DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there are three main problems they need to solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible
- How to increase the consistency of project vetting across different volunteers to improve the experience for teachers
- How to focus volunteer time on the applications that need the most assistance

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy`

- Literature & Writing, Social Sciences

Feature	Description
project_resource_summary	An explanation of the resources needed for the project. **Example:** • My students need hands on literacy materials to manage sensory needs!
project_essay_1	First application essay*
project_essay_2	Second application essay*
project_essay_3	Third application essay*
project_essay_4	Fourth application essay*
project_submitted_datetime	Datetime when project application was submitted. **Example:** 2016-04-28 12:43:56.245
teacher_id	A unique identifier for the teacher of the proposed project. **Example:** bdf8baa8fedef6bfeec7ae4ff1c15c56
teacher_prefix	Teacher's title. One of the following enumerated values: • nan • Dr. • Mr. • Mrs. • Ms. • Teacher.
teacher_number_of_previously_posted_projects	Number of project applications previously submitted by the same teacher. **Example:** 2

* See the section **Notes on the Essay Data** for more details about these features.

Additionally, the resources.csv data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

Feature	Description
id	A project_id value from the train.csv file. **Example:** p036502
description	Desciption of the resource. **Example:** Tenor Saxophone Reeds, Box of 25
quantity	Quantity of the resource required. **Example:** 3
price	Price of the resource required. **Example:** 9.95

Note: Many projects require multiple resources. The id value corresponds to a project_id in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

Label	Description
project_is_approved	A binary flag indicating whether DonorsChoose approved the project. A value of 0 indicates the project was not approved, and a value of 1 indicates the project was approved.

Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

- __project_essay_1:__ "Introduce us to your classroom"
- __project_essay_2:__ "Tell us more about your students"
- __project_essay_3:__ "Describe how your students will use the materials you're requesting"
- __project_essay_3:__ "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

your neighborhood, and your school are all helpful."

- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

  For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

In [2]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [3]:

```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

In [4]:

```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.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']
```

In [5]:

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

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

Out[5]:

	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

1.2 preprocessing of `project_subject_categories`

In [6]:

```
catogories = list(project_data['project_subject_categories'].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
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", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Science"
            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())

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

from collections import Counter
my_counter = Counter()
for word in project_data['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]))
```

1.3 preprocessing of `project_subject_subcategories`

In [7]:

```
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 = ""
    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","&", "Science"
            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())

project_data['clean_subcategories'] = sub_cat_list
project_data.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 project_data['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]))
```

1.3 Text preprocessing

In [8]:

```
# 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)
```

In [9]:

```
project_data.head(2)
```

Out[9]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Gra
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Gra

In [10]:

```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [11]:

```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
ucational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l
east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O
f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves
to get together and celebrate. Around Halloween there is a whole school parade to show off the bea
utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by
the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t
he hard work put in during the school year, with a dunk tank being the most popular activity.My st
udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged
chairs. As I will only have a total of ten in the classroom and not enough for each student to hav
e an individual one, they will be used in a variety of ways. During independent reading time they
will be used as special chairs students will each use on occasion. I will utilize them in place of
chairs at my small group tables during math and reading times. The rest of the day they will be us
ed by the students who need the highest amount of movement in their life in order to stay focused
on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki
Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i
n group with me on the Hokki Stools, they are always moving, but at the same time doing their
work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta
ken. There are always students who head over to the kidney table to get one of the stools who are
disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours
a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th
e same time. These stools will help students to meet their 60 minutes a day of movement by
allowing them to activate their core muscles for balance while they sit. For many of my students,
these chairs will take away the barrier that exists in schools for a child who can't sit
still.nannan
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of
desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work
hard to create a warm inviting themed room for my students look forward to coming to each day.\r\n
\r\nMy class is made up of 28 wonderfully unique boys and girls of mixed races in
Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free a
nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept, which is very uniq
ue as there are no walls separating the classrooms. These 9 and 10 year-old students are very eage
r learners; they are like sponges, absorbing all the information and experiences and keep on wanti
ng more.With these resources such as the comfy red throw pillows and the whimsical nautical hangin
g decor and the blue fish nets, I will be able to help create the mood in our classroom setting to
be one of a themed nautical environment. Creating a classroom environment is very important in the
success in each and every child's education. The nautical photo props will be used with each child
as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pic
tures of each child with them, have them developed, and then hung in our classroom ready for their
first day of 4th grade.  This kind gesture will set the tone before even the first day of school!
The nautical thank you cards will be used throughout the year by the students as they create thank
you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our
classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of
my own pocket on resources to get our classroom ready. Please consider helping with this project t
o make our new school year a very successful one. Thank you!nannan
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out
```

```
for my students. I teach in a Title I school where most of the students receive free or reduced pr
ice lunch.  Despite their disabilities and limitations, my students love coming to school and come
eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr
oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able
to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev
elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l
earn through games, my kids don't want to sit and do worksheets. They want to learn to count by ju
mping and playing. Physical engagement is the key to our success. The number toss and color and sh
ape mats can make that happen. My students will forget they are doing work and just have the fun a
6 year old deserves.nannan
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The grea
t teacher inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% Af
rican-American, making up the largest segment of the student body. A typical school in Dallas is m
ade up of 23.2% African-American students. Most of the students are on free or reduced lunch. We a
ren't receiving doctors, lawyers, or engineers children from rich backgrounds or neighborhoods. As
an educator I am inspiring minds of young children and we focus not only on academics but one smar
t, effective, efficient, and disciplined students with good character.In our classroom we can util
ize the Bluetooth for swift transitions during class. I use a speaker which doesn't amplify the so
und enough to receive the message. Due to the volume of my speaker my students can't hear videos o
r books clearly and it isn't making the lessons as meaningful. But with the bluetooth speaker my s
tudents will be able to hear and I can stop, pause and replay it at any time.\r\nThe cart will all
ow me to have more room for storage of things that are needed for the day and has an extra part to
it I can use.  The table top chart has all of the letter, words and pictures for students to learn
about different letters and it is more accessible.nannan
==================================================
```

In [12]:

```python
# 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 [13]:

```python
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations. \r\n\r\nThe materials we have are the ones I seek out
for my students. I teach in a Title I school where most of the students receive free or reduced pr
ice lunch.  Despite their disabilities and limitations, my students love coming to school and come
eager to learn and explore.Have you ever felt like you had ants in your pants and you needed to gr
oove and move as you were in a meeting? This is how my kids feel all the time. The want to be able
to move as they learn or so they say.Wobble chairs are the answer and I love then because they dev
elop their core, which enhances gross motor and in Turn fine motor skills. \r\nThey also want to l
earn through games, my kids do not want to sit and do worksheets. They want to learn to count by j
umping and playing. Physical engagement is the key to our success. The number toss and color and s
hape mats can make that happen. My students will forget they are doing work and just have the fun
a 6 year old deserves.nannan
==================================================
```

In [14]:

```python
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cogniti
ve delays, gross/fine motor delays, to autism. They are eager beavers and always strive to work th
eir hardest working past their limitations.     The materials we have are the ones I seek out for
my students. I teach in a Title I school where most of the students receive free or reduced price
lunch.  Despite their disabilities and limitations, my students love coming to school and come eag
er to learn and explore.Have you ever felt like you had ants in your pants and you needed to groov
e and move as you were in a meeting? This is how my kids feel all the time. The want to be able to
move as they learn or so they say.Wobble chairs are the answer and I love then because they develo
p their core, which enhances gross motor and in Turn fine motor skills.   They also want to learn t
hrough games, my kids do not want to sit and do worksheets. They want to learn to count by jumping
and playing. Physical engagement is the key to our success. The number toss and color and shape ma
ts can make that happen. My students will forget they are doing work and just have the fun a 6 yea
r old deserves.nannan
```

In [15]:

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

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitiv
e delays gross fine motor delays to autism They are eager beavers and always strive to work their
hardest working past their limitations The materials we have are the ones I seek out for my studen
ts I teach in a Title I school where most of the students receive free or reduced price lunch
Despite their disabilities and limitations my students love coming to school and come eager to lea
rn and explore Have you ever felt like you had ants in your pants and you needed to groove and mov
e as you were in a meeting This is how my kids feel all the time The want to be able to move as th
ey learn or so they say Wobble chairs are the answer and I love then because they develop their co
re which enhances gross motor and in Turn fine motor skills They also want to learn through games
my kids do not want to sit and do worksheets They want to learn to count by jumping and playing Ph
ysical engagement is the key to our success The number toss and color and shape mats can make that
happen My students will forget they are doing work and just have the fun a 6 year old deserves nan
nan
```

In [16]:

```
# https://gist.github.com/sebleier/554280
# 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", "you've",
\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having',
'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', '
while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during',
'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under'
, 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll'
, 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "do
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
"mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn',
"wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [17]:

```
# Combining all the above stundents
from tqdm import tqdm
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)
    # 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 [01:32<00:00, 1177.08it/s]
```

In [18]:

```
# after preprocesing
preprocessed_essays[20000]
```

Out[18]:

```
'my kindergarten students varied disabilities ranging speech language delays cognitive delays gros
s fine motor delays autism they eager beavers always strive work hardest working past limitations
the materials ones i seek students i teach title i school students receive free reduced price lunc
h despite disabilities limitations students love coming school come eager learn explore have ever
felt like ants pants needed groove move meeting this kids feel time the want able move learn say w
obble chairs answer i love develop core enhances gross motor turn fine motor skills they also want
learn games kids not want sit worksheets they want learn count jumping playing physical engagement
key success the number toss color shape mats make happen my students forget work fun 6 year old de
serves nannan'
```

1.4 Preprocessing of `project_title`

In [19]:

```
print(project_data['project_title'].values[20000])
print("="*50)
print(project_data['project_title'].values[99999])
print("="*50)
```

```
We Need To Move It While We Input It!
==================================================
Inspiring Minds by Enhancing the Educational Experience
==================================================
```

In [20]:

```
sent1 = decontracted(project_data['project_title'].values[2000])
print(sent1)
print("="*50)
```

```
Steady Stools for Active Learning
==================================================
```

In [21]:

```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_title = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent1 = decontracted(sentance)
    sent1 = sent1.replace('\\r', ' ')
    sent1 = sent1.replace('\\"', ' ')
    sent1 = sent1.replace('\\n', ' ')
    sent1 = re.sub('[^A-Za-z0-9]+', ' ', sent1)
    # https://gist.github.com/sebleier/554280
    sent1 = ' '.join(e for e in sent1.split() if e.lower() not in stopwords)
    preprocessed_title.append(sent1.lower().strip())
```

```
100%|██████████| 109248/109248 [00:03<00:00, 28817.17it/s]
```

In [22]:

```
project_catogories = list(project_data['project_grade_category'].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

project_cat_list = []
for i in project_catogories:
    temp = ""
    for j in i.split(','):
        j = j.replace(' ','_') # we are placeing all the ' '(space)
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('-','_')
    project_cat_list.append(temp.strip())

project_data['clean_projectcategories'] = project_cat_list
project_data.drop(['project_grade_category'], axis=1, inplace=True)

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

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

In [23]:

```
project_data['clean_projectcategories']=project_data['clean_projectcategories'].str.lower()
```

In [24]:

```
#for teacher prefix
#https://www.geeksforgeeks.org/python-pandas-dataframe-fillna-to-replace-null-values-in-dataframe/
project_data["teacher_prefix"].fillna( method ='ffill', inplace = True)
```

In [25]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [26]:

```
project_data['clean_essays'] = preprocessed_essays
project_data.drop(['project_essay_1'], axis=1, inplace=True)
project_data.drop(['project_essay_2'], axis=1, inplace=True)
project_data.drop(['project_essay_3'], axis=1, inplace=True)
project_data.drop(['project_essay_4'], axis=1, inplace=True)
```

1. count the total no of words in essay and make new feature column and add it to dataset
2. same for titles

In [27]:

```
X_essa=[]
for i in project_data['clean_essays']:
    b=len(i.split())
    X_essa.append(b)
project_data['no_essay']=X_essa
```

In [28]:

```
project_data['clean_titles'] = preprocessed_title
```

In [29]:

```
X_tri=[]
for i in project_data['clean_titles']:
    b=len(i.split())
    X_tri.append(b)
project_data['notitlewords']=X_tri
```

In [30]:

```
project_data.drop(['project_title'] , axis=1 , inplace=True)
```

Sentiment Score of each of the essay

WHAT IS SEMANTIC ANALYSIS?
Sentiment Analysis, or Opinion Mining, is a sub-field of Natural Language Processing (NLP) that tries to identify and extract opinions within a given text. The aim of sentiment analysis is to gauge the attitude, sentiments, evaluations, attitudes and emotions of a speaker/writer based on the computational treatment of subjectivity in a text.
https://medium.com/analytics-vidhya/simplifying-social-media-sentiment-analysis-using-vader-in-python-f9e6ec6fc52f

In [31]:

```
import nltk
nltk.download('vader_lexicon')
```

```
[nltk_data] Error loading vader_lexicon: <urlopen error [Errno 11001]
[nltk_data]     getaddrinfo failed>
```

Out[31]:

```
False
```

In [32]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer


sid = SentimentIntensityAnalyzer()
```

In [33]:

```
ss_neg=[]
ss_pos=[]
ss_neu=[]
ss_compound=[]
for i in project_data['clean_essays']:
    ss = sid.polarity_scores(i)
    ss_neg.append(ss['neg'])
    ss_neu.append(ss['neu'])
    ss_pos.append(ss['pos'])
    ss_compound.append(ss['compound'])
```

In [34]:

```
project_data['ss_neg']=ss_neg
project_data['ss_pos']=ss_pos
project_data['ss_neu']=ss_neu
project_data['ss_compound']=ss_compound
```

In [35]:

```
project_data.head(2)
```

Out[35]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My opp beg
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	My to h

2 rows × 23 columns

In [36]:

```
project_data.count()
```

Out[36]:

```
Unnamed: 0                                      109248
id                                              109248
teacher_id                                      109248
teacher_prefix                                  109248
school_state                                    109248
project_submitted_datetime                      109248
project_resource_summary                        109248
teacher_number_of_previously_posted_projects    109248
project_is_approved                             109248
clean_categories                                109248
clean_subcategories                             109248
essay                                           109248
clean_projectcategories                         109248
price                                           109248
quantity                                        109248
clean_essays                                    109248
no_essay                                        109248
clean_titles                                    109248
notitlewords                                    109248
ss_neg                                          109248
ss_pos                                          109248
ss_neu                                          109248
ss_compound                                     109248
dtype: int64
```

2. Support Vector Machines

2.1 Splitting data into Train and cross validation(or test): Stratified Sampling

In [37]:

```
y=project_data['project_is_approved'].values
project_data.drop(['project_is_approved'] , axis=1, inplace = True)
X=project_data
```

In [38]:

```
X.head(2)
```

Out[38]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	pro
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My opp beg
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	My to h

2 rows × 22 columns

SPLITTING USING TRAIN_TEST_SPLIT

In [39]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [40]:

```
#Shape of training , test and cross validation data
print("X_train {0} ||  Y_train {1}".format(X_train.shape,y_train.shape))
print("X_cv {0}   || Y_cv {1}".format(X_cv.shape,y_cv.shape))
print("X_test {0} || Y_test {1}".format(X_test.shape,y_test.shape))
```

```
X_train (49041, 22) ||  Y_train (49041,)
X_cv (24155, 22)   || Y_cv (24155,)
X_test (36052, 22) || Y_test (36052,)
```

2.2 Make Data Model Ready: encoding numerical, categorical features

2.2.1 vectorizing categorical data

In [41]:

```
vectorizer_clean = CountVectorizer()
vectorizer_clean.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_ccat_ohe = vectorizer_clean.transform(X_train['clean_categories'].values)
X_cv_ccat_ohe = vectorizer_clean.transform(X_cv['clean_categories'].values)
X_test_ccat_ohe = vectorizer_clean.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_ccat_ohe.shape, y_train.shape)
print(X_cv_ccat_ohe.shape, y_cv.shape)
print(X_test_ccat_ohe.shape, y_test.shape)
print(vectorizer_clean.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language',
'math_science', 'music_arts', 'specialneeds', 'warmth']
====================================================================================================
```

In [42]:

```
 vectorizer_clsub = CountVectorizer()
vectorizer_clsub.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_cscat_ohe = vectorizer_clsub.transform(X_train['clean_subcategories'].values)
X_cv_cscat_ohe = vectorizer_clsub.transform(X_cv['clean_subcategories'].values)
X_test_cscat_ohe = vectorizer_clsub.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_cscat_ohe.shape, y_train.shape)
print(X_cv_cscat_ohe.shape, y_cv.shape)
print(X_test_cscat_ohe.shape, y_test.shape)
print(vectorizer_clsub.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'environmentalscience',
'esl', 'extracurricular', 'financialliteracy', 'foreignlanguages', 'gym_fitness',
'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'm
athematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socia
lsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
===================================================================================================
```

In [43]:

```
#FOR SCHOOL STATE
vectorizer_school = CountVectorizer()
vectorizer_school.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_school.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer_school.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer_school.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_school.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'k
s', 'ky', 'la', 'ma', '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 [44]:

```
vectorizer_cp = CountVectorizer()
vectorizer_cp.fit(X_train['clean_projectcategories'].values) # fit has to happen only on train
data

# we use the fitted CountVectorizer to convert the text to vector
X_train_cpro_ohe = vectorizer_cp.transform(X_train['clean_projectcategories'].values)
X_cv_cpro_ohe = vectorizer_cp.transform(X_cv['clean_projectcategories'].values)
X_test_cpro_ohe = vectorizer_cp.transform(X_test['clean_projectcategories'].values)

print("After vectorizations")
print(X_train_cpro_ohe.shape, y_train.shape)
print(X_cv_cpro_ohe.shape, y_cv.shape)
print(X_test_cpro_ohe.shape, y_test.shape)
print(vectorizer_cp.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
====================================================================================================
```

In [45]:

```
vectorizer_teacher = CountVectorizer()
vectorizer_teacher.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_ohe = vectorizer_teacher.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer_teacher.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer_teacher.transform(X_test['teacher_prefix'].values)

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer_teacher.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 5) (49041,)
(24155, 5) (24155,)
(36052, 5) (36052,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================================
```

2.2.2 Vectorizing Numerical Features

PRICE

In [46]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['price'].values.reshape(-1,1))

X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(-1,1))
X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(-1,1))
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

QUANTITY

In [47]:

```
import warnings
warnings.filterwarnings('ignore')
```

In [48]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['quantity'].values.reshape(-1,1))

X_train_quan_norm = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
X_cv_quan_norm = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
X_test_quan_norm = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_quan_norm.shape, y_train.shape)
print(X_cv_quan_norm.shape, y_cv.shape)
print(X_test_quan_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

NO of previous posted project

In [49]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

X_train_tno_norm = normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].va
lues.reshape(-1,1))
X_cv_tno_norm = normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.r
eshape(-1,1))
X_test_tno_norm =
normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_tno_norm.shape, y_train.shape)
print(X_cv_tno_norm.shape, y_cv.shape)
print(X_test_tno_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

No of words in titles

In [50]:

```
from sklearn.preprocessing import Normalizer
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['notitlewords'].values.reshape(-1,1))

X_train_titleno_norm = normalizer.transform(X_train['notitlewords'].values.reshape(-1,1))
X_cv_titleno_norm = normalizer.transform(X_cv['notitlewords'].values.reshape(-1,1))
X_test_titleno_norm = normalizer.transform(X_test['notitlewords'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_titleno_norm.shape, y_train.shape)
print(X_cv_titleno_norm.shape, y_cv.shape)
print(X_test_titleno_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

No of words in essay

In [51]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['no_essay'].values.reshape(-1,1))

X_train_essayno_norm = normalizer.transform(X_train['no_essay'].values.reshape(-1,1))
X_cv_essayno_norm = normalizer.transform(X_cv['no_essay'].values.reshape(-1,1))
X_test_essayno_norm = normalizer.transform(X_test['no_essay'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_essayno_norm.shape, y_train.shape)
print(X_cv_essayno_norm.shape, y_cv.shape)
print(X_test_essayno_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

Normalize semantic analysis

In [52]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['ss_neg'].values.reshape(-1,1))

X_train_ssneg_norm = normalizer.transform(X_train['ss_neg'].values.reshape(-1,1))
```

```
X_cv_ssneg_norm = normalizer.transform(X_cv['ss_neg'].values.reshape(-1,1))
X_test_ssneg_norm = normalizer.transform(X_test['ss_neg'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_ssneg_norm.shape, y_train.shape)
print(X_cv_ssneg_norm.shape, y_cv.shape)
print(X_test_ssneg_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

In [53]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['ss_pos'].values.reshape(-1,1))

X_train_sspos_norm = normalizer.transform(X_train['ss_pos'].values.reshape(-1,1))
X_cv_sspos_norm = normalizer.transform(X_cv['ss_pos'].values.reshape(-1,1))
X_test_sspos_norm = normalizer.transform(X_test['ss_pos'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_sspos_norm.shape, y_train.shape)
print(X_cv_sspos_norm.shape, y_cv.shape)
print(X_test_sspos_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

In [54]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['ss_compound'].values.reshape(-1,1))

X_train_sscompound_norm = normalizer.transform(X_train['ss_compound'].values.reshape(-1,1))
X_cv_sscompound_norm = normalizer.transform(X_cv['ss_compound'].values.reshape(-1,1))
X_test_sscompound_norm = normalizer.transform(X_test['ss_compound'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_sscompound_norm.shape, y_train.shape)
print(X_cv_sscompound_norm.shape, y_cv.shape)
print(X_test_sscompound_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

In [55]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['ss_neu'].values.reshape(-1,1))

X_train_ssneu_norm = normalizer.transform(X_train['ss_neu'].values.reshape(-1,1))
X_cv_ssneu_norm = normalizer.transform(X_cv['ss_neu'].values.reshape(-1,1))
X_test_ssneu_norm = normalizer.transform(X_test['ss_neu'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_ssneu_norm.shape, y_train.shape)
print(X_cv_ssneu_norm.shape, y_cv.shape)
print(X_test_ssneu_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

2.3 Make Data Model Ready: encoding eassay, and project_title

BAG OF WORDS

In [56]:

```
from sklearn.feature_extraction.text import CountVectorizer
vectorizerb = CountVectorizer(min_df=10, max_features=5000)
vectorizerb.fit(X_train['clean_essays'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizerb.transform(X_train['clean_essays'].values)
X_cv_essay_bow = vectorizerb.transform(X_cv['clean_essays'].values)
X_test_essay_bow = vectorizerb.transform(X_test['clean_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
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
====================================================================================================
```

In [57]:

```
# BOW project titles
from sklearn.feature_extraction.text import CountVectorizer
vectorizert = CountVectorizer(min_df=10, max_features=5000)
vectorizert.fit(X_train['clean_titles'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_bow = vectorizert.transform(X_train['clean_titles'].values)
X_cv_titles_bow = vectorizert.transform(X_cv['clean_titles'].values)
X_test_titles_bow = vectorizert.transform(X_test['clean_titles'].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
(49041, 1966) (49041,)
(24155, 1966) (24155,)
(36052, 1966) (36052,)
====================================================================================================
```

TFIDF

In [58]:

```
#FOR ESSAY
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tf = TfidfVectorizer(min_df=10)
vectorizer_tf.fit(X_train['clean_essays'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer_tf.transform(X_train['clean_essays'].values)
X_cv_essay_tfidf = vectorizer_tf.transform(X_cv['clean_essays'].values)
X_test_essay_tfidf = vectorizer_tf.transform(X_test['clean_essays'].values)

print(X_train_essay_tfidf.shape)
print(X_cv_essay_tfidf.shape)
print(X_test_essay_tfidf.shape)
```

```
(49041, 12125)
(24155, 12125)
(36052, 12125)
```

In [59]:

```
#for project title
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_selection import SelectKBest, chi2

vectorizer_t = TfidfVectorizer(min_df=10, max_features=5000)
vectorizer_t.fit(X_train['clean_titles'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_tfidf = vectorizer_t.transform(X_train['clean_titles'].values)
X_cv_titles_tfidf = vectorizer_t.transform(X_cv['clean_titles'].values)
X_test_titles_tfidf = vectorizer_t.transform(X_test['clean_titles'].values)
print("Train shape:",X_train_titles_tfidf.shape)
print("CV shape:",X_cv_titles_tfidf.shape)
print("Test shape:",X_test_titles_tfidf.shape)
```

```
Train shape: (49041, 1966)
CV shape: (24155, 1966)
Test shape: (36052, 1966)
```

In [60]:

```
from tqdm import tqdm_notebook as tq
```

In [61]:

```
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tq(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!")
    print("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')
```

```
Loading Glove Model


Done. 1917494  words loaded!
```

In [62]:

```
words_train_essays = []

for i in X_train['clean_essays']:
    words_train_essays.extend(i.split(' '))
```

In [63]:

```
## Find the total number of words in the Train data of Essays.

print("all the words in the corpus", len(words_train_essays))
```

```
all the words in the corpus 7432789
```

In [64]:

```
## Find the unique words in this set of words

words_train_essay = set(words_train_essays)
print("the unique words in the corpus", len(words_train_essay))
```

```
the unique words in the corpus 41218
```

In [65]:

```
## Find the words present in both Glove Vectors as well as our corpus.

inter_words = set(model.keys()).intersection(words_train_essay)

print("The number of words that are present in both glove vectors and our corpus are {} which \
is nearly {}% ".format(len(inter_words), np.round((float(len(inter_words))/len(words_train_essay))
*100)))
```

```
The number of words that are present in both glove vectors and our corpus are 37804 which is
nearly 92.0%
```

In [66]:

```
words_corpus_train_essay = {}

words_glove = set(model.keys())

for i in words_train_essay:
    if i in words_glove:
        words_corpus_train_essay[i] = model[i]

print("word 2 vec length", len(words_corpus_train_essay))
```

```
word 2 vec length 37804
```

In [67]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/

import pickle
with open('glove_vectors', 'wb') as f:
    pickle.dump(words_corpus_train_essay, f)
```

In [68]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

train essay for avg w2v

In [69]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_train = [];

for sentence in tq(X_train['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # 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 glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train.append(vector)

print(len(avg_w2v_vectors_train))
print(len(avg_w2v_vectors_train[0]))
```

```
49041
300
```

TEST TITLES

In [70]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_test = [];

for sentence in tq(X_test['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # 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 glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test.append(vector)

print(len(avg_w2v_vectors_test))
print(len(avg_w2v_vectors_test[0]))
```

```
36052
300
```

CROSS VALIDATION

In [71]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_cv = [];
```

```
avg_w2v_vectors_cv = [];

for sentence in tq(X_cv['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # 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 glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_cv.append(vector)

print(len(avg_w2v_vectors_cv))
print(len(avg_w2v_vectors_cv[0]))
```

```
24155
300
```

TRAIN TITLES

In [72]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tq(X_train['clean_titles']): # for each title
    vector = np.zeros(300) # 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 glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_train.append(vector)

print(len(avg_w2v_vectors_titles_train))
print(len(avg_w2v_vectors_titles_train[0]))
```

```
49041
300
```

TEST TITLES

In [73]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tq(X_test['clean_titles']): # for each title
    vector = np.zeros(300) # 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 glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_test.append(vector)

print(len(avg_w2v_vectors_titles_test))
print(len(avg_w2v_vectors_titles_test[0]))
```

```
36052
300
```

CROSS VALIDATION TITLES

In [74]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tq(X_cv['clean_titles']): # for each title
    vector = np.zeros(300) # 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 glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_cv.append(vector)

print(len(avg_w2v_vectors_titles_cv))
print(len(avg_w2v_vectors_titles_cv[0]))
```

```
24155
300
```

TFIDF Weighted W2V

In [75]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['clean_essays'])
# 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())
```

In [76]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tq(X_train['clean_essays']): # 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(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_train.append(vector)

print(len(tfidf_w2v_vectors_train))
print(len(tfidf_w2v_vectors_train[0]))
```

```
49041
300
```

In [77]:

```
# compute average word2vec for each review.
#test essay

tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tq(X_test['clean_essays']): # 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(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_test.append(vector)

print(len(tfidf_w2v_vectors_test))
print(len(tfidf_w2v_vectors_test[0]))
```

```
36052
300
```

In [78]:

```
# compute average word2vec for each review.
#cross validation essay
tfidf_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tq(X_cv['clean_essays']): # 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(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_cv.append(vector)

print(len(tfidf_w2v_vectors_cv))
print(len(tfidf_w2v_vectors_cv[0]))
```

```
24155
300
```

TRAIN TITLES

In [79]:

```
tfidf_w2v_vectors_titles_train = [];

for sentence in tq(X_train['clean_titles']): # 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(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_train.append(vector)

print(len(tfidf_w2v_vectors_titles_train))
print(len(tfidf_w2v_vectors_titles_train[0]))
```

```
49041
300
```

In [80]:

```
# compute average word2vec for each review.
#test titles
tfidf_w2v_vectors_titles_test = [];

for sentence in tq(X_test['clean_titles']): # 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(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_test.append(vector)

print(len(tfidf_w2v_vectors_titles_test))
print(len(tfidf_w2v_vectors_titles_test[0]))
```

```
36052
300
```

In [81]:

```
# compute average word2vec for each review.
#cross validation titles
tfidf_w2v_vectors_titles_cv = [];

for sentence in tq(X_cv['clean_titles']): # 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(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_titles_cv.append(vector)

print(len(tfidf_w2v_vectors_titles_cv))
print(len(tfidf_w2v_vectors_titles_cv[0]))
```

```
24155
300
```

2.4 Appling Support Vector Machines on different kind of featurization as mentioned in the instructions

Apply Support Vector Machines on different kind of featurization as mentioned in the instructions
For Every model that you work on make sure you do the step 2 and step 3 of instrucations

SGDClassifier ON BAG OF WORDS

COMBINING ALL FEATURES

In [82]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_trs1 = hstack((X_train_ccat_ohe , X_train_cscat_ohe , X_train_state_ohe, X_train_cpro_ohe , X_tra
in_teacher_ohe, X_train_essay_bow, X_train_titles_bow , X_train_price_norm, X_train_quan_norm , X_t
rain_tno_norm)).tocsr()
X_cvs1 = hstack((X_cv_ccat_ohe , X_cv_cscat_ohe , X_cv_state_ohe, X_cv_cpro_ohe , X_cv_teacher_ohe,
X_cv_essay_bow, X_cv_titles_bow , X_cv_price_norm, X_cv_quan_norm , X_cv_tno_norm)).tocsr()
X_tes1 = hstack((X_test_ccat_ohe , X_test_cscat_ohe , X_test_state_ohe, X_test_cpro_ohe , X_test_te
acher_ohe, X_test_essay_bow, X_test_titles_bow , X_test_price_norm, X_test_quan_norm ,
X_test_tno_norm)).tocsr()
```

In [83]:

```
print("Final Data matrix")
print(X_trs1.shape, y_train.shape)
print(X_cvs1.shape, y_cv.shape)
print(X_tes1.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 7068) (49041,)
(24155, 7068) (24155,)
(36052, 7068) (36052,)
====================================================================================================
```

In [84]:

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

    t = threshould[np.argmax(fpr*(1-tpr))]

    # (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 [85]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
```

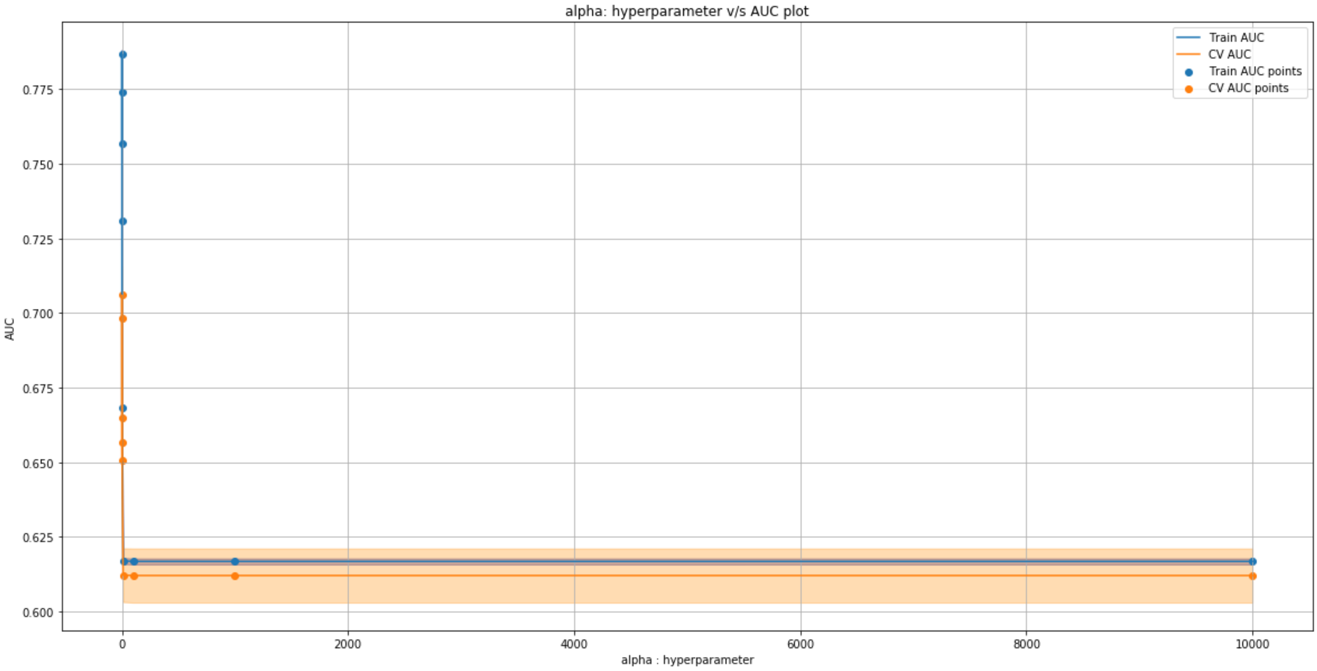
L2 REGULARIZATION

In [86]:

```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')

parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_trs1, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [87]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



Observation:-

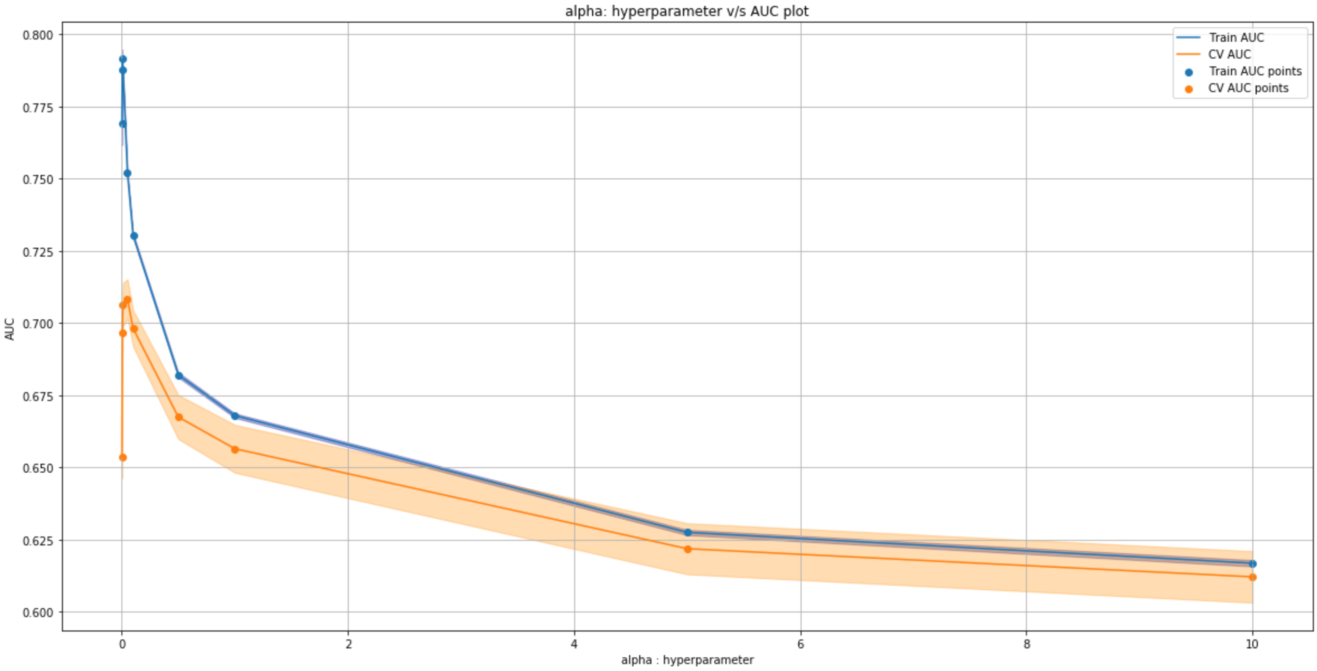
1. from the above graph we cannot determine the hyperparameter so we try different value of alpha

In [88]:

```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')

parameters = {'alpha':[0.001,0.005,0.01,0.05,0.1,0.5,1,5,10]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_trs1, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [89]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```

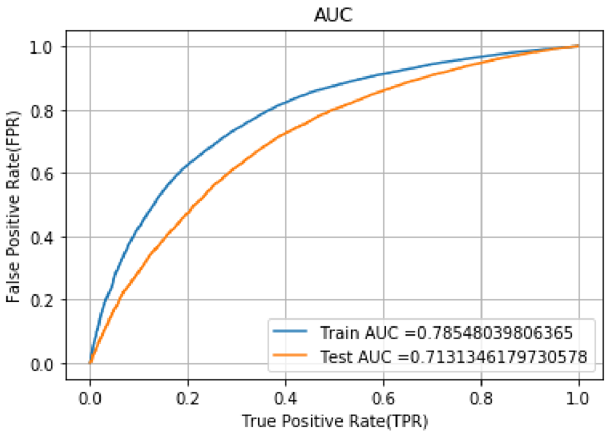


In [90]:

```
best_alpha=0.01
```

In [91]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l2', alpha=best_alpha,class_weight='balanced')

model.fit(X_trs1, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_trs1)
y_test_pred = model.decision_function(X_tes1)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



CONFUSION MATRIX

In [92]:

```
conf_matr_df_train_bow = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

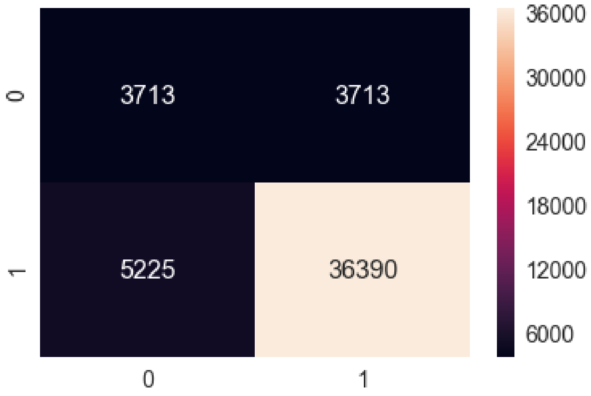
```
the maximum value of tpr*(1-fpr) 0.25 for threshold -0.638
```

In [93]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_bow, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[93]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949fa119b0>
```



L1 REGULARIZATION

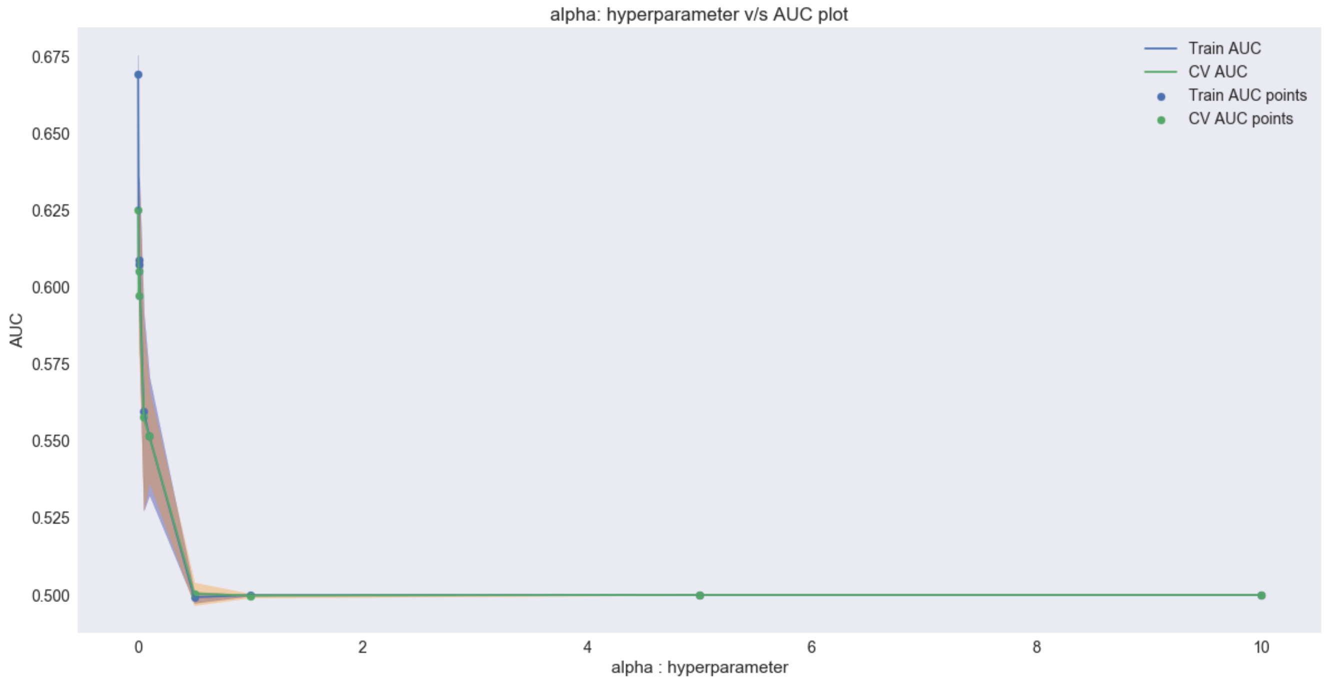
In [94]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[0.001,0.005,0.01,0.05,0.1,0.5,1,5,10]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_trs1, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

```
cv_auc_std= clf.cv_results_['std_test_score']
```

In [95]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



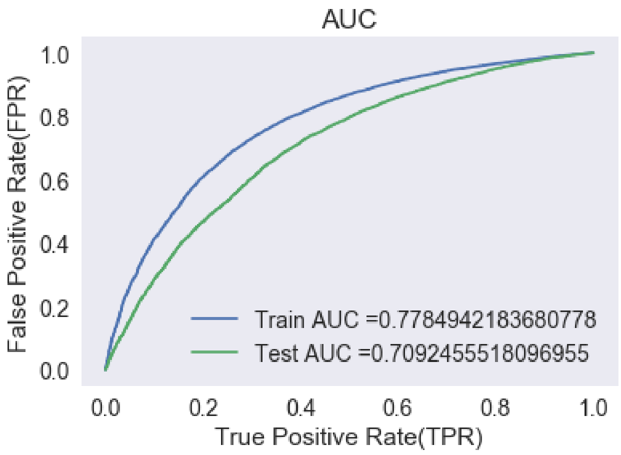
In [96]:

```
best_alpha=0.01
```

In [97]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l2', alpha=best_alpha,class_weight='balanced')

model.fit(X_trs1, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_trs1)
y_test_pred = model.decision_function(X_tes1)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



OBSERVATION

1. we compare both the result with l1 and l2 regularization
2. both of the regularization gives nearly same AUC curve.

CONFUSION MATRIX

In [98]:

```
conf_matr_df_train_bow = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

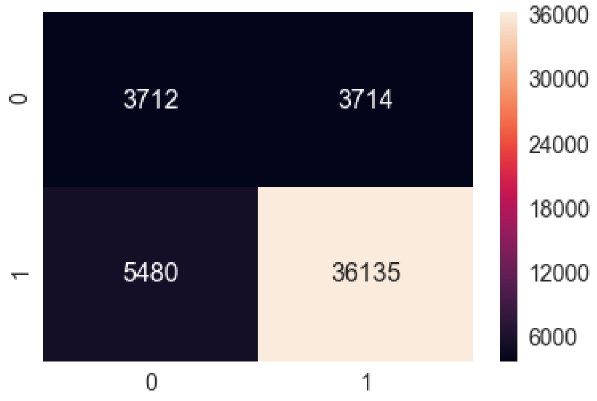
```
the maximum value of tpr*(1-fpr) 0.2499999818661462 for threshold -0.325
```

In [99]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_bow, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[99]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949fcbaa90>
```



SET-2 categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay

In [100]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_tfidf = hstack((X_train_ccat_ohe , X_train_cscat_ohe , X_train_state_ohe, X_train_cpro_ohe , X
_train_teacher_ohe, X_train_essay_tfidf, X_train_titles_tfidf , X_train_price_norm,
X_train_quan_norm , X_train_tno_norm)).tocsr()
X_cr_tfidf = hstack((X_cv_ccat_ohe , X_cv_cscat_ohe , X_cv_state_ohe, X_cv_cpro_ohe , X_cv_teacher_
ohe, X_cv_essay_tfidf, X_cv_titles_tfidf , X_cv_price_norm, X_cv_quan_norm , X_cv_tno_norm)).tocsr(
)
X_te_tfidf = hstack((X_test_ccat_ohe , X_test_cscat_ohe , X_test_state_ohe, X_test_cpro_ohe , X_tes
t_teacher_ohe, X_test_essay_tfidf, X_test_titles_tfidf , X_test_price_norm, X_test_quan_norm , X_te
st_tno_norm)).tocsr()
```

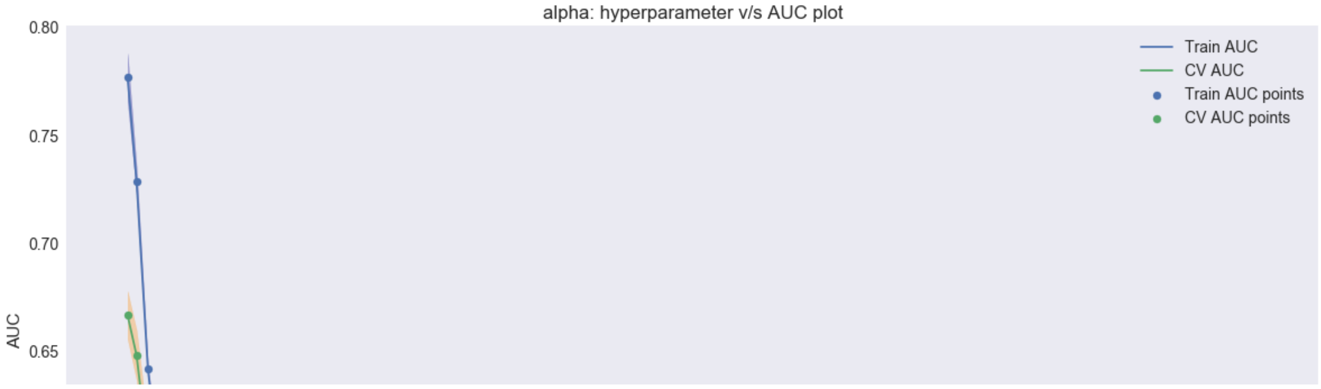
L2 REGULARIZATION

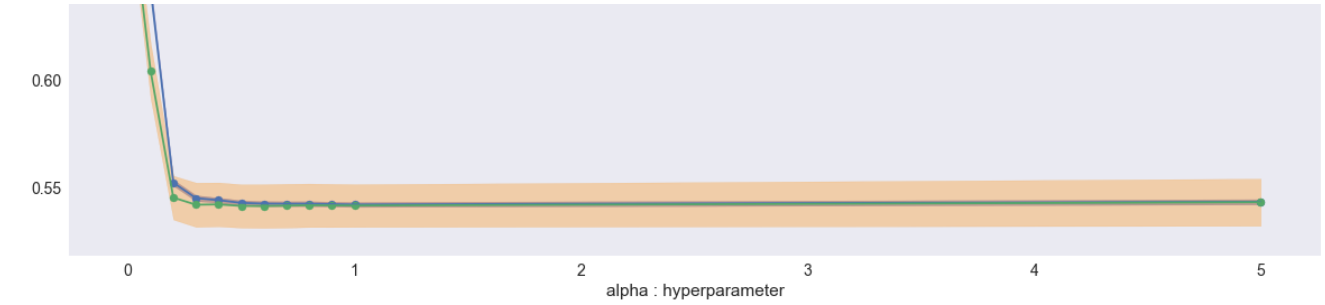
In [101]:

```
sv = SGDClassifier(loss='hinge', penalty='l2')

parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_tfidf, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [102]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```





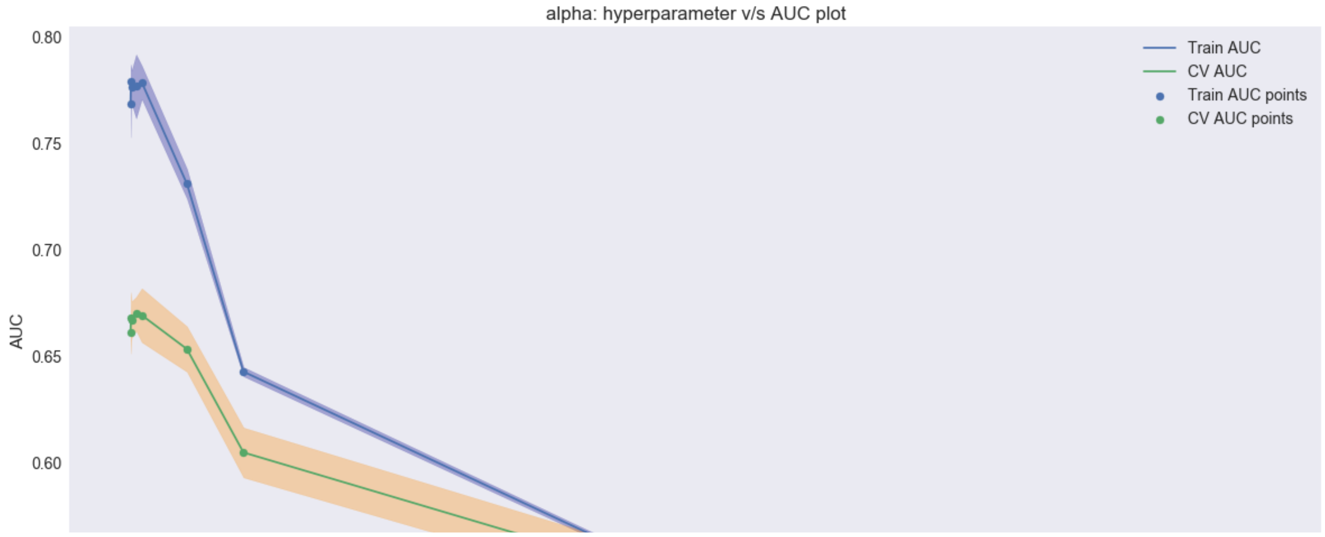
After 0.1 train and cv score becomes nearly same so we try different values less than 0.1

In [103]:

```
sv = SGDClassifier(loss='hinge', penalty='l2')

parameters = {'alpha':[0.0001,0.0005,0.001,0.005,0.01, 0.05, 0.1,0.5,1]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_tfidf, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [104]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



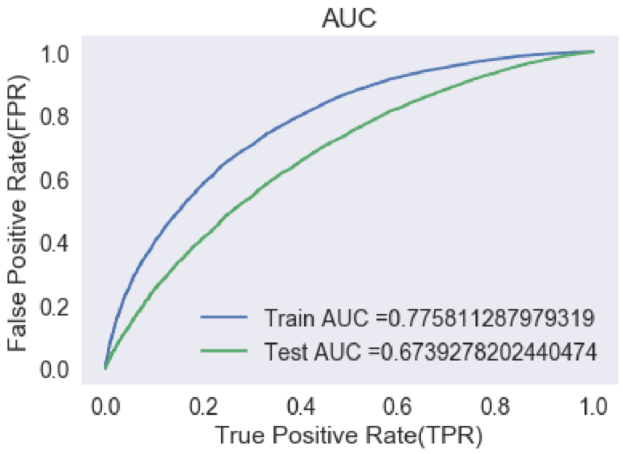
0.55
0.0
0.2
0.4
0.6
0.8
1.0
alpha : hyperparameter

In [105]:

```
best_alpha=0.005
```

In [107]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l2', alpha=best_alpha)

model.fit(X_tr_tfidf, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_tr_tfidf)
y_test_pred = model.decision_function(X_te_tfi)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



CONFUSION MATRIX

In [109]:

```
conf_matr_df_train_ifidf = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

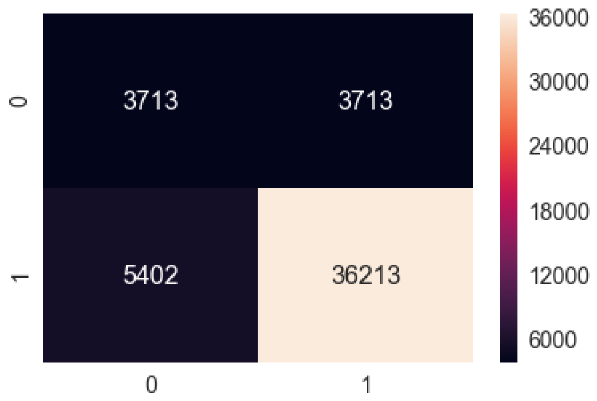
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.0
```

In [110]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_ifidf, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[110]:
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x19375ffec50>
```



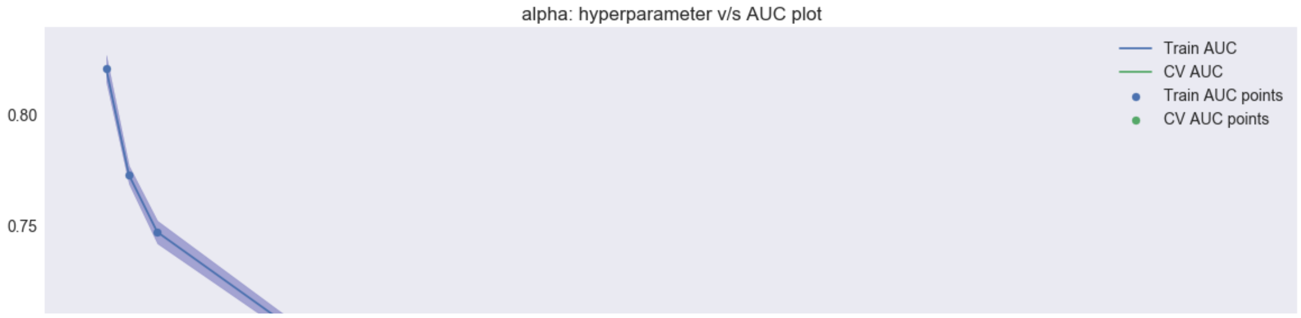
L1 Regularization

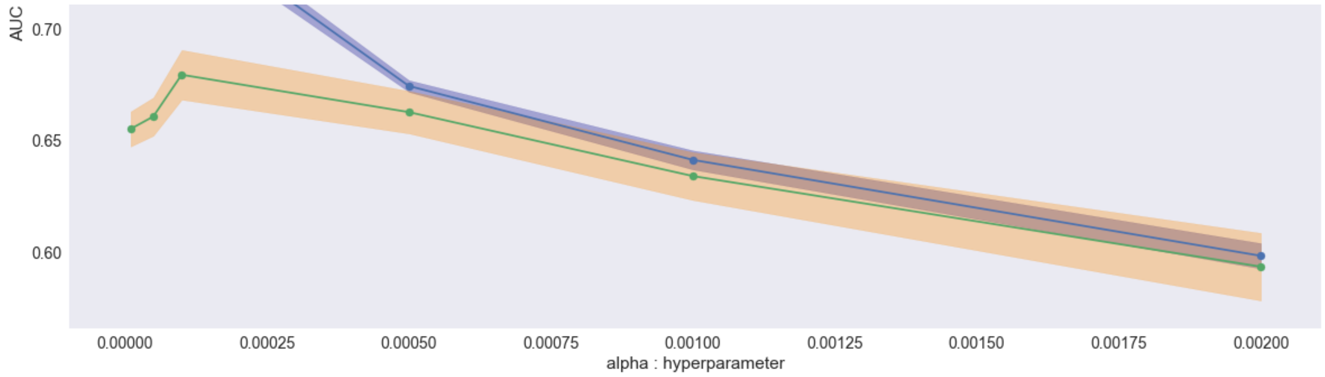
```
In [112]:
```

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[0.00001,0.00005,0.0001,0.0005,0.001,0.002]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_tfidf, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

```
In [113]:
```

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



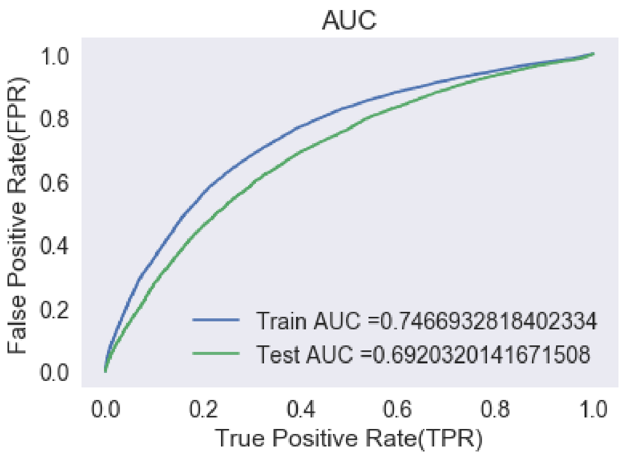


In [114]:

```
best_alpha=0.0001
```

In [115]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l1', alpha=best_alpha,class_weight='balanced')

model.fit(X_tr_tfidf, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_tr_tfidf)
y_test_pred = model.decision_function(X_te_tfidf)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



CONFUSION MATRIX

In [116]:

```
conf_matr_df_train_ifidf_l1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

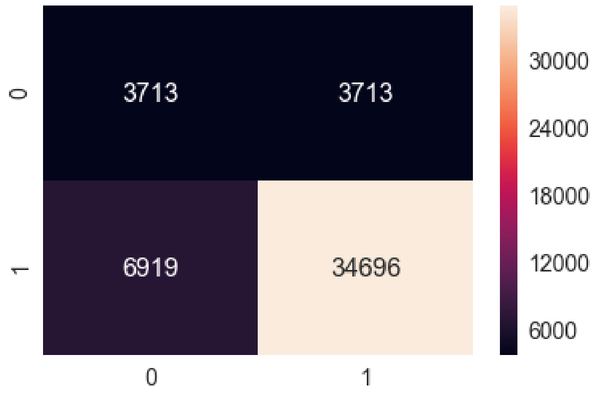
```
the maximum value of tpr*(1-fpr) 0.25 for threshold -0.825
the maximum value of tpr*(1-fpr) 0.25 for threshold -0.825
```

In [117]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_ifidf_l1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[117]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949f6910f0>
```



SET 3:categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)

In [118]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_avg = hstack((X_train_ccat_ohe , X_train_cscat_ohe , X_train_state_ohe, X_train_cpro_ohe , X_t
rain_teacher_ohe,avg_w2v_vectors_train,avg_w2v_vectors_titles_train, X_train_price_norm,
X_train_quan_norm , X_train_tno_norm)).tocsr()
X_cr_avg = hstack((X_cv_ccat_ohe , X_cv_cscat_ohe , X_cv_state_ohe, X_cv_cpro_ohe ,
X_cv_teacher_ohe, avg_w2v_vectors_cv,avg_w2v_vectors_titles_cv , X_cv_price_norm, X_cv_quan_norm ,
X_cv_tno_norm)).tocsr()
X_te_avg = hstack((X_test_ccat_ohe , X_test_cscat_ohe , X_test_state_ohe, X_test_cpro_ohe , X_test_
teacher_ohe, avg_w2v_vectors_test,avg_w2v_vectors_titles_test, X_test_price_norm, X_test_quan_norm
, X_test_tno_norm)).tocsr()
```

L2 REGULARIZATION

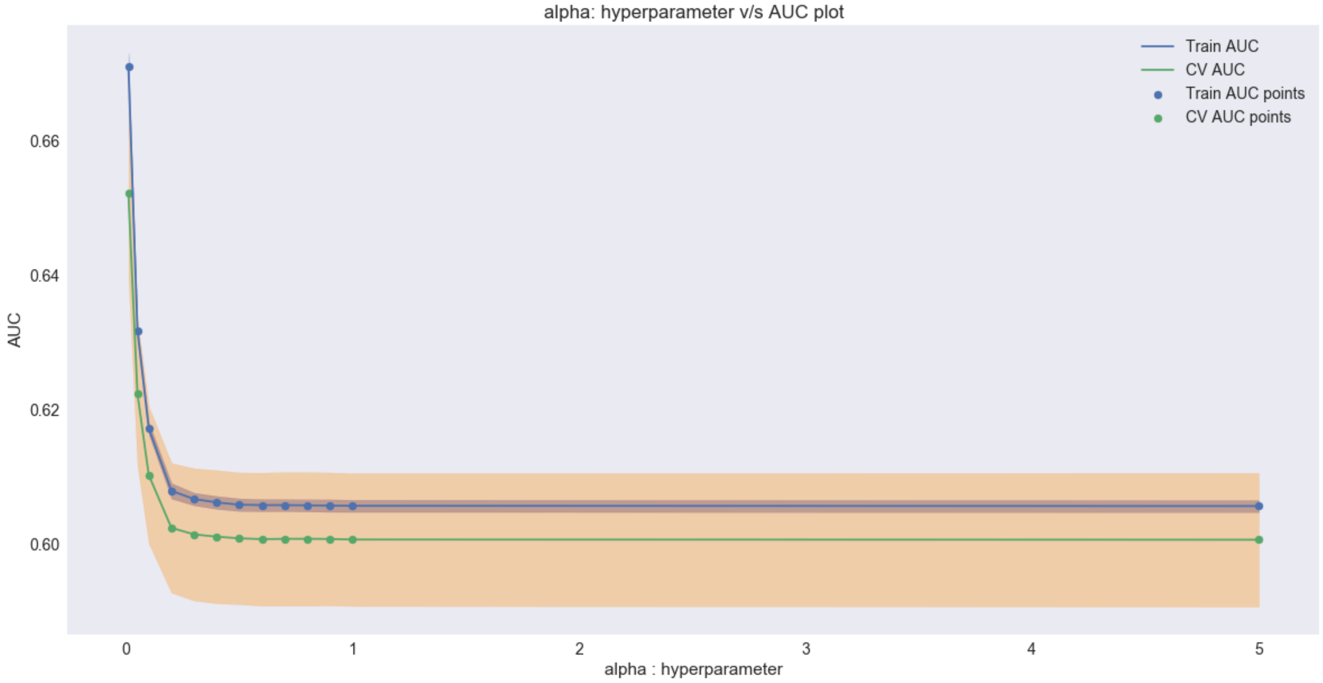
In [119]:

```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')

parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5.0]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_avg, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [120]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')
```

```
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



AFTer 0.1 my graph is constant so try low value of alpha

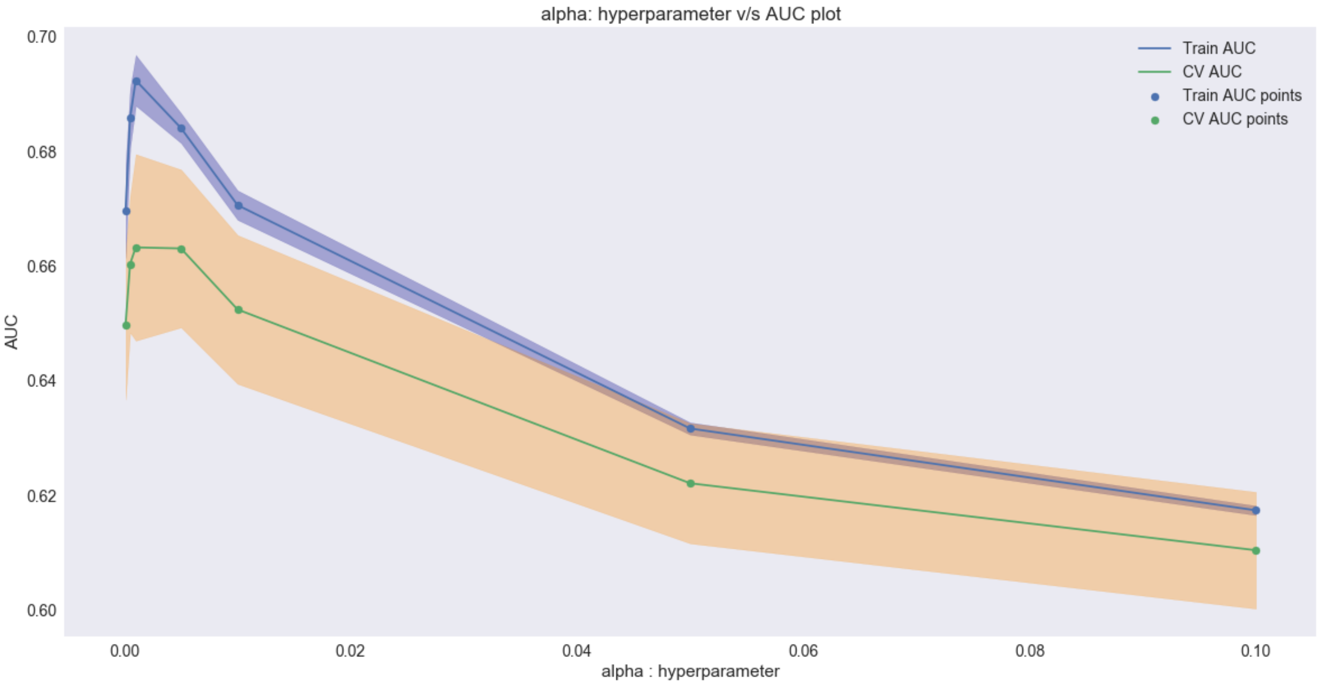
In [121]:

```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')

parameters = {'alpha':[0.0001,0.0005,0.001,0.005,0.01, 0.05, 0.1]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_avg, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [122]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')
```

```
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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```

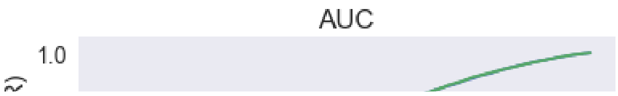


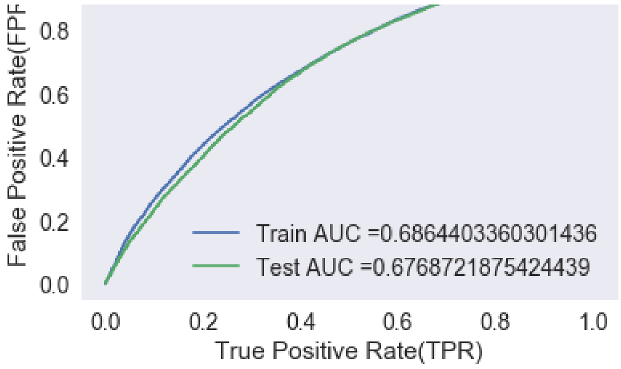
In [123]:

```
best_alpha=0.0005
```

In [124]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l2', alpha=best_alpha,class_weight='balanced')

model.fit(X_tr_avg, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_tr_avg)
y_test_pred = model.decision_function(X_te_avg)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```





CONFUSION MATRIX

In [125]:

```
conf_matr_df_train_avg_l2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

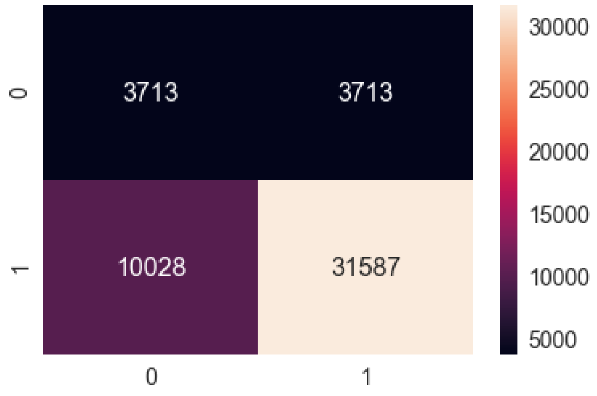
```
the maximum value of tpr*(1-fpr) 0.25 for threshold -0.239
```

In [126]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_avg_l2, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[126]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949f2df390>
```



L1 Regularization

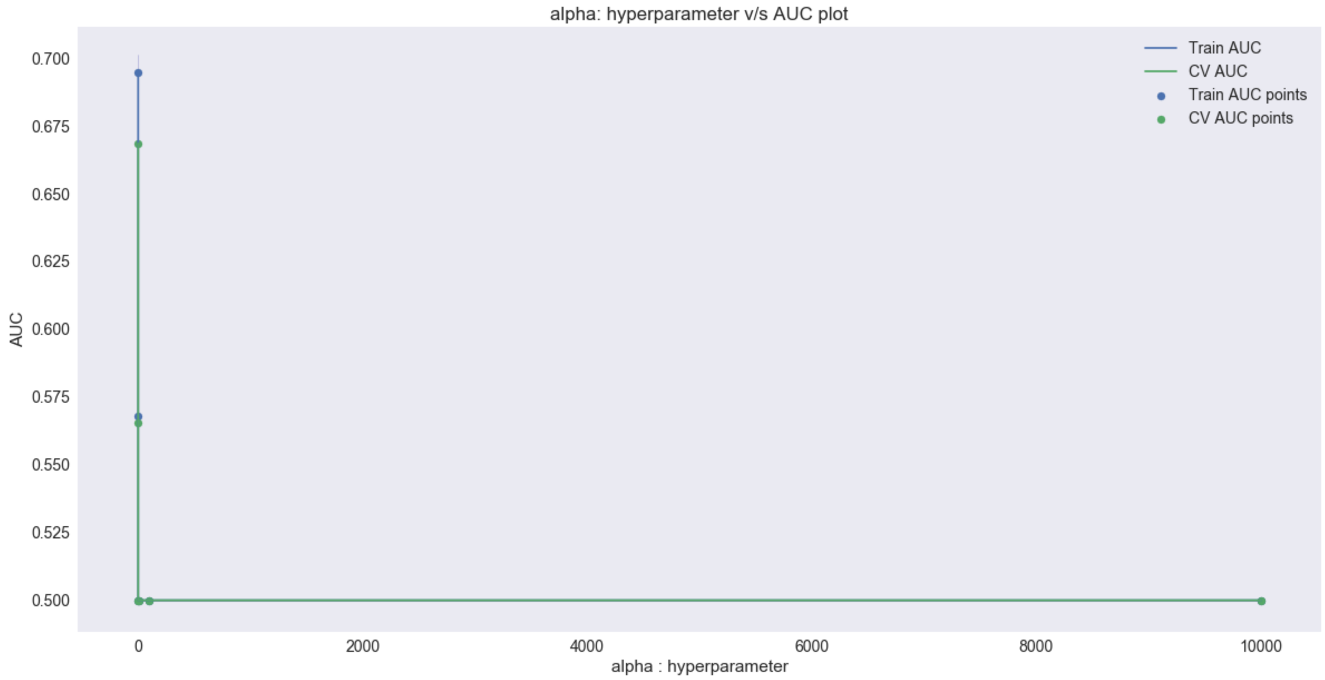
In [127]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[10**-4,10**-2,10**-1,10**1,10**2,10**4]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_avg, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [128]:

```
plt.figure(figsize=(20,10))

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

```
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



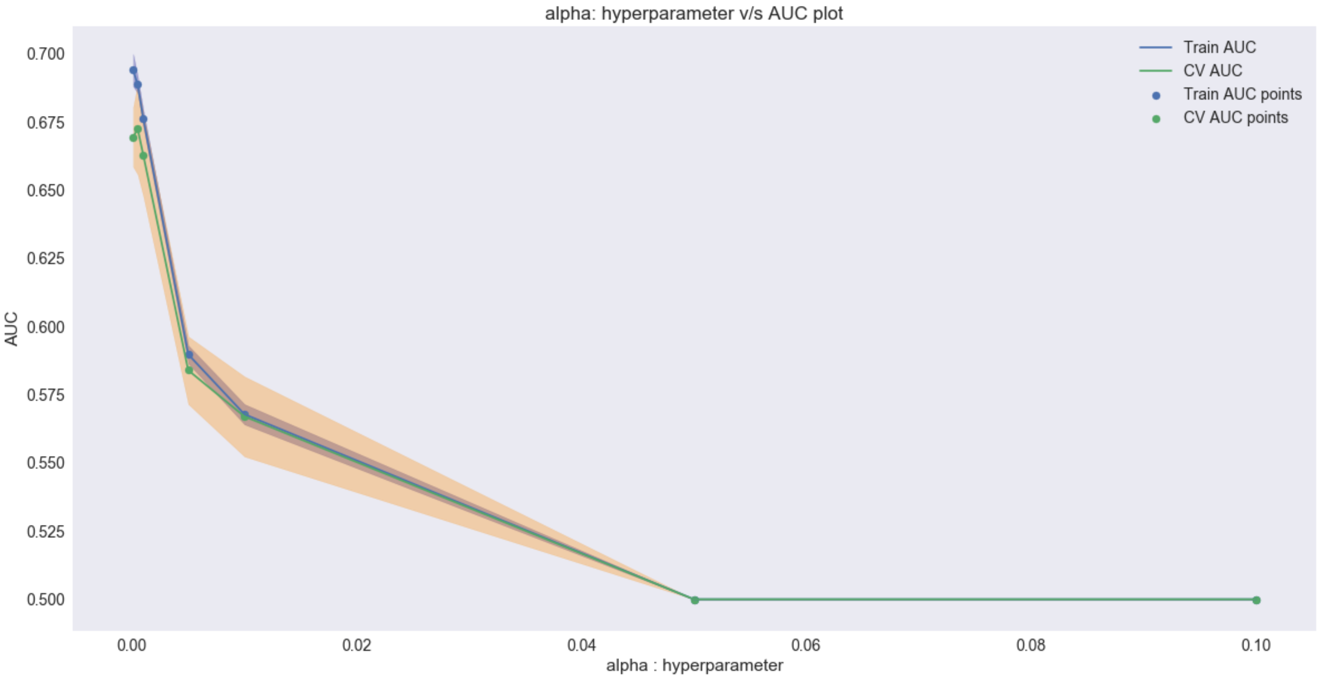
AFTER parameter 0.1 all value over lap so we take point less than that

In [129]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[10**-4,0.0005,10**-3,0.005,10**-2,0.05,10**-1]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_avg, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [130]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



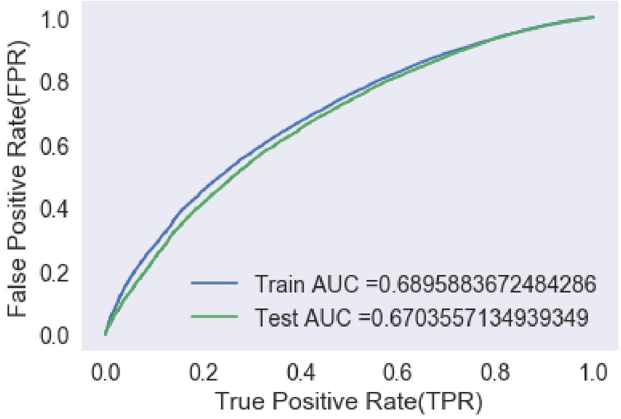
In [131]:

```
best_alpha=0.0001
```

In [132]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l1', alpha=best_alpha,class_weight='balanced')

model.fit(X_tr_avg, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_tr_avg)
y_test_pred = model.decision_function(X_te_avg)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

AUC



CONFUSION MATRIX

In [133]:

```
conf_matr_df_train_ifidf_l1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

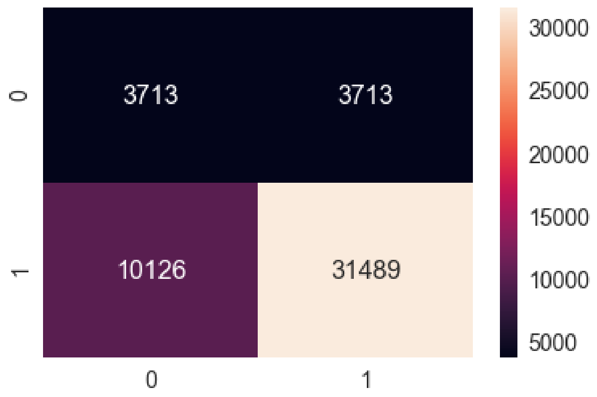
```
the maximum value of tpr*(1-fpr) 0.25 for threshold 4.462
```

In [134]:

```
sns.set(font_scale=1.4)
sns.heatmap(conf_matr_df_train_ifidf_l1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[134]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949f5c65c0>
```



SET 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

In [135]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_weigh = hstack((X_train_ccat_ohe , X_train_cscat_ohe , X_train_state_ohe, X_train_cpro_ohe , X
_train_teacher_ohe,tfidf_w2v_vectors_train,tfidf_w2v_vectors_titles_train, X_train_price_norm, X_t
rain_quan_norm , X_train_tno_norm)).tocsr()
X_cr_weigh = hstack((X_cv_ccat_ohe , X_cv_cscat_ohe , X_cv_state_ohe, X_cv_cpro_ohe , X_cv_teacher_
ohe, tfidf_w2v_vectors_cv,tfidf_w2v_vectors_titles_cv , X_cv_price_norm, X_cv_quan_norm ,
X_cv_tno_norm)).tocsr()
X_te_weigh = hstack((X_test_ccat_ohe , X_test_cscat_ohe , X_test_state_ohe, X_test_cpro_ohe , X_tes
t_teacher_ohe, tfidf_w2v_vectors_test,tfidf_w2v_vectors_titles_test, X_test_price_norm,
X_test_quan_norm , X_test_tno_norm)).tocsr()
```

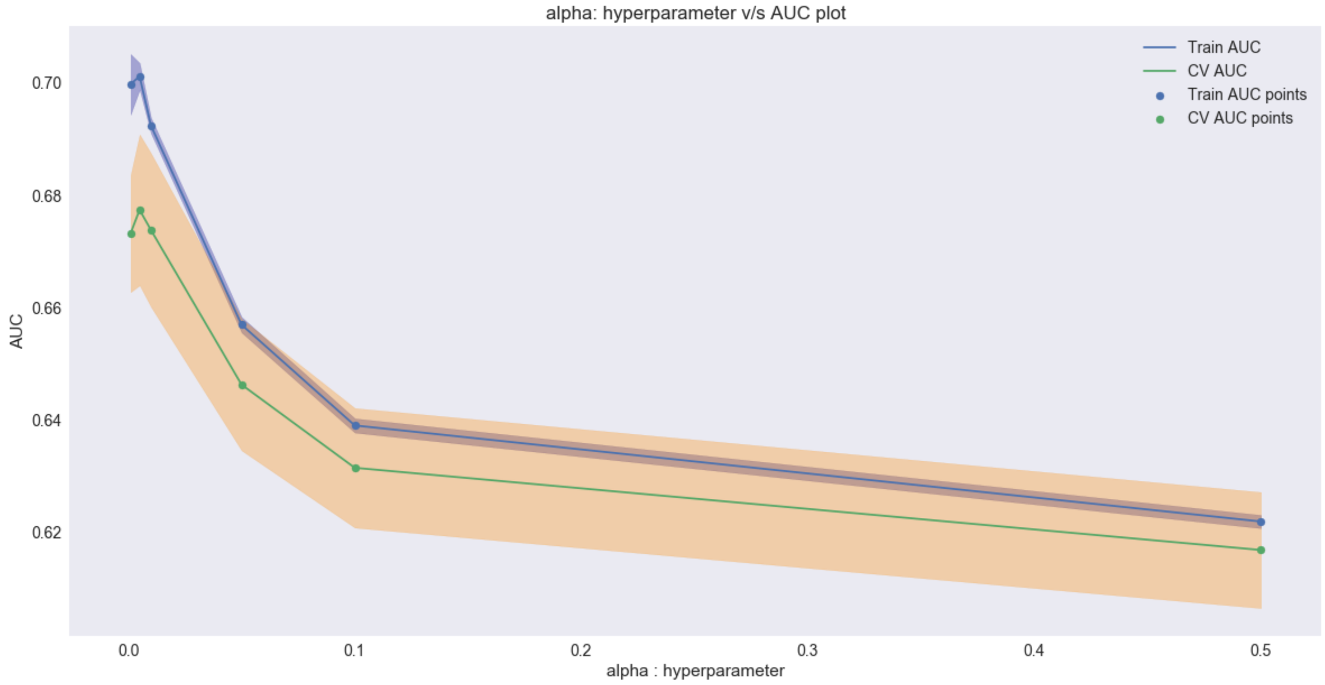
L2 REGULARIZATION

In [136]:

```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')

parameters = {'alpha':[0.001,0.005,0.01,0.05,0.1, 0.5]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_weigh, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [137]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```

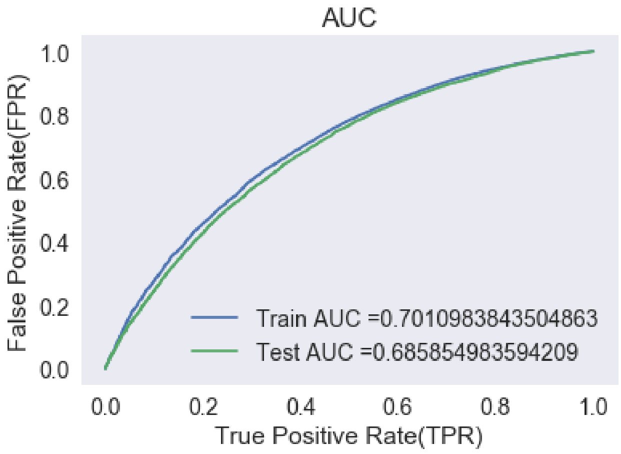


In [138]:

```
best_alpha=0.005
```

In [139]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l2', alpha=best_alpha,class_weight='balanced')

model.fit(X_tr_weigh, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_tr_weigh)
y_test_pred = model.decision_function(X_te_weigh)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



CONFUSION MATRIX

In [140]:

```
conf_matr_df_train_weigh_l2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

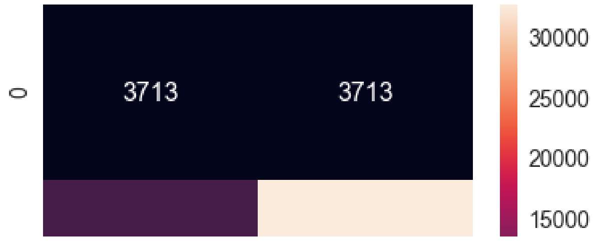
```
the maximum value of tpr*(1-fpr) 0.25 for threshold -0.345
```

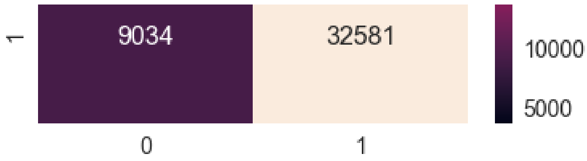
In [141]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_weigh_l2, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[141]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949fb244e0>
```





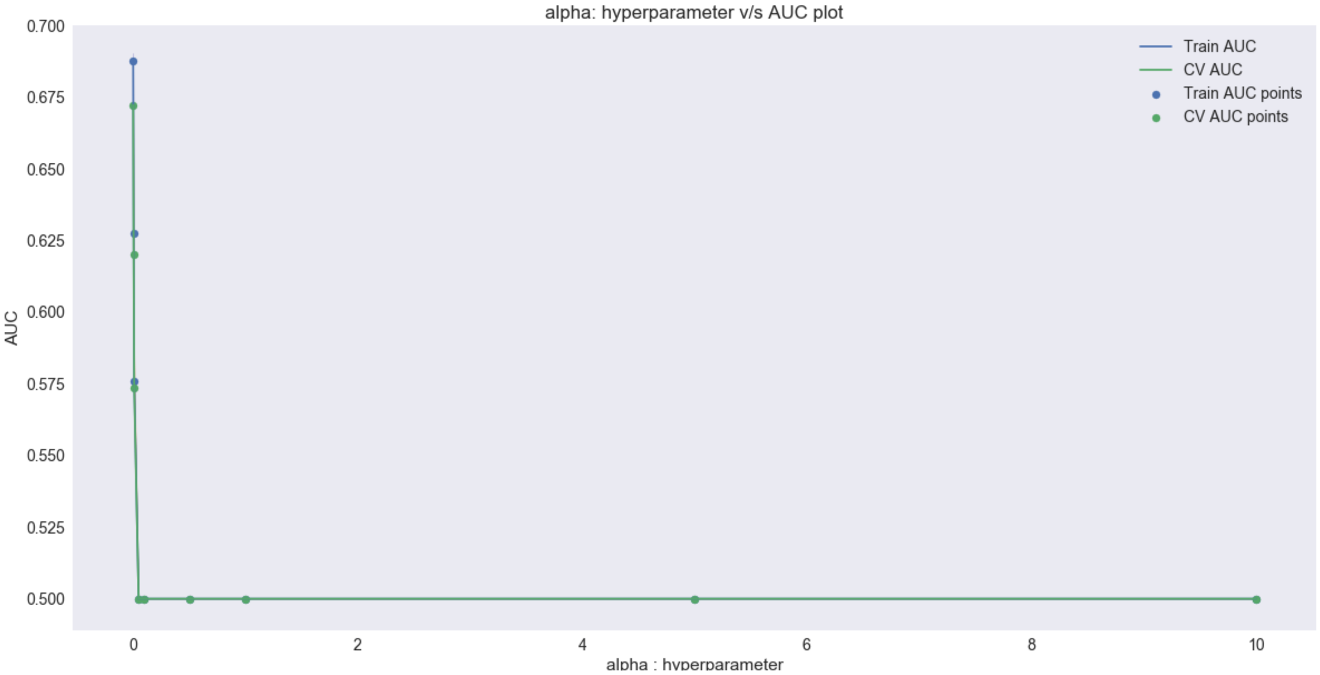
L1 Regularization

In [142]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[0.001,0.005,0.01,0.05,0.1,0.5,1,5,10]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_weigh, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [143]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



alpha : hyperparameter

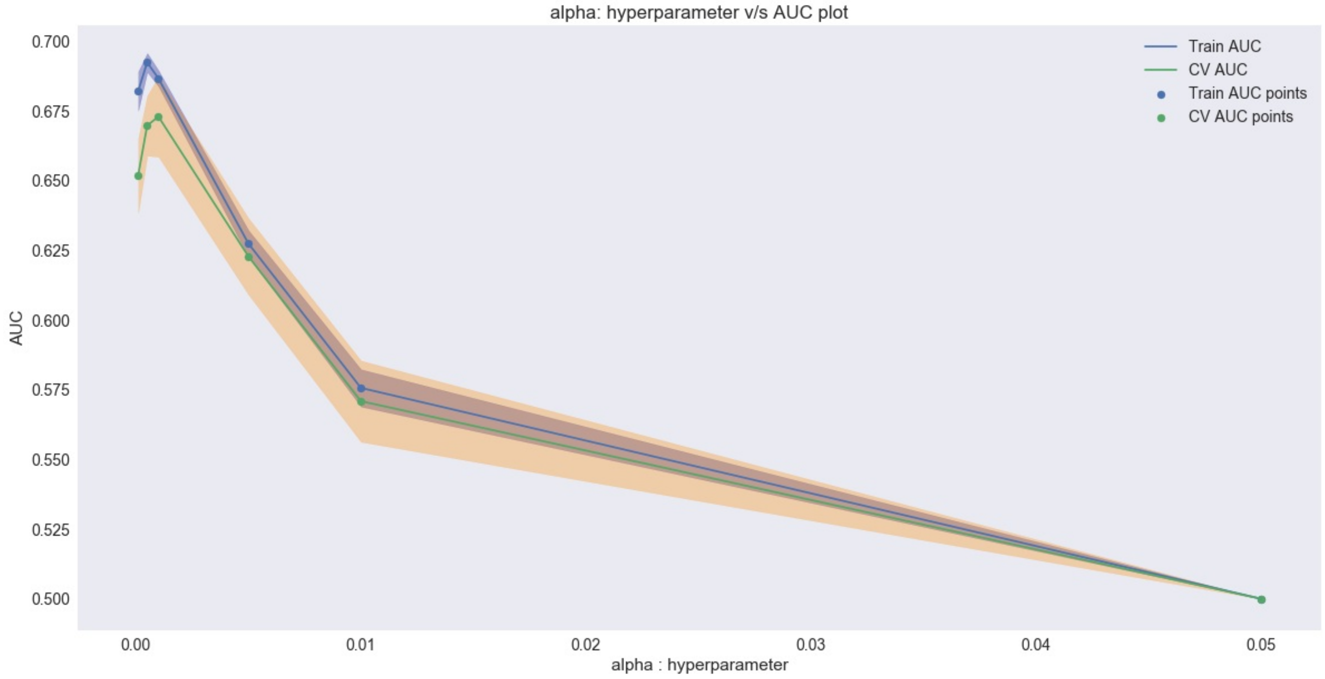
Most of the point overlap so we take other value of alphas

In [144]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[0.0001,0.0005,0.001,0.005,0.01,0.05]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_tr_weigh, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [145]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```

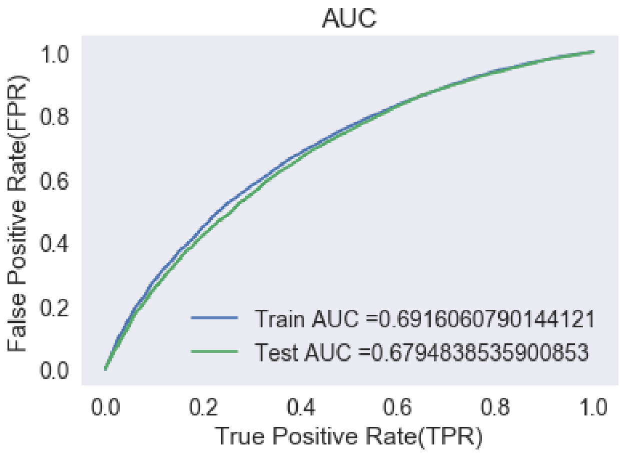


In [146]:

```
best_alpha=0.0005
```

In [147]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l1', alpha=best_alpha,class_weight='balanced')

model.fit(X_tr_weigh, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = model.decision_function(X_tr_weigh)
y_test_pred = model.decision_function(X_te_weigh)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



CONFUSION MATRIX

In [148]:

```
conf_matr_df_train_weigh_l1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

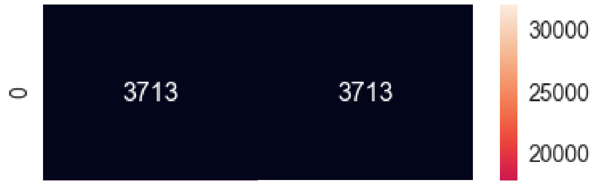
```
the maximum value of tpr*(1-fpr) 0.25 for threshold -0.292
```

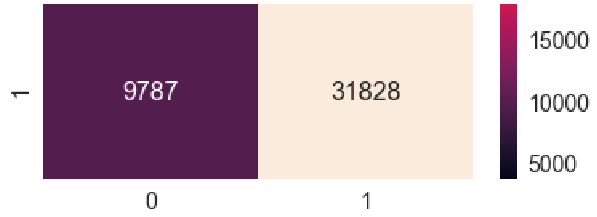
In [149]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_weigh_l1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[149]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949fa6cf60>
```





2.5 Support Vector Machines with added Features `Set 5`

TRUNCATED SVD
https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html
In particular, truncated SVD works on term count/tf-idf matrices as returned by the vectorizers in sklearn.feature_extraction.text. In that context, it is known as latent semantic analysis (LSA).

elbow method https://www.scikit-yb.org/en/latest/api/cluster/elbow.html

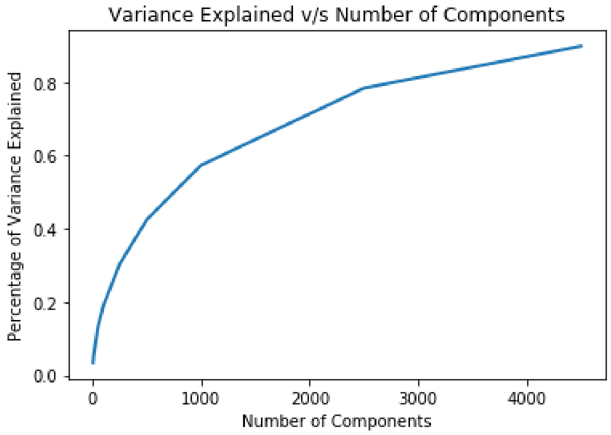
In [84]:

```
from sklearn.decomposition import TruncatedSVD
index = [5,10,50,100,250,500,1000,2500,4500]
var_sum=[]
for i in tqdm(index):
    svd = TruncatedSVD(n_components= i, n_iter=7, random_state=42)
    svd.fit(X_train_essay_tfidf)
    var_sum.append(svd.explained_variance_ratio_.sum())
```

```
100%|██████████| 9/9 [24:56<00:00, 370.75s/it]
```

In [85]:

```
plt.xlabel("Number of Components")
plt.ylabel("Percentage of Variance Explained")
plt.title("Variance Explained v/s Number of Components")
plt.plot(index,var_sum,lw=2)
plt.show()
```



TRAIN DATA

In [84]:

```
svd = TruncatedSVD(n_components= 5000, n_iter=7, random_state=42)
svd.fit(X_train_essay_tfidf)
svd_train = svd.transform(X_train_essay_tfidf)
```

TEST DATA

In [85]:

```
svd = TruncatedSVD(n_components= 5000, n_iter=7, random_state=42)
svd.fit(X_test_essay_tfidf)
svd_test = svd.transform(X_test_essay_tfidf)
```

CROSSVALIDATION DATA

In [86]:

```
svd = TruncatedSVD(n_components= 5000, n_iter=7, random_state=42)
svd.fit(X_cv_essay_tfidf)
svd_cv = svd.transform(X_cv_essay_tfidf)
```

In [93]:

```
svd_cv
```

Out[93]:

```
array([[ 2.71790580e-01,  1.49654176e-01,  4.80840391e-02, ...,
         5.45320850e-03,  2.35627579e-04,  3.50622393e-03],
       [ 2.51055112e-01, -7.37305198e-02,  8.25539133e-02, ...,
        -4.24353068e-03,  5.42020076e-03, -4.14003136e-03],
       [ 2.64125325e-01, -1.17579421e-01,  1.80969673e-01, ...,
         7.09464322e-03, -8.38638900e-04,  3.40864791e-03],
       ...,
       [ 1.95469156e-01,  2.41566204e-02, -4.54651903e-02, ...,
        -1.71051322e-03,  4.16887209e-03, -1.69033758e-03],
       [ 2.71810902e-01, -5.68467651e-02,  5.61947481e-02, ...,
         4.12444216e-03, -3.66348793e-03,  1.32171424e-03],
       [ 3.50757197e-01,  5.86302189e-02, -9.69348758e-02, ...,
         3.05515604e-03,  4.01251435e-03, -8.16984252e-03]])
```

In [150]:

```
from scipy.sparse import hstack
X_train_add = hstack((X_train_ccat_ohe , X_train_cscat_ohe , X_train_state_ohe, X_train_cpro_ohe ,
X_train_teacher_ohe, X_train_price_norm, X_train_quan_norm , X_train_tno_norm,X_train_titleno_norm
,X_train_essayno_norm,X_train_ssneg_norm,X_train_sspos_norm,X_train_sscompound_norm,X_train_ssneu_r
orm,svd_train)).tocsr()
X_cv_add=hstack((X_cv_ccat_ohe , X_cv_cscat_ohe , X_cv_state_ohe, X_cv_cpro_ohe , X_cv_teacher_ohe,
X_cv_price_norm, X_cv_quan_norm ,
X_cv_tno_norm,X_cv_titleno_norm,X_cv_essayno_norm,X_cv_ssneg_norm,X_cv_sspos_norm,X_cv_sscompound_r
orm,X_cv_ssneu_norm,svd_cv)).tocsr()
X_test_add= hstack((X_test_ccat_ohe , X_test_cscat_ohe , X_test_state_ohe, X_test_cpro_ohe , X_test
_teacher_ohe,X_test_price_norm, X_test_quan_norm ,
X_test_tno_norm,X_test_titleno_norm,X_test_essayno_norm,X_test_ssneg_norm,X_test_sspos_norm,X_test_
sscompound_norm,X_test_ssneu_norm,svd_test)).tocsr()
```

L1 REGULARIZATION

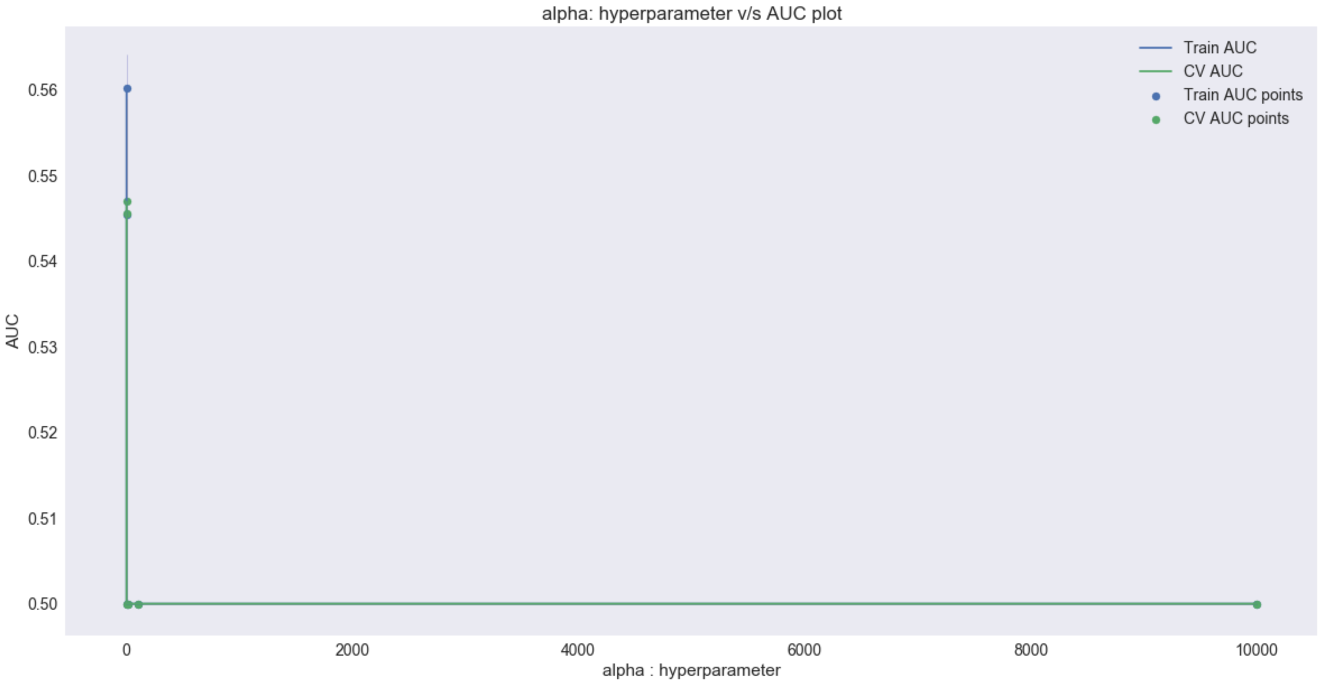
In [151]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[10**-4,10**-2,10**-1,10**1,10**2,10**4]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_train_add, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [152]:

```
plt.figure(figsize=(20,10))

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

```
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



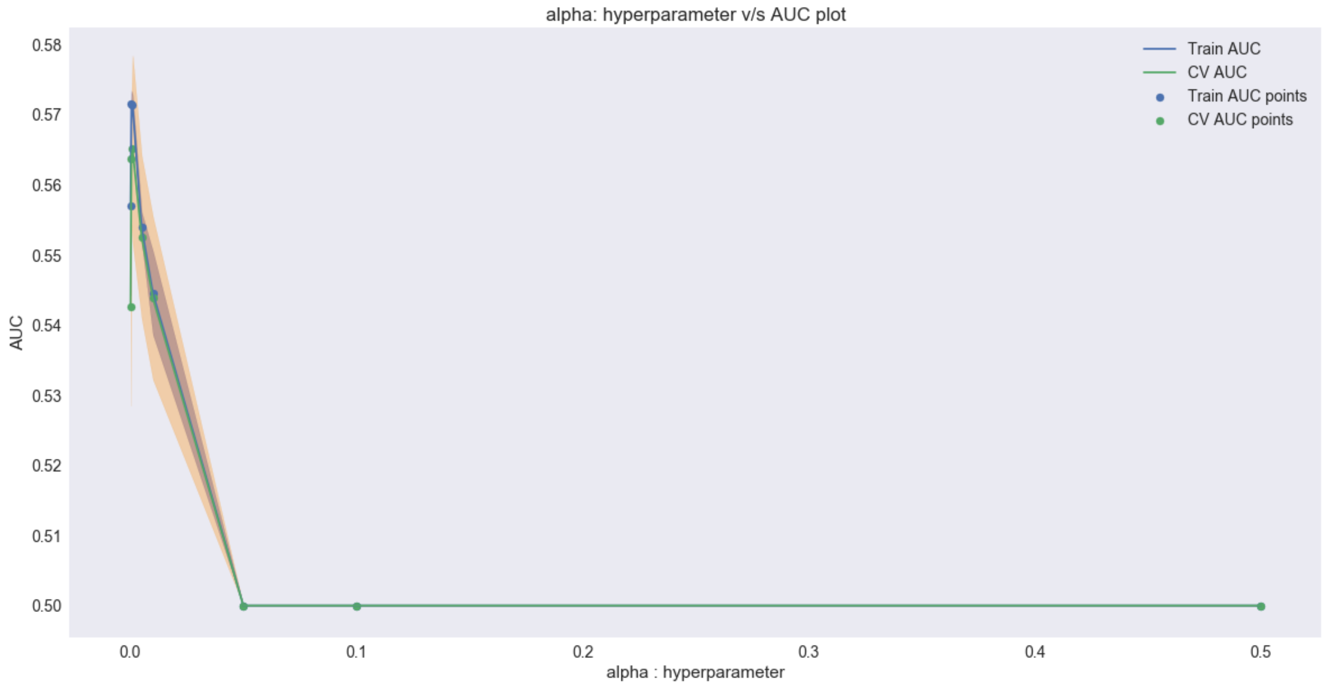
try different value for alpha

In [153]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[10**-4,0.0005,0.001,0.005,10**-2,0.05,0.1,0.5]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_train_add, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [154]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```

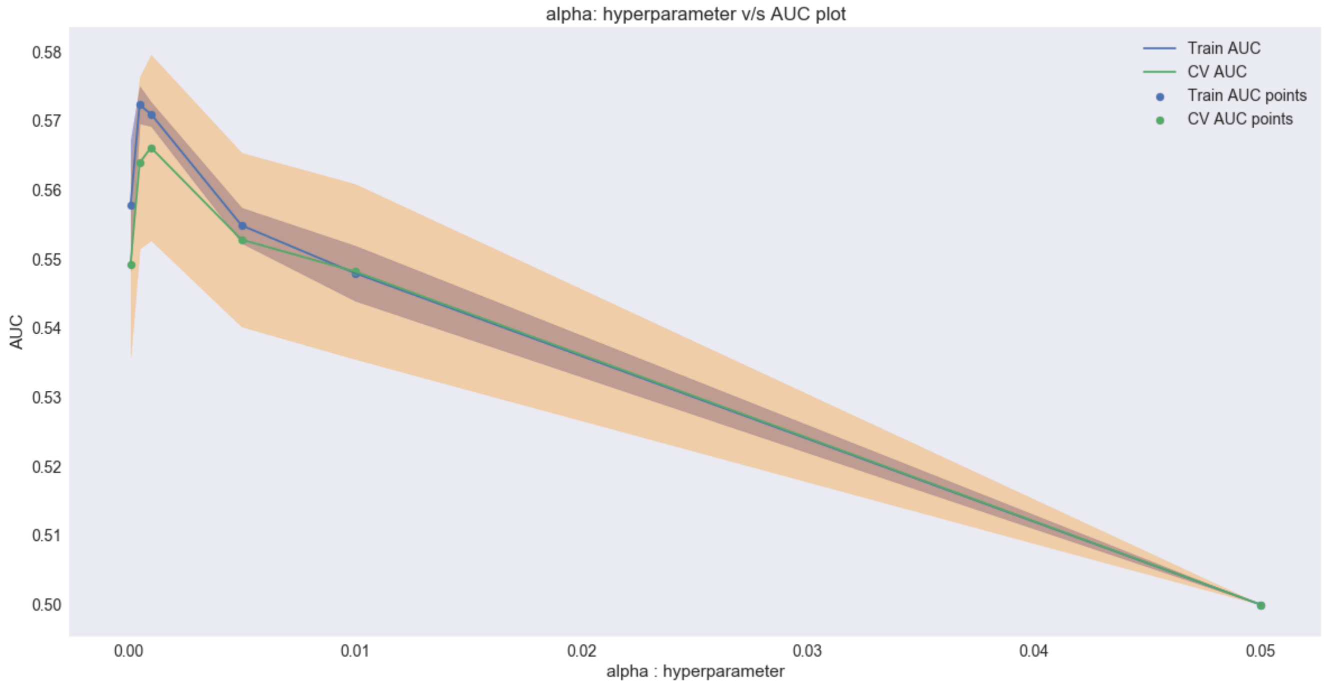


In [155]:

```
sv = SGDClassifier(loss='hinge', penalty='l1',class_weight='balanced')

parameters = {'alpha':[10**-4,0.0005,0.001,0.005,10**-2,0.05]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_train_add, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [156]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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


plt.legend()
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```

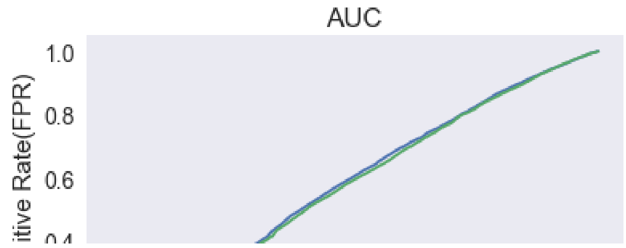


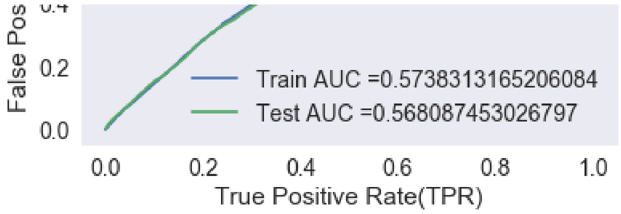
In [157]:

```
best_alpha=0.0005
```

In [158]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l1', alpha=best_alpha,class_weight='balanced')

model.fit(X_train_add, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_train_add)
y_test_pred = model.decision_function(X_test_add)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```





CONFUSION MATRIX

In [159]:

```
conf_matr_df_train_add_l1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

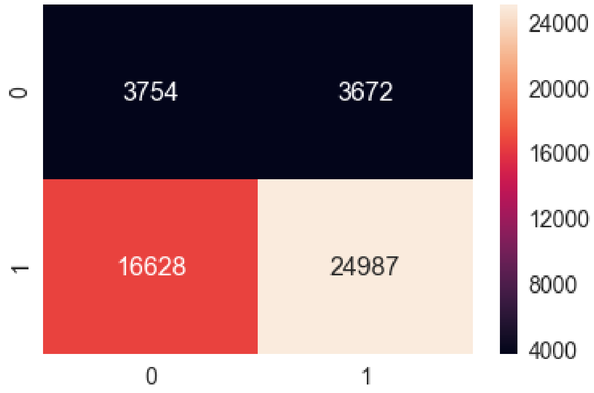
```
the maximum value of tpr*(1-fpr) 0.24996951699174744 for threshold -0.16
```

In [160]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_add_l1, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[160]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949fac7438>
```



L2 REGULARIZATION

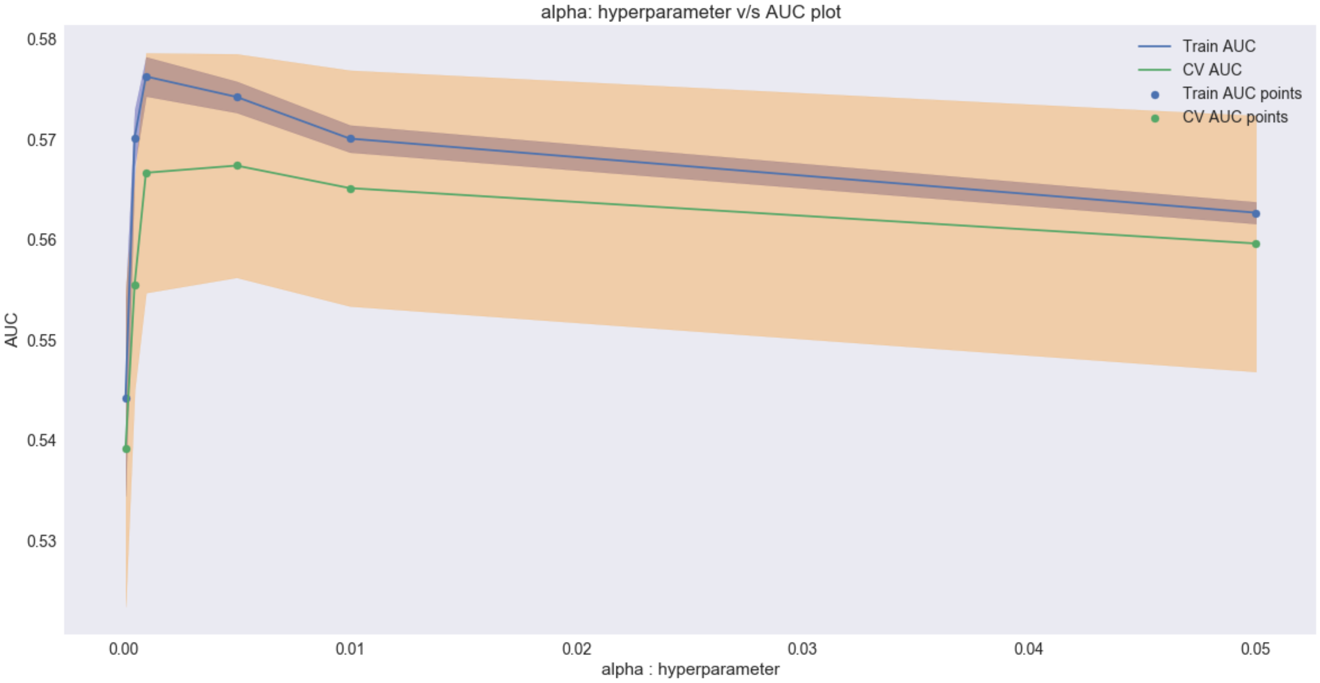
In [161]:

```
sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')

parameters = {'alpha':[10**-4,0.0005,0.001,0.005,10**-2,0.05]}

clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

clf.fit(X_train_add, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
```

In [162]:

```
plt.figure(figsize=(20,10))

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
```

```
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color=
'darkorange')

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 : hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



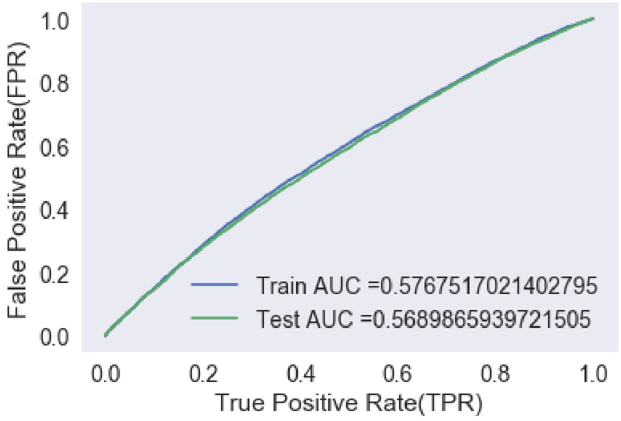
In [163]:

```
best_alpha=0.001
```

In [164]:

```
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l2', alpha=best_alpha,class_weight='balanced')

model.fit(X_train_add, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = model.decision_function(X_train_add)
y_test_pred = model.decision_function(X_test_add)

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.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```

AUC



CONFUSION MATRIX

In [165]:

```
conf_matr_df_train_add_l2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred,
tr_thresholds, train_fpr, train_fpr)), range(2),range(2))
```

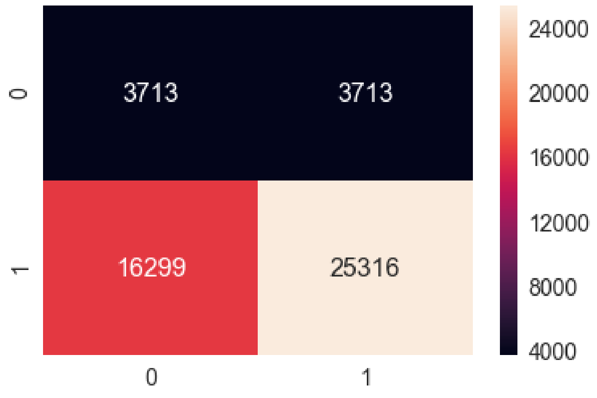
```
the maximum value of tpr*(1-fpr) 0.25 for threshold -0.875
```

In [166]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_add_l2, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[166]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1949fa0f828>
```



3. Conclusion

In [167]:

```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "tuned_parameter:@", "AUC","Which regularization performs b
etter"]

x.add_row(["BOW", "Support Vector Machine", "L1:0.01" " L2:0.01", "L1:0.70" " L2:0.71","L2
performs better than L1"])
x.add_row(["TFIDF", "Support Vector Machine", "L1:0.0001" " L2:0.005", "L1:0.70" " L2:0.67","L1
performs better than L2"])
x.add_row(["AVG W2V", "Support Vector Machine","L1:0.0001" " L2:0.0005", "L1:0.67" "
L2:0.67","Both perfoms same"])
x.add_row(["TFIDF W2V", "Support Vector Machine","L1:0.0005" " L2:0.005", "L1:0.70" " L2:0.68","L1
performs better than L2"])
x.add_row(["WITHOUT TEXT", "Support Vector Machine","L1:0.0005" " L2:0.001", "L1:0.55" " L2:0.55",
"Both perfoms same"])


print(x)
```

```
+--------------+------------------------+---------------------+-----------------+------------------
------------------+
|  Vectorizer  |         Model          |  tuned_parameter:@  |       AUC       | Which regularizat
on performs better |
+--------------+------------------------+---------------------+-----------------+------------------
------------------+
|     BOW      | Support Vector Machine |   L1:0.01 L2:0.01   | L1:0.70 L2:0.71 |       L2 performs
better than L1        |
|    TFIDF     | Support Vector Machine |  L1:0.0001 L2:0.005 | L1:0.70 L2:0.67 |       L1 performs
better than L2        |
|   AVG W2V    | Support Vector Machine | L1:0.0001 L2:0.0005 | L1:0.67 L2:0.67 |           Both per
foms same             |
|  TFIDF W2V   | Support Vector Machine |  L1:0.0005 L2:0.005 | L1:0.70 L2:0.68 |       L1 performs
better than L2        |
| WITHOUT TEXT | Support Vector Machine |  L1:0.0005 L2:0.001 | L1:0.55 L2:0.55 |           Both per
foms same             |
+--------------+------------------------+---------------------+-----------------+------------------
------------------+
```

OBSERVATION

1. Without text data AUC score is very less.
2. Highest AUC score which is obtained is 0.71
3. model is good because for every vectorizer AUC score is greater than 0.5
4. there is not much difference when using different regularization technique

END