vectorizer8.fit_transform(x_train['cleaned_essays'])
print("Shape of matrix after one hot encodig ",preprocessed_essays_xtr_tfidf.shape)

preprocessed_essays_xtest_tfidf = vectorizer8.transform(x_test['cleaned_essays'])
print("Shape of matrix after one hot encodig ",preprocessed_essays_xtest_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (35000, 10483)
Shape of matrix after one hot encodig  (15000, 10483)
```

CHECK FOR VARIANCE EXPLAINED BY n_components and find best no. of component

In [127]:
```
from sklearn.decomposition import TruncatedSVD

svd = TruncatedSVD(n_components=6000, algorithm='randomized', n_iter=5, random_state=None, tol=0.0001)
svd.fit(preprocessed_essays_xtr_tfidf)

```

Out[127]:
```
TruncatedSVD(algorithm='randomized', n_components=6000, n_iter=5,
       random_state=None, tol=0.0001)
```

In [128]:
```
# List of explained variances
tsvd_var_ratios = svd.explained_variance_ratio_
np.cumsum(tsvd_var_ratios)
```

Out[128]:
```
array([0.00398695, 0.01444983, 0.02338521, ..., 0.95587842, 0.95589644,
       0.95591441])
```

In [129]:
```
# Create a function for find best no. of components
def select_n_components(var_ratio, goal_var: float):
    # Set initial variance explained so far
    total_variance = 0.0

    # Set initial number of features
    n_components = 0

    # For the explained variance of each feature:
    for explained_variance in var_ratio:


        total_variance += explained_variance


        n_components += 1


        if total_variance >= goal_var:

            break


    return n_components
```

Find total of 95% var explained

In [130]:
```
n_components=select_n_components(tsvd_var_ratios, 0.95)
n_components
```

Out[130]:
```
5706
```

In [131]:
```
from sklearn.decomposition import TruncatedSVD

svd_tr = TruncatedSVD(n_components=5722, algorithm='randomized', n_iter=5, random_state=None, tol=0.001)
svd_train = svd_tr.fit_transform(preprocessed_essays_xtr_tfidf)
svd_test = svd_tr.transform(preprocessed_essays_xtest_tfidf)
```

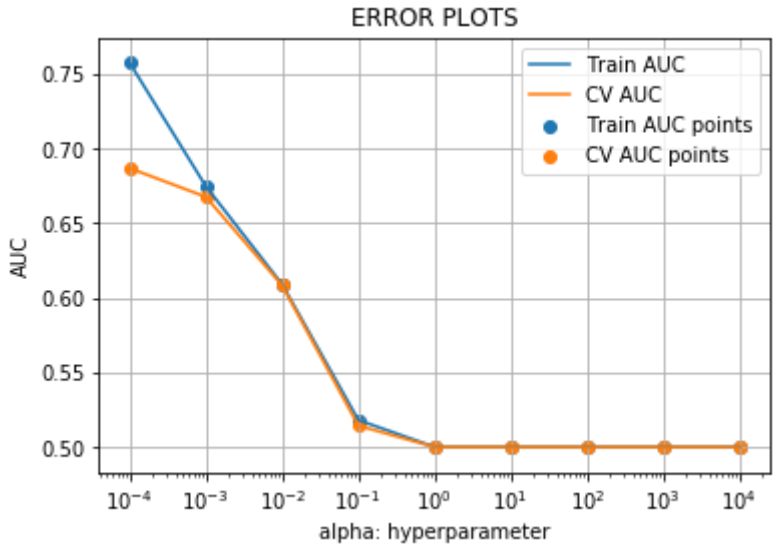
In [132]:
```
from scipy.sparse import hstack
X_train_s5=hstack((svd_train,x_train_clean_cat_ohe,x_train_clean_subcat_ohe,x_train_state_ohe,x_train_teacher_pre,x_
                   ,x_train_quantity_std )).tocsr()

X_test_s5=hstack((svd_test,x_test_clean_cat_ohe,x_test_clean_subcat_ohe, x_test_state_ohe, x_test_teacher_pre, x_tes

                   ,x_test_quantity_std)).tocsr()
```

In [133]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier


clf_param_grid = {
    'alpha' : [10**-x for x in range(-4,5)],
    'penalty' : ['l1','l2']
}
SGD5 = SGDClassifier(class_weight='balanced')

estimator5 = GridSearchCV(SGD5, param_grid=clf_param_grid ,cv=5, verbose=21, scoring="roc_auc",n_jobs=3)
estimator5.fit(X_train_s5,y_train)

print(estimator5.best_params_)
```

```
[Parallel(n_jobs=3)]: Using backend LokyBackend with 3 concurrent workers.
[Parallel(n_jobs=3)]: Done   1 tasks      | elapsed:  2.0min
[Parallel(n_jobs=3)]: Done   2 tasks      | elapsed:  2.0min
[Parallel(n_jobs=3)]: Done   3 tasks      | elapsed:  2.1min
[Parallel(n_jobs=3)]: Done   4 tasks      | elapsed:  3.0min
[Parallel(n_jobs=3)]: Done   5 tasks      | elapsed:  3.1min
[Parallel(n_jobs=3)]: Done   6 tasks      | elapsed:  3.1min
[Parallel(n_jobs=3)]: Done   7 tasks      | elapsed:  3.5min
[Parallel(n_jobs=3)]: Done   8 tasks      | elapsed:  4.0min
[Parallel(n_jobs=3)]: Done   9 tasks      | elapsed:  4.4min
[Parallel(n_jobs=3)]: Done  10 tasks      | elapsed:  5.2min
[Parallel(n_jobs=3)]: Done  11 tasks      | elapsed:  5.4min
[Parallel(n_jobs=3)]: Done  12 tasks      | elapsed:  5.4min
[Parallel(n_jobs=3)]: Done  13 tasks      | elapsed:  6.6min
[Parallel(n_jobs=3)]: Done  14 tasks      | elapsed:  6.7min
[Parallel(n_jobs=3)]: Done  15 tasks      | elapsed:  6.7min
[Parallel(n_jobs=3)]: Done  16 tasks      | elapsed:  7.0min
[Parallel(n_jobs=3)]: Done  17 tasks      | elapsed:  7.6min
```

In [134]:
```
b5=estimator5.best_params_["alpha"]
p5=estimator5.best_params_["penalty"]
```

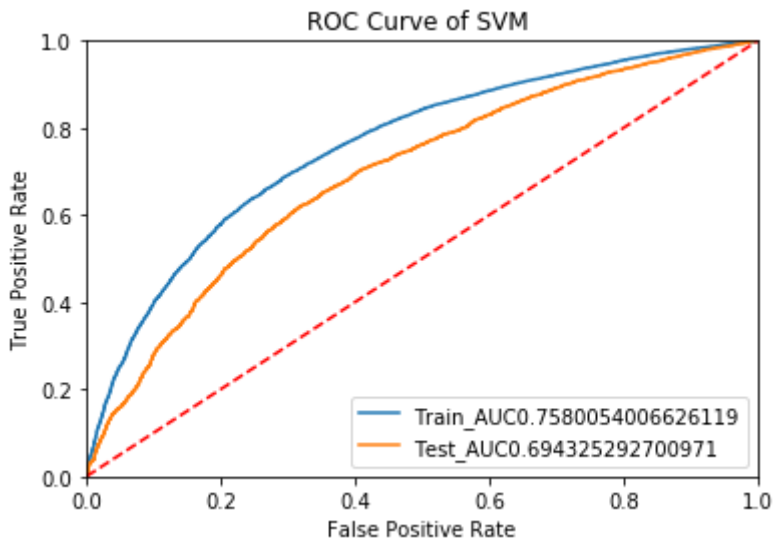
In [137]:
```
train_auc5= estimator5.cv_results_['mean_train_score'][estimator5.cv_results_['param_penalty']==p5]
train_auc_std5= estimator5.cv_results_['std_train_score'][estimator5.cv_results_['param_penalty']==p5]
cv_auc5 = estimator5.cv_results_['mean_test_score'][estimator5.cv_results_['param_penalty']==p5]
cv_auc_std5= estimator5.cv_results_['std_test_score'][estimator5.cv_results_['param_penalty']==p5]

ax=plt.subplot()
plt.plot(clf_param_grid['alpha'][:9], train_auc5, label='Train AUC')

# this code is copied from here: https://stackoverflow.com/a/58805565/5085059
#plt.gca().fill_between(clf_param_grid['alpha'][:9],train_auc5 - train_auc_std5,train_auc5 + train_auc_std5,alpha=0.
# create a shaded area between [mean - std, mean + std]

plt.plot(clf_param_grid['alpha'][:9], cv_auc5, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/58805565/5085059
#plt.gca().fill_between(clf_param_grid['alpha'][:9],cv_auc5 - cv_auc_std5,cv_auc5 + cv_auc_std5,alpha=0.5,color='dar

plt.scatter(clf_param_grid['alpha'][:9], train_auc5, label='Train AUC points')
plt.scatter(clf_param_grid['alpha'][:9], cv_auc5, label='CV AUC points')
plt.axis([10**-2,10**5,0.675,0.710])
plt.xscale('log')
plt.axis('tight')
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [138]:
```
model_new5=SGDClassifier( penalty=p5, alpha=b5,class_weight='balanced')
model_new5.fit(X_train_s5,y_train)
```

Out[138]:
```
SGDClassifier(alpha=0.0001, average=False, class_weight='balanced',
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=None,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l1',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
```

In [184]:
```
score_roc_train = model_new5.decision_function(X_train_s5)
fpr_train, tpr_train, threshold_train = roc_curve(y_train, sigmoid_v(score_roc_train))
roc_auc_train = auc(fpr_train, tpr_train)

score_roc_test = model_new5.decision_function(X_test_s5)
fpr_test, tpr_test, threshold_test = roc_curve(y_test, sigmoid_v(score_roc_test))
roc_auc_test = auc(fpr_test, tpr_test)


plt.plot(fpr_train, tpr_train, label = "Train_AUC"+str(auc(fpr_train, tpr_train)))
plt.plot(fpr_test, tpr_test, label = "Test_AUC"+str(auc(fpr_test, tpr_test)))
plt.legend(loc = 'lower right')

plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])

plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('ROC Curve of SVM ')
plt.show()
```

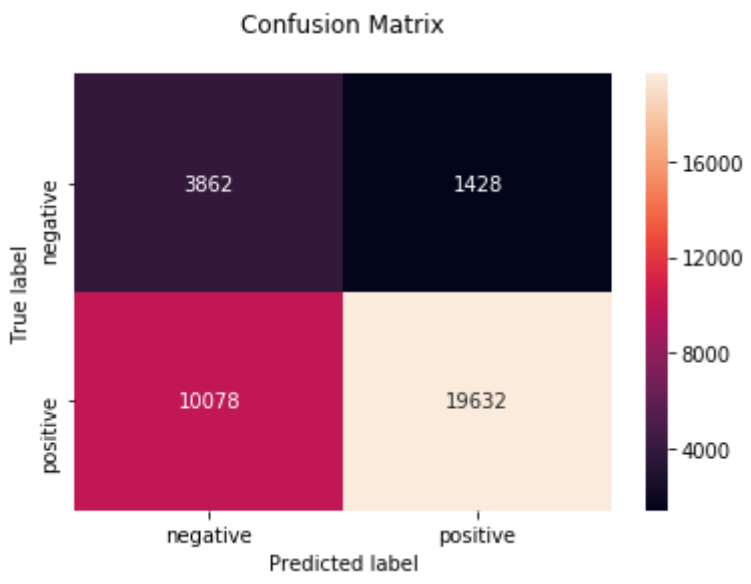


In [185]:
```
y_train_pred = model_new5.predict(X_train_s5)
y_test_pred = model_new5.predict(X_test_s5)
```

In [186]:
```
from sklearn.metrics import confusion_matrix

ax = plt.subplot()

print("Train confusion matrix")
cnn_train = confusion_matrix(y_train, predict(y_train_pred, threshold_train, fpr_train, tpr_train))
sns.heatmap(cnn_train,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.484920253057438 for threshold 0.482
```

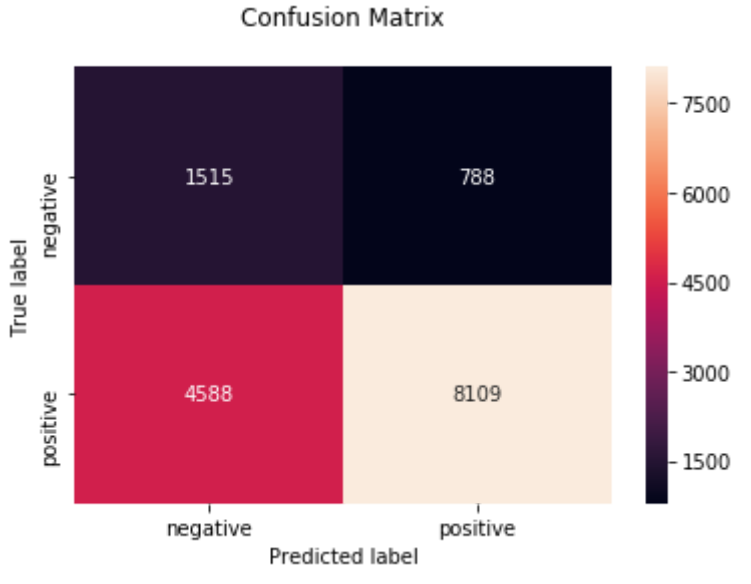
Out[186]:
```
Text(0.5, 1.0, 'Confusion Matrix\n')
```



In [187]:
```
from sklearn.metrics import confusion_matrix

ax = plt.subplot()

print("test confusion matrix")
cnn_test = confusion_matrix(y_test, predict(y_test_pred, threshold_test, fpr_test, tpr_test))
sns.heatmap(cnn_test,annot = True,ax=ax,fmt='d')
ax.set_xlabel('Predicted label')
ax.set_ylabel('True label')
ax.xaxis.set_ticklabels(['negative','positive'])
ax.yaxis.set_ticklabels(['negative','positive'])
plt.title('Confusion Matrix\n')
```

```
test confusion matrix
the maximum value of tpr*(1-fpr) 0.42276687703999477 for threshold 0.514
```

Out[187]:
```
Text(0.5, 1.0, 'Confusion Matrix\n')
```



In [146]:
```
from sklearn.metrics import classification_report
print("_" * 101)
print("Classification Report: \n")
print(classification_report(y_test,y_test_pred))
print("_" * 101)

```

```
_____________________________________________________________________________________________________
Classification Report:

              precision    recall  f1-score   support

           0       0.25      0.66      0.36      2303
           1       0.91      0.64      0.75     12697

   micro avg       0.64      0.64      0.64     15000
   macro avg       0.58      0.65      0.56     15000
weighted avg       0.81      0.64      0.69     15000

_____________________________________________________________________________________________________
```

In [151]:
```
from prettytable import PrettyTable

pretty = PrettyTable()

pretty.field_names = ['Vectorizer','Model','Hyperparameter_alpha','Hyperparameter_penalty','AUC']

pretty.add_row(['BOW','BRUTE',b1,p1,'0.71'])
pretty.add_row(['TF-IDF','BRUTE',b2,p2,'0.69'])
pretty.add_row(['AVG W2V','BRUTE',b3,p3,'0.68'])
pretty.add_row(['TFIDF WEIGHTED','BRUTE',b4,p4,'0.69'])
pretty.add_row(['TRUNCATED SVD','BRUTE',b5,p5,'0.69'])
```

In [152]:
```
print(pretty)
```

```
+----------------+-------+----------------------+------------------------+------+
|   Vectorizer   | Model | Hyperparameter_alpha | Hyperparameter_penalty | AUC  |
+----------------+-------+----------------------+------------------------+------+
|      BOW       | BRUTE |         0.1          |           l2           | 0.71 |
|     TF-IDF     | BRUTE |        0.001         |           l2           | 0.69 |
|    AVG W2V     | BRUTE |        0.001         |           l2           | 0.68 |
| TFIDF WEIGHTED | BRUTE |         0.01         |           l2           | 0.69 |
| TRUNCATED SVD  | BRUTE |        0.0001        |           l1           | 0.69 |
+----------------+-------+----------------------+------------------------+------+
```