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 [31]:

```
%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
```

In [0]:

```
!pip install -U -q PyDrive
from pydrive.auth import GoogleAuth
from pydrive.drive import GoogleDrive
from google.colab import auth
from oauth2client.client import GoogleCredentials
```

```
    |████████████████████████████████| 993kB 3.5MB/s
  Building wheel for PyDrive (setup.py) ... done
```

In [0]:

```
auth.authenticate_user()
gauth = GoogleAuth()
gauth.credentials = GoogleCredentials.get_application_default()
drive = GoogleDrive(gauth)
```

```
WARNING: Logging before flag parsing goes to stderr.
W0626 15:44:18.025993 139702998689664 lazy_loader.py:50]
The TensorFlow contrib module will not be included in TensorFlow 2.0.
For more information, please see:
  * https://github.com/tensorflow/community/blob/master/rfcs/20180907-contrib-sunset.md
  * https://github.com/tensorflow/addons
  * https://github.com/tensorflow/io (for I/O related ops)
If you depend on functionality not listed there, please file an issue.
```

In [0]:

```
downloaded = drive.CreateFile({'id':'1hfC8UNsUYP9kaV0649ia8Wt-PcYz1lMO'}) # replace the id with id of file you want to access
downloaded.GetContentFile('resources.csv')


downloaded = drive.CreateFile({'id':'1GNlumJi7f_eP0pcGWjaDaYeLPWMs5gj1'}) # replace the id with id of file you want to access
downloaded.GetContentFile('train_data.csv')

downloaded = drive.CreateFile({'id':'1n6Rlh7nEpEnqGCj0wssp6iwAuwoROY_Z'}) # replace the id with id of file you want to access
downloaded.GetContentFile('glove_vectors(1).csv')
```

1.1 Reading Data

In [32]:

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

In [33]:

```
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 [34]:

```
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[34]:

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

In [35]:

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


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

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


project_data.head(2)
```

Out[35]:

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

1.2 preprocessing of `project_subject_categories`

In [36]:

```
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 & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "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 [37]:

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

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

sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "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 [38]:

```
# 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 [39]:

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

Out[39]:

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

In [40]:

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

In [41]:

```python
# printing some random reviews
print(project_data['essay'].values[0])
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)
```

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom as well as the STEM j
ournals, which my students really enjoyed.  I would love to implement more of the Lakeshore STEM k
its in my classroom for the next school year as they provide excellent and engaging STEM
lessons.My students come from a variety of backgrounds, including language and socioeconomic statu
s.  Many of them don't have a lot of experience in science and engineering and these kits give me
the materials to provide these exciting opportunities for my students.Each month I try to do
several science or STEM/STEAM projects.  I would use the kits and robot to help guide my science i
nstruction in engaging and meaningful ways.  I can adapt the kits to my current language arts paci
ng guide where we already teach some of the material in the kits like tall tales (Paul Bunyan) or
Johnny Appleseed.  The following units will be taught in the next school year where I will
implement these kits: magnets, motion, sink vs. float, robots.  I often get to these units and don
't know If I am teaching the right way or using the right materials.    The kits will give me
additional ideas, strategies, and lessons to prepare my students in science.It is challenging to d
evelop high quality science activities.  These kits give me the materials I need to provide my
students with science activities that will go along with the curriculum in my classroom.  Although
I have some things (like magnets) in my classroom, I don't know how to use them effectively.  The
kits will provide me with the right amount of materials and show me how to use them in an
appropriate way.
==================================================
I teach high school English to students with learning and behavioral disabilities. My students all
vary in their ability level. However, the ultimate goal is to increase all students literacy level
s. This includes their reading, writing, and communication levels.I teach a really dynamic group o
f students. However, my students face a lot of challenges. My students all live in poverty and in
a dangerous neighborhood. Despite these challenges, I have students who have the the desire to def
eat these challenges. My students all have learning disabilities and currently all are performing
below grade level. My students are visual learners and will benefit from a classroom that fulfills
their preferred learning style.The materials I am requesting will allow my students to be prepared
for the classroom with the necessary supplies.  Too often I am challenged with students who come t
o school unprepared for class due to economic challenges.  I want my students to be able to focus
on learning and not how they will be able to get school supplies.  The supplies will last all year
.  Students will be able to complete written assignments and maintain a classroom journal.  The ch
art paper will be used to make learning more visual in class and to create posters to aid students
in their learning.  The students have access to a classroom printer.  The toner will be used to pr
int student work that is completed on the classroom Chromebooks.I want to try and remove all barri
ers for the students learning and create opportunities for learning. One of the biggest barriers i
s the students not having the resources to get pens, paper, and folders. My students will be able
to increase their literacy skills because of this project.
==================================================
\"Life moves pretty fast. If you don't stop and look around once in awhile, you could miss it.\"
from the movie, Ferris Bueller's Day Off.  Think back...what do you remember about your
grandparents?  How amazing would it be to be able to flip through a book to see a day in their
lives?My second graders are voracious readers! They love to read both fiction and nonfiction books
.  Their favorite characters include Pete the Cat, Fly Guy, Piggie and Elephant, and Mercy Watson.
They also love to read about insects, space and plants. My students are hungry bookworms! My stude
nts are eager to learn and read about the world around them. My kids love to be at school and are
like little sponges absorbing everything around them. Their parents work long hours and usually do
not see their children. My students are usually cared for by their grandparents or a family
friend. Most of my students do not have someone who speaks English at home. Thus it is difficult f
or my students to acquire language.Now think forward... wouldn't it mean a lot to your kids,
nieces or nephews or grandchildren, to be able to see a day in your life today 30 years from now?
Memories are so precious to us and being able to share these memories with future generations will
be a rewarding experience.  As part of our social studies curriculum, students will be learning ab
out changes over time.  Students will be studying photos to learn about how their community has ch
anged over time.  In particular, we will look at photos to study how the land, buildings,
clothing, and schools have changed over time.  As a culminating activity, my students will capture
a slice of their history and preserve it through scrap booking. Key important events in their
young lives will be documented with the date, location, and names.   Students will be using photos
from home and from school to create their second grade memories.   Their scrap books will preserve
their unique stories for future generations to enjoy.Your donation to this project will provide my
second graders with an opportunity to learn about social studies in a fun and creative manner.  Th
rough their scrapbooks, children will share their story with others and have a historical document
for the rest of their lives.
for the rest of their lives.
==================================================
\"A person's a person, no matter how small.\" (Dr.Seuss) I teach the smallest students with the bi
ggest enthusiasm for learning. My students learn in many different ways using all of our senses an
d multiple intelligences. I use a wide range of techniques to help all my students succeed. \r\nSt
udents in my class come from a variety of different backgrounds which makes for wonderful sharing
of experiences and cultures, including Native Americans.\r\nOur school is a caring community of su
ccessful learners which can be seen through collaborative student project based learning in and ou
t of the classroom. Kindergarteners in my class love to work with hands-on materials and have many
different opportunities to practice a skill before it is mastered. Having the social skills to wor
k cooperatively with friends is a crucial aspect of the kindergarten curriculum.Montana is the
perfect place to learn about agriculture and nutrition. My students love to role play in our
pretend kitchen in the early childhood classroom. I have had several kids ask me, \"Can we try coo
king with REAL food?\" I will take their idea and create \"Common Core Cooking Lessons\" where we
learn important math and writing concepts while cooking delicious healthy food for snack time. My
students will have a grounded appreciation for the work that went into making the food and knowled
ge of where the ingredients came from as well as how it's healthy for their bodies. This project w
ould expand our learning of nutrition and agricultural cooking recipes by having us peel our own a
pples to make homemade applesauce, make our own bread, and mix up healthy plants from our classroo
m garden in the spring. We will also create our own cookbooks to be printed and shared with famili
es. \r\nStudents will gain math and literature skills as well as a life long enjoyment for healthy
cooking.nannan
==================================================
My classroom consists of twenty-two amazing sixth graders from different cultures and backgrounds.
They are a social bunch who enjoy working in partners and working with groups. They are hard-worki
ng and eager to head to middle school next year. My job is to get them ready to make this
transition and make it as smooth as possible. In order to do this, my students need to come to
school every day and feel safe and ready to learn. Because they are getting ready to head to
middle school, I give them lots of choice- choice on where to sit and work, the order to complete
assignments, choice of projects, etc. Part of the students feeling safe is the ability for them to
come into a welcoming, encouraging environment. My room is colorful and the atmosphere is casual.
I want them to take ownership of the classroom because we ALL share it together. Because my time w
ith them is limited, I want to ensure they get the most of this time and enjoy it to the best of t
heir abilities.Currently, we have twenty-two desks of differing sizes, yet the desks are similar t
o the ones the students will use in middle school. We also have a kidney table with crates for sea
ting. I allow my students to choose their own spots while they are working independently or in
groups. More often than not, most of them move out of their desks and onto the crates. Believe it
or not, this has proven to be more successful than making them stay at their desks! It is because
of this that I am looking toward the “Flexible Seating” option for my classroom.\r\n The students
look forward to their work time so they can move around the room. I would like to get rid of the c
onstricting desks and move toward more “fun” seating options. I am requesting various seating so m
y students have more options to sit. Currently, I have a stool and a papasan chair I inherited fro
m the previous sixth-grade teacher as well as five milk crate seats I made, but I would like to gi
ve them more options and reduce the competition for the “good seats”. I am also requesting two rug
s as not only more seating options but to make the classroom more welcoming and appealing. In orde
r for my students to be able to write and complete work without desks, I am requesting a class set
of clipboards. Finally, due to curriculum that requires groups to work together, I am requesting t
ables that we can fold up when we are not using them to leave more room for our flexible seating o
ptions.\r\nI know that with more seating options, they will be that much more excited about coming
to school! Thank you for your support in making my classroom one students will remember
forever!nannan
==================================================
```

In [42]:

```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 [43]:

```
# 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 [44]:

```
project_grade= list(project_data['project_grade_category'].values)
# remove special characters from list of strings python:
# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/

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

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

my_counter = Counter()
for word in project_data['clean_grade'].values:
     my_counter.update(word.split())
project_grade_category_dict= dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), key=lambda
kv: kv[1]))
```

In [45]:

```
# train test split

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(project_data,
project_data['project_is_approved'],stratify = project_data['project_is_approved'], test_size=0.33
)
X_train,X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [46]:

```
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, stratify= y_train,test_size = 0.3
3)
```

In [47]:

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

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

In [48]:

```
#droping the y labels
#https://stackoverflow.com/questions/13411544/delete-column-from-pandas-dataframe-by-column-name

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

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

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

In [49]:

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



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





#Proprocessing for essay
# Combining all the above students
from tqdm import tqdm
preprocessed_essays_cv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
```

```
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_cv.append(sent.lower().strip())
```

```
100%|█████████████████████████████████████████████████████████████████████████████| 32857/32857 [00:
33<00:00, 979.74it/s]
100%|█████████████████████████████████████████████████████████████████████████████| 36052/36052 [00:
46<00:00, 771.81it/s]
100%|█████████████████████████████████████████████████████████████████████████████| 16184/16184 [00:
24<00:00, 650.10it/s]
```

1.4 Preprocessing of `project_title`

In [50]:

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



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




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

```
100%|███████████████████████████████████████████████████████████████████████████| 16184/16184
[00:01<00:00, 14447.95it/s]
100%|███████████████████████████████████████████████████████████████████████████| 32857/32857
[00:02<00:00, 15451.08it/s]
100%|███████████████████████████████████████████████████████████████████████████| 36052/36052
[00:02<00:00, 14871.05it/s]
```

In [51]:

```
# similarly you can preprocess the titles also
```

1.5 Preparing data for models

In [52]:

```
project_data.columns
```

Out[52]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_title', 'project_essay_1', 'project_essay_2',
       'project_essay_3', 'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'clean_grade'],
      dtype='object')
```

we are going to consider

```
- school_state : categorical data
- clean_categories : categorical data
- clean_subcategories : categorical data
- project_grade_category : categorical data
- teacher_prefix : categorical data

- project_title : text data
- text : text data
- project_resource_summary: text data (optinal)

- quantity : numerical (optinal)
- teacher_number_of_previously_posted_projects : numerical
- price : numerical
```

1.5.1 Vectorizing Categorical data

- https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/

clean_categories_one_hot_encodin

In [53]:

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



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

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
After vectorizations
(32857, 9) (32857,)
(16184, 9) (16184,)
(36052, 9) (36052,)
```

clean_subcategories_one_hot_encoding

In [54]:

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


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

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
After vectorizations
(32857, 30) (32857,)
(16184, 30) (16184,)
(36052, 30) (36052,)
```

school_state_one_hot_encoding

In [55]:

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


# convert train,cv and test data of clean_categories into vectors
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_state = CountVectorizer(vocabulary=list(sorted_school_state_dict.keys()), lowercase=Fal
se, binary=True)
vectorizer_state.fit(project_data['school_state'].values)
# firstly convert fit the train data into the vector then it learn the vocablery
# we use the fitted CountVectorizer to convert the text to vector
X_train_school_state = vectorizer_state.transform(X_train['school_state'].values)
X_cv_school_state = vectorizer_state.transform(X_cv['school_state'].values)
X_test_school_state = vectorizer_state.transform(X_test['school_state'].values)
print(vectorizer_state.get_feature_names())


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

```
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME', 'HI', 'DC', 'NM', 'KS', 'I
A', 'ID', 'AR', 'CO', 'MN', 'OR', 'KY', 'MS', 'NV', 'MD', 'CT', 'TN', 'UT', 'AL', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'WA', 'MA', 'LA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'NY', 'TX
', 'CA']
After vectorizations
(32857, 51) (32857,)
(16184, 51) (16184,)
(36052, 51) (36052,)
```

project_grade_one_hot_encoding

In [57]:

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



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

```
['9-12', '6-8', '3-5', 'PreK-2']
After vectorizations
(32857, 4) (32857,)
(16184, 4) (16184,)
(36052, 4) (36052,)
```

In [58]:

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

In [59]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_t = CountVectorizer(vocabulary=list(sorted_teacher_prefix_dict.keys()), lowercase=False
,binary=True)
vectorizer_t.fit(project_data['teacher_prefix'].values.astype('U'))
# firstly convert fit the train data into the vectorizer
# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_prefix = vectorizer_t.transform(X_train['teacher_prefix'].values.astype('U'))
X_cv_teacher_prefix= vectorizer_t.transform(X_cv['teacher_prefix'].values.astype('U'))
X_test_teacher_prefix = vectorizer_t.transform(X_test['teacher_prefix'].values.astype('U'))
print(vectorizer_t.get_feature_names())



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

```
['null', 'Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
After vectorizations
(32857, 6) (32857,)
(16184, 6) (16184,)
(36052, 6) (36052,)
```

1.5.2.1 Bag of words

essay_bow_vectorizing

In [60]:

```
#essay_bow_vectorizing

X_train_essay=preprocessed_essays_train
X_cv_essay=preprocessed_essays_cv
X_test_essay=preprocessed_essays_test

vectorizer_bow = CountVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer_bow.fit(X_train_essay)#learned from trained data

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

title_bow_vectorizing

In [61]:

```
#title_bow_vectorizing

X_train_title=preprocessed_titles_train
X_cv_title=preprocessed_titles_cv
X_test_title=preprocessed_titles_test

vectorizer_title_bow = CountVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer_title_bow.fit(X_train_title)#learned from trainned data

# we use the fitted CountVectorizer to convert the text to vector
X_train_bow_title = vectorizer_title_bow.transform(X_train_title)
X_cv_bow_title= vectorizer_title_bow.transform(X_cv_title)
X_test_bow_title = vectorizer_title_bow.transform(X_test_title)


print("After vectorizations")
print(X_train_bow_title.shape, y_train.shape)
print(X_cv_bow_title.shape, y_cv.shape)
print(X_test_bow_title.shape, y_test.shape)
```

```
After vectorizations
(32857, 2277) (32857,)
(16184, 2277) (16184,)
(36052, 2277) (36052,)
```

1.5.2.2 TFIDF vectorizer

# essay_tfidf_vectorizing

In [62]:

```
#essay_tfidf_vectorizing
from sklearn.feature_extraction.text import TfidfVectorizer

# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_essay_tfidf = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer_essay_tfidf.fit(X_train_essay)#learned from trained data


# we use the fitted CountVectorizer to convert the text to vector
X_train_tf_essay = vectorizer_essay_tfidf.transform(X_train_essay)
X_cv_tf_essay= vectorizer_essay_tfidf.transform(X_cv_essay)
X_test_tf_essay = vectorizer_essay_tfidf.transform(X_test_essay)

print("After vectorizations")
print(X_train_tf_essay.shape, y_train.shape)
print(X_cv_tf_essay.shape, y_cv.shape)
print(X_test_tf_essay.shape, y_test.shape)
```

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

title_tfidf_vectorizing

In [63]:

```
#title_tfidf_vectorizing

from sklearn.feature_extraction.text import TfidfVectorizer

# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_tfidf_title = TfidfVectorizer(min_df=10,max_features=5000,ngram_range=(1, 2))
vectorizer_tfidf_title.fit(X_train_title)# learned from trained data

# we use the fitted CountVectorizer to convert the text to vector
X_train_tf_title = vectorizer_tfidf_title.transform(X_train_title)
X_cv_tf_title= vectorizer_tfidf_title.transform(X_cv_title)
X_test_tf_title = vectorizer_tfidf_title.transform(X_test_title)


print("After vectorizations")
print(X_train_tf_title.shape, y_train.shape)
print(X_cv_tf_title.shape, y_cv.shape)
print(X_test_tf_title.shape, y_test.shape)
```

```
After vectorizations
(32857, 2277) (32857,)
(16184, 2277) (16184,)
(36052, 2277) (36052,)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [64]:

```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

# ============================
Output:

Loading Glove Model
1917495it [06:32, 4879.69it/s]
Done. 1917495  words loaded!

# ============================

words = []
for i in preproced_texts:
    words.extend(i.split(' '))

for i in preproced_titles:
    words.extend(i.split(' '))
print("all the words in the coupus", len(words))
words = set(words)
print("the unique words in the coupus", len(words))

inter_words = set(model.keys()).intersection(words)
print("The number of words that are present in both glove vectors and our coupus", \
      len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")

words_courpus = {}
words_glove = set(model.keys())
for i in words:
    if i in words_glove:
        words_courpus[i] = model[i]
print("word 2 vec length", len(words_courpus))


# 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_courpus, f)


'''
```

Out[64]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef
loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\',
encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n
word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        m
odel[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel =
loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading G
love Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n#
============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\'
\'))\n\nfor i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the
coupus", len(words))\nwords = set(words)\nprint("the unique words in the coupus",
len(words))\n\ninter_words = set(model.keys()).intersection(words)\nprint("The number of words tha
t are present in both glove vectors and our coupus",       len(inter_words),"
(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove =
set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\n
print("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python
: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport pic
kle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [66]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors (1)', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [67]:

```
tfidf_model = TfidfVectorizer()
tfidf_model = tfidf_model.fit(X_train.essay)
```

In [68]:

```
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

essay_avg_w2v_vectorizing

In [69]:

```
#average word2vec vectorization
essay_avg_w2v = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(preprocessed_essays_train): # for each essay in training data
    vector = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        if word in glove_words:
            vector += model[word][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    essay_avg_w2v.append(vector)
print(len(essay_avg_w2v))
print(len(essay_avg_w2v[0]))
print('='*50)




essay_test_avg_w2v = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(preprocessed_essays_test): # for each essay in training data
    vector = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        if word in glove_words:
            vector += model[word][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    essay_test_avg_w2v.append(vector)

print(len(essay_test_avg_w2v))
print(len(essay_test_avg_w2v[0]))





essay_cv_avg_w2v = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(preprocessed_essays_cv): # for each essay in training data
    vector = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        if word in glove_words:
            vector += model[word][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    essay_cv_avg_w2v.append(vector)

print(len(essay_cv_avg_w2v))
print(len(essay_cv_avg_w2v[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 32857/32857
[00:13<00:00, 2455.83it/s]
```

```
32857
50
==================================================
```

```
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[00:13<00:00, 2614.27it/s]
```

```
36052
50
```

```
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[00:06<00:00, 2646.85it/s]
```

```
16184
50
```

In [70]:

```
# Changing list to numpy arrays
#https://docs.scipy.org/doc/numpy/reference/generated/numpy.asarray.html
essay_avg_w2v = np.array(essay_avg_w2v)
essay_cv_avg_w2v = np.array(essay_cv_avg_w2v)
essay_test_avg_w2v  = np.array(essay_test_avg_w2v )
```

title_avg_w2v_vectorizing

In [71]:

```
#title_avg_w2v vectorization
title_avg_w2v = []; # the avg-w2v for each title is stored in this list
for sentence in tqdm(preprocessed_titles_train): # for each title in training data
    vector = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the title
    for word in sentence.split(): # for each word in a title
        if word in glove_words:
            vector += model[word][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    title_avg_w2v.append(vector)

print(len(title_avg_w2v))
print(len(title_avg_w2v[0]))
print('='*50)

# average Word2Vec
# compute average word2vec for each review.
title_test_avg_w2v = []; # the avg-w2v for each title is stored in this list
for sentence in tqdm(preprocessed_titles_test): # for each title in training data
    vector = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the title
    for word in sentence.split(): # for each word in a title
        if word in glove_words:
            vector += model[word][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    title_test_avg_w2v.append(vector)

print(len(title_test_avg_w2v))
print(len(title_test_avg_w2v[0]))
print('='*50)

# average Word2Vec
# compute average word2vec for each review.
title_cv_avg_w2v = []; # the avg-w2v for each title is stored in this list
for sentence in tqdm(preprocessed_titles_cv): # for each title in training data
    vector = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the title
    for word in sentence.split(): # for each word in a title
        if word in glove_words:
            vector += model[word][:50]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    title_cv_avg_w2v.append(vector)

print(len(title_cv_avg_w2v))
print(len(title_cv_avg_w2v[0]))
print('='*50)
```

```
100%|███████████████████████████████████████████████████████████████████████████| 32857/32857
[00:00<00:00, 60497.65it/s]
```

```
32857
50
==================================================
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100%|███████████████████████████████████████████████████████████████████████████| 36052/36052
[00:00<00:00, 64502.46it/s]
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```
36052
50
==================================================
```

```
100%|███████████████████████████████████████████████████████████████████████████| 16184/16184
[00:00<00:00, 56239.30it/s]
```

```
16184
50
==================================================
```

In [72]:

```
title_avg_w2v  = np.array(title_avg_w2v )
title_cv_avg_w2v = np.array(title_cv_avg_w2v)
title_test_avg_w2v = np.array(title_test_avg_w2v)
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

essay_tfidf_weighted_w2v_vectorizing

In [73]:

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

In [74]:

```
# tfidf_avg_w2v
# compute tfidf average word2vec for each review.
essay_train_tfidf_w2v_vectors = []; # the tfidf avg-w2v for each essay is stored in this list
for sentence in tqdm(preprocessed_essays_train): # 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 essay
    for word in sentence.split(): # for each word in a essay
        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
    essay_train_tfidf_w2v_vectors.append(vector)

print(len(essay_train_tfidf_w2v_vectors[0]))


# tfidf_avg_w2v
# compute tfidf average word2vec for each review.
```

```
essay_cv_tfidf_w2v_vectors = []; # the tfidf avg-w2v for each essay is stored in this list
for sentence in tqdm(preprocessed_essays_cv): # for each essay
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        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
    essay_cv_tfidf_w2v_vectors.append(vector)

print(len(essay_cv_tfidf_w2v_vectors[0]))




# tfidf_avg_w2v
# compute tfidf average word2vec for each essay.
essay_test_tfidf_w2v_vectors = []; # the tfidf avg-w2v for each essay is stored in this list
for sentence in tqdm(preprocessed_essays_test): # for each essay
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        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
    essay_test_tfidf_w2v_vectors.append(vector)

print(len(essay_test_tfidf_w2v_vectors[0]))
```

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100%|██████████████████████████████████████████████████████████████████████████████| 32857/32857 [01:
26<00:00, 380.47it/s]
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300
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42<00:00, 384.29it/s]
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300
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37<00:00, 368.68it/s]
```

```
300
```

In [75]:

```
# Changing list to numpy arrays
essay_train_tfidf_w2v_vectors = np.array(essay_train_tfidf_w2v_vectors)
essay_cv_tfidf_w2v_vectors = np.array(essay_cv_tfidf_w2v_vectors)
essay_test_tfidf_w2v_vectors  = np.array(essay_test_tfidf_w2v_vectors )
```

title_tfidf_avg_w2v_vectorizing

In [76]:

```
# tfidf_avg_w2v
# compute average word2vec for each title.
title_tfidf_w2v_vectors = []; # the tfidf avg-w2v for each title is stored in this list
for sentence in tqdm(preprocessed_titles_train): # 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 title
    for word in sentence.split(): # for each word in a title
        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
    title_tfidf_w2v_vectors.append(vector)

print(len(title_tfidf_w2v_vectors))
print(len(title_tfidf_w2v_vectors[0]))


# tfidf_average_Word2Vec vectorization
# compute average tfidf_avg_w2v for each title.
title_cv_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_cv): # 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
    title_cv_tfidf_w2v_vectors.append(vector)

print(len(title_cv_tfidf_w2v_vectors))
print(len(title_cv_tfidf_w2v_vectors[0]))


# tfidf_average_Word2Vec
# compute tfidf_average_word2vec for each title.
title_test_tfidf_w2v_vectors = []; # the tfidf_avg-w2v for each title is stored in this list
for sentence in tqdm(preprocessed_titles_test): # for each title
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the title
    for word in sentence.split(): # for each word in a title
        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
    title_test_tfidf_w2v_vectors.append(vector)

print(len(title_test_tfidf_w2v_vectors))
print(len(title_test_tfidf_w2v_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 32857/32857
[00:01<00:00, 23195.40it/s]
```

```
32857
300
```

```
100%|██████████████████████████████████████████████████████████████████████████| 16184/16184
```

```
[00:00<00:00, 23706.35it/s]
```

```
16184
300
```

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[00:01<00:00, 23844.29it/s]
```

```
36052
300
```

In [77]:

```
# Changing list to numpy arrays
title_tfidf_w2v_vectors = np.array(title_tfidf_w2v_vectors)
title_cv_tfidf_w2v_vectors = np.array(title_cv_tfidf_w2v_vectors)
title_test_tfidf_w2v_vectors  = np.array(title_test_tfidf_w2v_vectors )
```

1.5.3 Vectorizing Numerical features

In [78]:

```
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 [79]:

```
X_train = pd.merge(X_train, price_data, on = "id", how = "left")
X_test = pd.merge(X_test, price_data, on = "id", how = "left")
X_cv = pd.merge(X_cv, price_data, on = "id", how = "left")
```

price_standardization

In [80]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-
learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn import preprocessing


price_scalar = StandardScaler()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard
deviationof this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above mean and variance.
train_price_standar = price_scalar.transform(X_train['price'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
test_price_standar = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
# Now standardize the data with above maen and variance.
cv_price_standar = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))
```

quantity_standardization

In [81]:

```
price_scalar.fit(X_train['quantity'].values.reshape(-1,1)) # finding the mean and
standarddeviation of this data

#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.

train_qnty_standar = price_scalar.transform(X_train['quantity'].values.reshape(-1, 1))
cv_qnty_standar = price_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
```

```
test_qnty_standar = price_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
```

teacher_number_of_previously_posted_projects_standardization

In [82]:

```
price_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # fi
nding the mean and standard deviation of this data

#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")
# Now standardize the data with above maen and variance.


train_prev_proj_standar
=price_scalar.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,
1))
test_prev_proj_standar
=price_scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1
))
cv_prev_proj_standar = price_scalar.transform(X_cv['teacher_number_of_previously_posted_projects']
.values.reshape(-1, 1))
```

1. **[Task-1] Apply Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on these feature sets**

    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **The hyper paramter tuning (best alpha in range [10^-4 to 10^4], and the best penalty among 'l1', 'l2')**

    - Find the best hyper parameter which will give the maximum AUC value
    - Find the best hyper paramter using k-fold cross validation or simple cross validation data
    - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

3. **Representation of results**

    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure.
    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
    - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points. Please visualize your confusion matrices using seaborn heatmaps.

4. **[Task-2] Apply the Support Vector Machines on these features by finding the best hyper paramter as suggested in step 2 and step 3**

    - Consider these set of features Set 5 :
        - **school_state** : categorical data
        - **clean_categories** : categorical data
        - **clean_subcategories** : categorical data
        - **project_grade_category** :categorical data
        - **teacher_prefix** : categorical data
        - **quantity** : numerical data
        - **teacher_number_of_previously_posted_projects** : numerical data
        - **price** : numerical data
        - **sentiment score's of each of the essay** : numerical data
        - **number of words in the title** : numerical data
        - **number of words in the combine essays** : numerical data
        - **Apply TruncatedSVD on TfidfVectorizer of essay text, choose the number of components (`n_components`) using elbow method** : numerical data

    - **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

1.5.4 Merging all the above features

Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

In [83]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_tr_bow = hstack((X_train_bow_title,X_train_bow,X_train_teacher_prefix,X_train_cat,X_train_subcat
,X_train_project_grade_category,X_train_school_state,train_qnty_standar,train_price_standar,train_p
rev_proj_standar))
X_cv_bow = hstack((X_cv_bow_title,X_cv_bow,X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,X_cv_project_gr
ade_category,X_cv_school_state,cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))
X_test_bow =
hstack((X_test_bow_title,X_test_bow,X_test_teacher_prefix,X_test_cat,X_test_subcat,X_test_project_g
rade_category,X_test_school_state,test_qnty_standar,test_price_standar,test_prev_proj_standar))
```

In [84]:

```
print(X_tr_bow.shape, y_train.shape)
print(X_cv_bow.shape, y_train.shape)
print(X_test_bow.shape, y_train.shape)
```

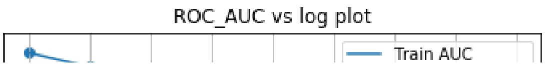
```
(32857, 7380) (32857,)
(16184, 7380) (32857,)
(36052, 7380) (32857,)
```

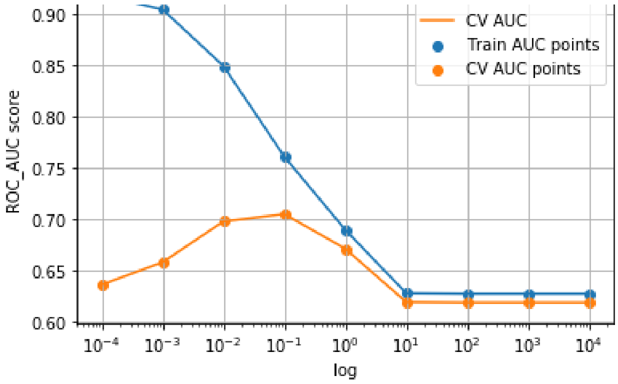
In [85]:

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

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

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





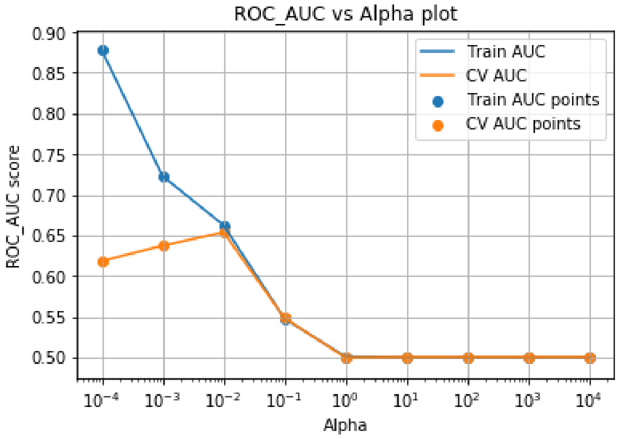
In [86]:

```
# hyperparameter tuning with l1 reg
#parameters = {'alpha':
[0.007,0.009,0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,1.2,1.4,1.6,1.8,2,2.2,2.4,2.6,2.8,3,3,
4,4.5,5]}
import warnings
warnings.filterwarnings("ignore")


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

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

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



observation: l2 regualization is doing better than l1 regularization

fitting_best_alpha_hyper_parameter_to_the_model¶

In [87]:

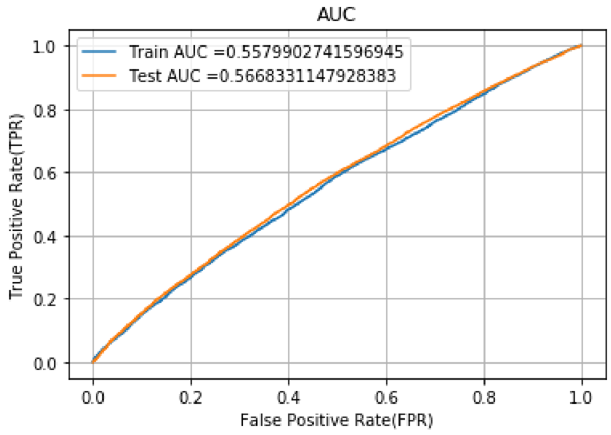
```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
```

```
from sklearn.metrics import roc_curve, auc
Classifier_bow = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 10)
Classifier_bow.fit(X_tr_bow ,y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn..
r_model.SGDClassifier.decision_function
y_train_pred = Classifier_bow.decision_function(X_tr_bow)
y_test_pred = Classifier_bow.decision_function(X_test_bow)

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

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



In [88]:

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

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

In [89]:

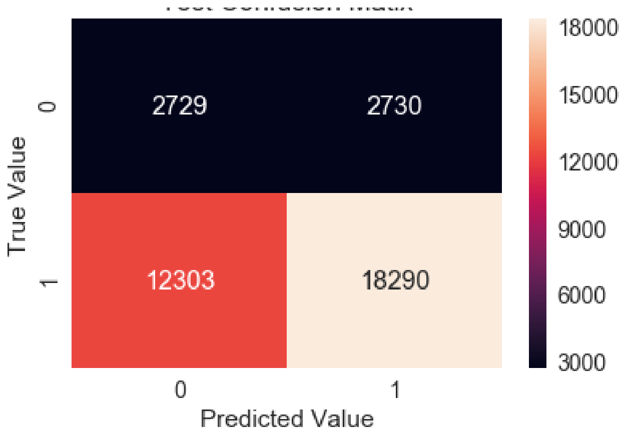
```
import seaborn as sea
test_confusion_matrix = pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred, te_thresholds,tes
t_fpr,test_fpr)),range(2),range(2))
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.99
```

Out[89]:

```
Text(0.5,1,'Test Confusion Matix')
```

Test Confusion Matix



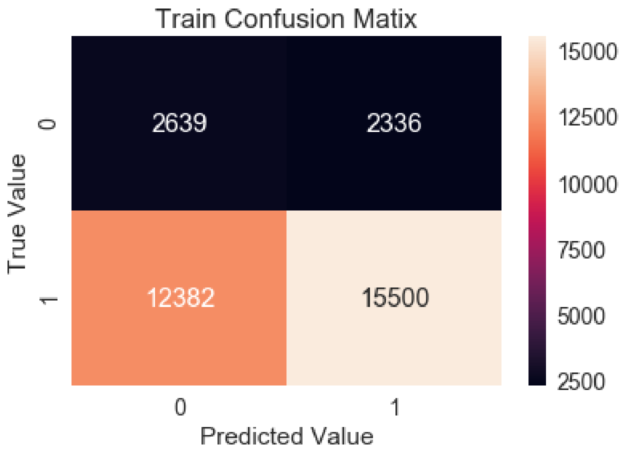
In [90]:

```
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred, te_thresholds
,train_fpr,train_fpr)),range(2),range(2))
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.01
```

Out[90]:

```
Text(0.5,1,'Train Confusion Matix')
```



Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)

In [91]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_tr_tfidf =
hstack((X_train_tf_essay,X_train_tf_title,X_train_teacher_prefix,X_train_cat,X_train_subcat,X_train
_project_grade_category,X_train_school_state,train_qnty_standar,train_price_standar,train_prev_proj
_standar))

X_cv_tfidf =
hstack((X_cv_tf_essay,X_cv_tf_title,X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,X_cv_project_grade_cat
egory,X_cv_school_state,cv_qnty_standar,cv_price_standar,cv_prev_proj_standar))

X_test_tfidf =
hstack((X_test_tf_essay,X_test_tf_title,X_test_teacher_prefix,X_test_cat,X_test_subcat,X_test_proje
ct_grade_category,X_test_school_state,test_qnty_standar,test_price_standar,test_prev_proj_standar)
)
```

```
print(X_cv_tfidf.shape, y_cv.shape)
print(X_tr_tfidf.shape, y_train.shape)
print(X_test_tfidf.shape, y_test.shape)
```

```
(16184, 7380) (16184,)
(32857, 7380) (32857,)
(36052, 7380) (36052,)
```

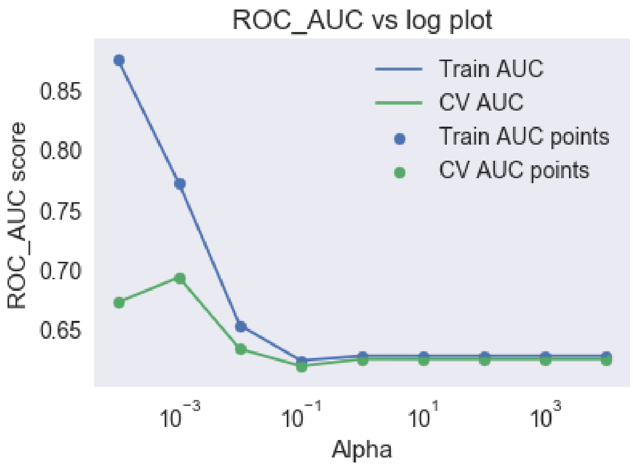
In [92]:

```
#BY USING L2 REGULARISER
# hyperparameter tuning with l2 reg
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
#from sklearn.datasets import *
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_tr_tfidf, y_train)

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

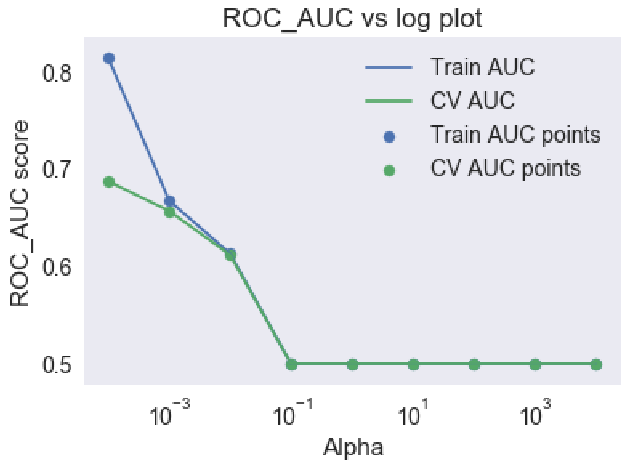
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')

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



In [93]:

```
# hyperparameter tuning with l1 reg reduce the alpha values in list
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_tr_tfidf, y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']
plt.plot(parameters['alpha'], train_auc, label='Train AUC')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xscale('log')
plt.xlabel("Alpha")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```



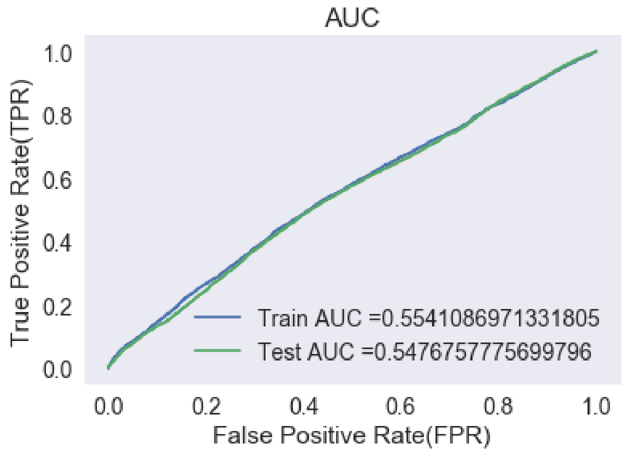
fitting_best_alpha_hyper_parameter_to_the_model¶

In [94]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_tfidf = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 1)
Classifier_tfidf.fit(X_tr_tfidf ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn..
r_model.SGDClassifier.decision_function
y_train_pred = Classifier_tfidf.decision_function(X_tr_tfidf)
y_test_pred = Classifier_tfidf.decision_function(X_test_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.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



In [95]:

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

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

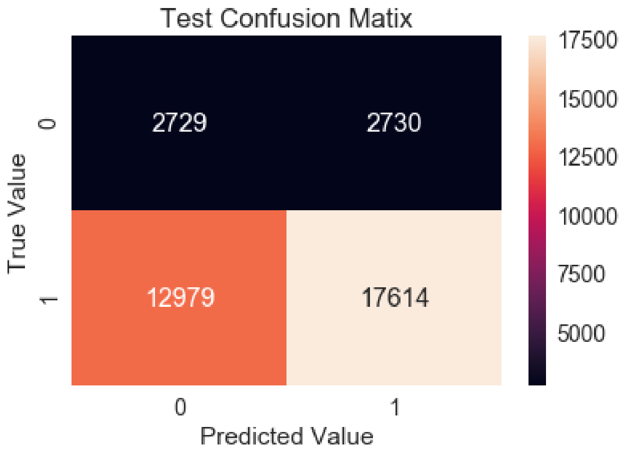
In [96]:

```
#CONFUSION MATRIX
import seaborn as sea
test_confusion_matrix =
pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_thresholds,test_fpr,test_fpr)), range(2
),range(2))
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.53
```

Out[96]:

```
Text(0.5,1,'Test Confusion Matix')
```



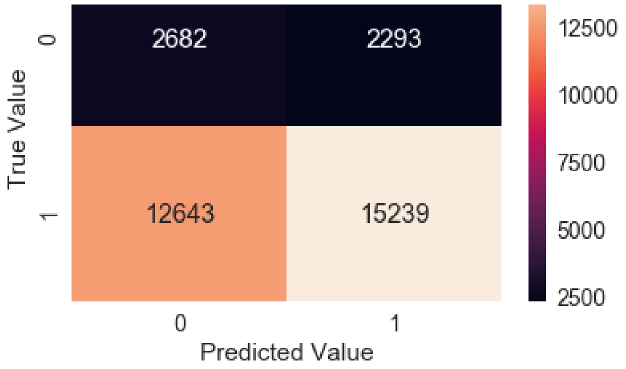
In [97]:

```
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresholds,
train_fpr,train_fpr)), range(2),range(2))
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.56
```

Out[97]:

```
Text(0.5,1,'Train Confusion Matix')
```



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

In [98]:

```
from scipy.sparse import hstack
import numpy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
X_tr_w2v =
hstack((essay_avg_w2v,title_avg_w2v,train_prev_proj_standar,train_price_standar,train_qnty_standar
, X_train_teacher_prefix,X_train_cat,X_train_subcat,
X_train_project_grade_category,X_train_school_state))
X_cv_w2v
=hstack((essay_cv_avg_w2v,title_cv_avg_w2v,cv_prev_proj_standar,cv_price_standar,cv_qnty_standar,X
_cv_teacher_prefix,X_cv_cat,X_cv_subcat,X_cv_project_grade_category,X_cv_school_state))
X_test_w2v
=hstack((essay_test_avg_w2v,title_test_avg_w2v,test_prev_proj_standar,test_price_standar,test_qnty_
standar,X_test_teacher_prefix,X_test_cat,X_test_subcat,X_test_project_grade_category,X_test_school_
state))

print(X_tr_w2v.shape, y_train.shape)
print(X_test_w2v.shape, y_test.shape)
print(X_cv_w2v.shape, y_cv.shape)
```

```
(32857, 203) (32857,)
(36052, 203) (36052,)
(16184, 203) (16184,)
```

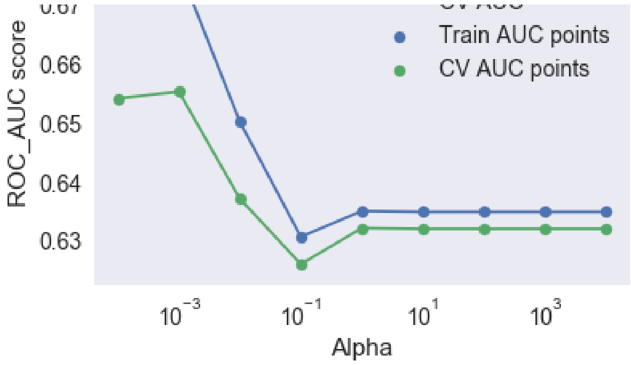
In [99]:

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

classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_tr_w2v, y_train)

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

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



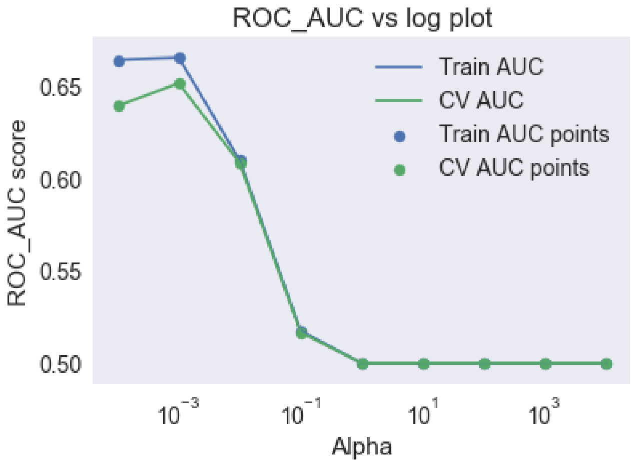
In [100]:

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

classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_tr_w2v, y_train)

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

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



fitting_best_alpha_hyper_parameter_to_the_model¶

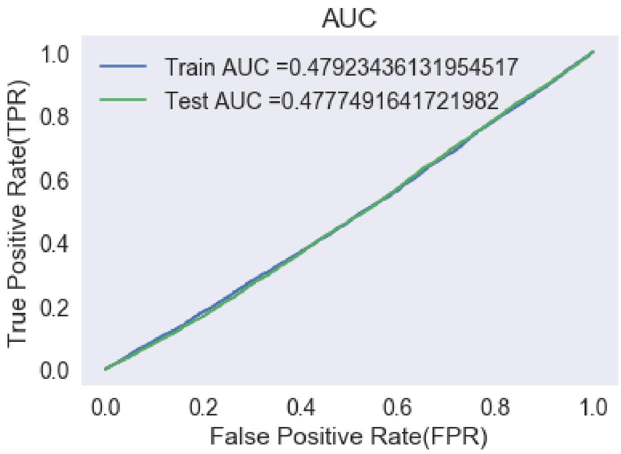
In [101]:

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

from sklearn.metrics import roc_curve, auc
Classifier_w2v = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 1)
Classifier_w2v.fit(X_tr_w2v ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn..
r_model.SGDClassifier.decision_function
y_train_pred = Classifier_w2v.decision_function(X_tr_w2v)
y_test_pred = Classifier_w2v.decision_function(X_test_w2v)
```

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

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



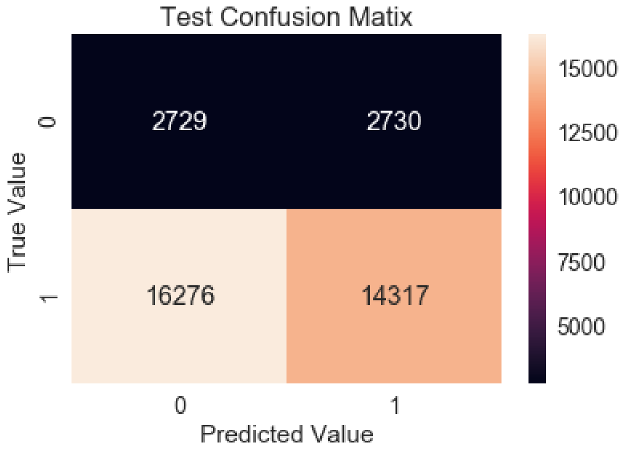
In [102]:

```
#CONFUSION MATRIX
import seaborn as sea
test_confusion_matrix = 
pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_thresholds,test_fpr,test_fpr)), range(2
),range(2))
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.04
```

Out[102]:

```
Text(0.5,1,'Test Confusion Matix')
```



In [103]:

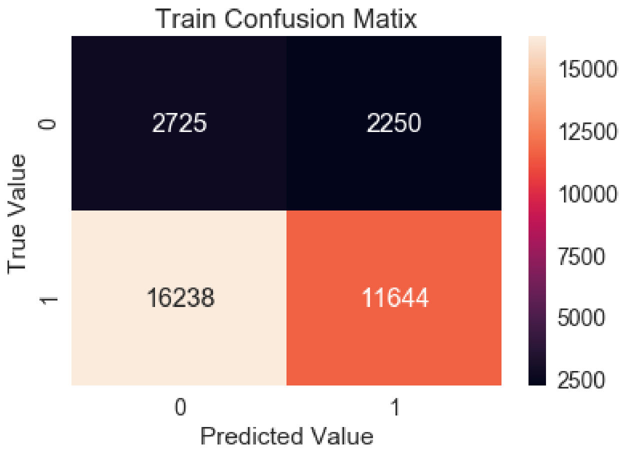
```
#CONFUSION MATRIX
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresholds,
train_fpr,train_fpr)), range(2),range(2))
```

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

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.05
```

Out[103]:

```
Text(0.5,1,'Train Confusion Matix')
```



Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

In [104]:

```
X_tr_avg_tfidf_w2v =hstack((essay_train_tfidf_w2v_vectors,
title_tfidf_w2v_vectors,train_prev_proj_standar,train_price_standar,train_qnty_standar,X_train_teac
her_prefix,X_train_cat,X_train_subcat,X_train_project_grade_category,X_train_school_state))
X_cv_avg_tfidf_w2v
=hstack((essay_cv_tfidf_w2v_vectors,title_cv_tfidf_w2v_vectors,cv_prev_proj_standar,cv_price_standa
r,cv_qnty_standar,X_cv_teacher_prefix,X_cv_cat,X_cv_subcat,X_cv_project_grade_category,X_cv_school_
state))
X_test_avg_tfidf_w2v =
hstack((essay_test_tfidf_w2v_vectors,title_test_tfidf_w2v_vectors,test_prev_proj_standar,test_price
_standar,test_qnty_standar,X_test_teacher_prefix,X_test_cat,X_test_subcat,X_test_project_grade_cate
gory,X_test_school_state))



print(X_tr_avg_tfidf_w2v.shape, y_test.shape)
print(X_test_avg_tfidf_w2v.shape, y_train.shape)
print(X_cv_avg_tfidf_w2v.shape, y_cv.shape)
```

```
(32857, 703) (36052,)
(36052, 703) (32857,)
(16184, 703) (16184,)
```

In [105]:

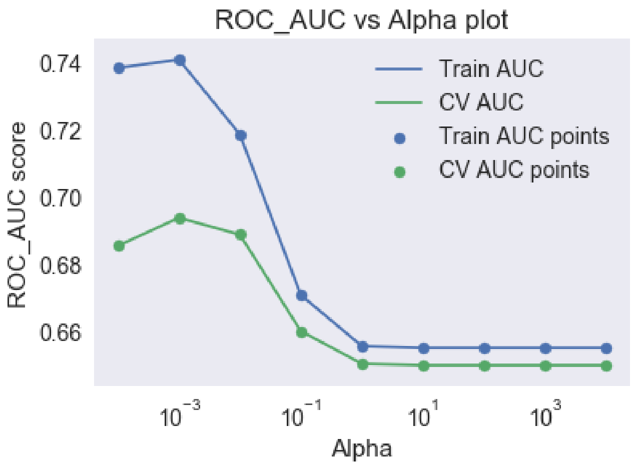
```
#l2 REGULARISER

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

classifier = GridSearchCV(SV, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_tr_avg_tfidf_w2v, y_train)

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

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



In [106]:

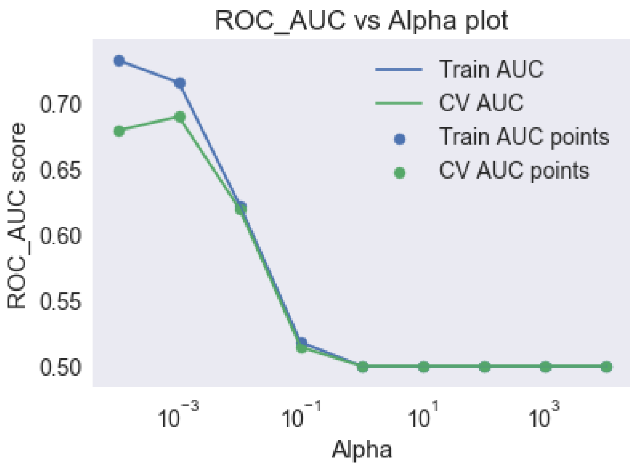
```
#L1 REGULARIZER

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

classifier = GridSearchCV(SV, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_tr_avg_tfidf_w2v, y_train)

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

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



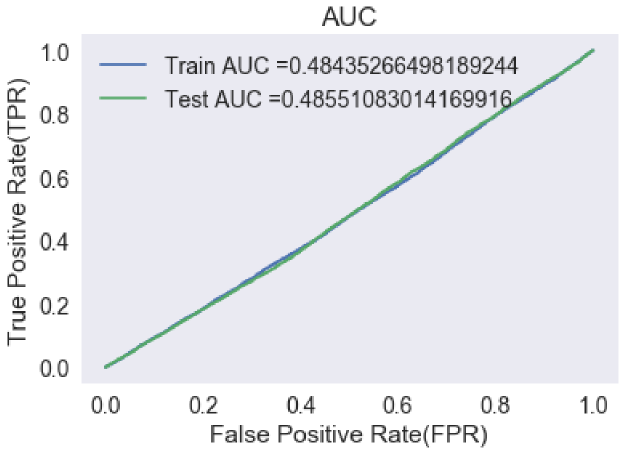
fitting_best_alpha_hyper_parameter_to_the_model¶

In [107]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_tfidf_w2v = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 1)
Classifier_tfidf_w2v.fit(X_tr_avg_tfidf_w2v ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn..
r_model.SGDClassifier.decision_function
y_train_pred = Classifier_tfidf_w2v.decision_function(X_tr_avg_tfidf_w2v)
y_test_pred = Classifier_tfidf_w2v.decision_function(X_test_avg_tfidf_w2v)

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

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



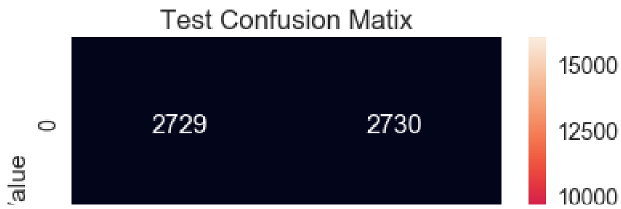
In [108]:

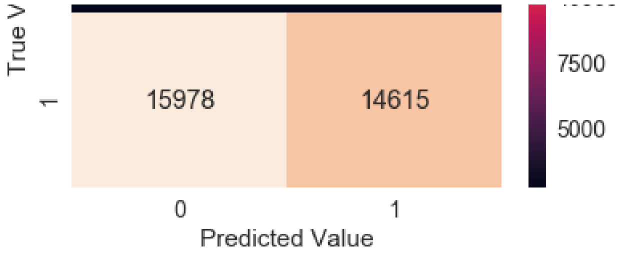
```
#CONFUSION MATRIX
import seaborn as sea
test_confusion_matrix =
pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_thresholds,test_fpr,test_fpr)), range(2
),range(2))
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.06
```

Out[108]:

```
Text(0.5,1,'Test Confusion Matix')
```





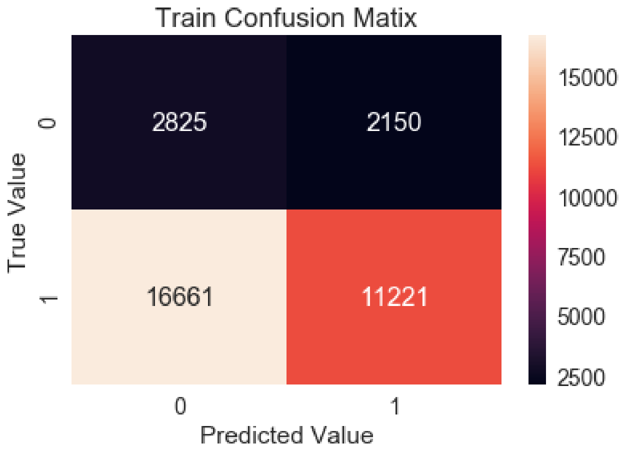
In [109]:

```
#CONFUSION MATRIX
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresholds,
train_fpr,train_fpr)), range(2),range(2))
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.06
```

Out[109]:

```
Text(0.5,1,'Train Confusion Matix')
```



In [111]:

```
# numbe of words in title andnumber of wo essay
train_word_count_essay = []
train_word_count_title = []
cv_word_count_essay = []
cv_word_count_title = []
test_word_count_essay = []
test_word_count_title = []

# training data
for title, essay in tqdm(zip(X_train_title, X_train_essay)):
  train_word_count_title.append(len(title.split()))
  train_word_count_essay.append(len(essay.split()))

train_word_count_title = np.array(train_word_count_title).reshape(-1,1)
train_word_count_essay = np.array(train_word_count_essay).reshape(-1,1)

# cross validation data
for title, essay in tqdm(zip(X_cv_title, X_cv_essay)):
  cv_word_count_title.append(len(title.split()))
  cv_word_count_essay.append(len(essay.split()))

cv_word_count_title = np.array(cv_word_count_title).reshape(-1,1)
cv_word_count_essay = np.array(cv_word_count_essay).reshape(-1,1)

# test data
for title, essay in tqdm(zip(X_test_title, X_test_essay)):
```

```
for title, essay in tqdm(zip(X_test_title, X_test_essay)):
  test_word_count_title.append(len(title.split()))
  test_word_count_essay.append(len(essay.split()))

test_word_count_title = np.array(test_word_count_title).reshape(-1,1)
test_word_count_essay = np.array(test_word_count_essay).reshape(-1,1)
```

```
32857it [00:00, 66429.34it/s]
16184it [00:00, 45880.19it/s]
36052it [00:00, 48459.32it/s]
```

In [112]:

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

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

Out[112]:

```
True
```

In [113]:

```
# sentiment polarity
import warnings
warnings.filterwarnings("ignore")
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()

sentiment_neg = []
sentiment_pos = []
sentiment_neu = []
sentiment_compound = []

# training data
for sentence in tqdm(X_train_essay):
  ss = sid.polarity_scores(sentence)
  sentiment_neg.append(ss['neg'])
  sentiment_pos.append(ss['pos'])
  sentiment_neu.append(ss['neu'])
  sentiment_compound.append(ss['compound'])

sentiment_neg = np.array(sentiment_neg).reshape(-1,1)
sentiment_pos = np.array(sentiment_pos).reshape(-1,1)
sentiment_neu = np.array(sentiment_neu).reshape(-1,1)
sentiment_compound = np.array(sentiment_compound).reshape(-1,1)

# cross validation
cv_sentiment_neg = []
cv_sentiment_pos = []
cv_sentiment_neu = []
cv_sentiment_compound = []

for sentence in tqdm(X_cv_essay):
  ss = sid.polarity_scores(sentence)
  cv_sentiment_neg.append(ss['neg'])
  cv_sentiment_pos.append(ss['pos'])
  cv_sentiment_neu.append(ss['neu'])
  cv_sentiment_compound.append(ss['compound'])

cv_sentiment_neg = np.array(cv_sentiment_neg).reshape(-1,1)
cv_sentiment_pos = np.array(cv_sentiment_pos).reshape(-1,1)
cv_sentiment_neu = np.array(cv_sentiment_neu).reshape(-1,1)
cv_sentiment_compound = np.array(cv_sentiment_compound).reshape(-1,1)

# test data
test_sentiment_neg = []
test_sentiment_pos = []
test_sentiment_neu = []
test_sentiment_compound = []
```

```
for sentence in tqdm(X_test_essay):
  ss = sid.polarity_scores(sentence)
  test_sentiment_neg.append(ss['neg'])
  test_sentiment_pos.append(ss['pos'])
  test_sentiment_neu.append(ss['neu'])
  test_sentiment_compound.append(ss['compound'])

test_sentiment_neg = np.array(test_sentiment_neg).reshape(-1,1)
test_sentiment_pos = np.array(test_sentiment_pos).reshape(-1,1)
test_sentiment_neu = np.array(test_sentiment_neu).reshape(-1,1)
test_sentiment_compound = np.array(test_sentiment_compound).reshape(-1,1)

# we can use these 4 things as features/attributes (neg, neu, pos, compound)
# neg: 0.0, neu: 0.753, pos: 0.247, compound: 0.93
```

```
100%|████████████████████████████████████████████████████████████████████████████| 32857/32857 [01:
30<00:00, 361.82it/s]
100%|████████████████████████████████████████████████████████████████████████████| 16184/16184 [00:
55<00:00, 291.79it/s]
100%|████████████████████████████████████████████████████████████████████████████| 36052/36052 [01:
58<00:00, 305.35it/s]
```

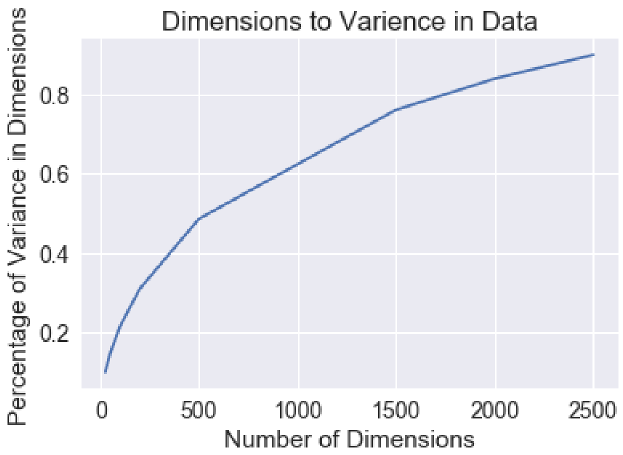
In [114]:

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

```
100%|████████████████████████████████████████████████████████████████████████████████████| 8/8 [08:
26<00:00, 112.49s/it]
```

In [115]:

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



In [116]:

```
svd = TruncatedSVD(n_components= 2000)
svd.fit(X_train_tf_essay)
#Transforms:
```

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

2.5 Support Vector Machines with added Features Set 5 ¶

In [117]:

```
# combine all
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_tr_svd =
hstack((X_train_teacher_prefix,X_train_cat,X_train_subcat,X_train_project_grade_category,X_train_sc
hool_state,train_qnty_standar,train_price_standar,train_prev_proj_standar,train_word_count_essay,t
rain_word_count_title,sentiment_pos,sentiment_neg,sentiment_compound))
X_test_svd = hstack((X_test_teacher_prefix,X_test_cat,X_test_subcat ,X_test_project_grade_category
,X_test_school_state,test_qnty_standar,test_price_standar,test_prev_proj_standar,test_word_count_es
say,test_word_count_title,test_sentiment_pos,test_sentiment_neg ,test_sentiment_compound))
```

In [118]:

```
#by l1 regularization
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV

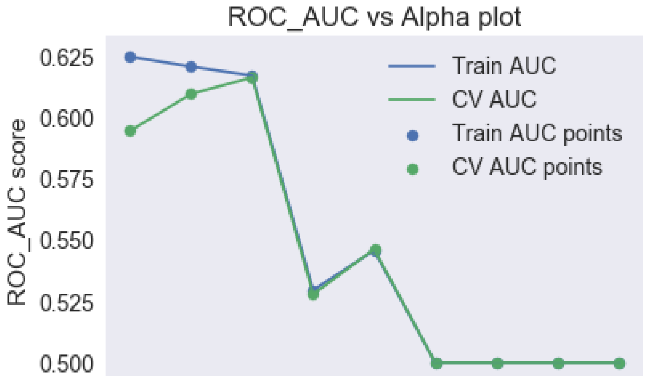
#from sklearn.datasets import *
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm

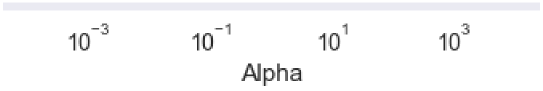
# hyperparameter tuning with l2 reg
#we are using L1 Regularizer
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
SV = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced',)
classifier = GridSearchCV(SV, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_tr_svd, y_train)

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

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

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





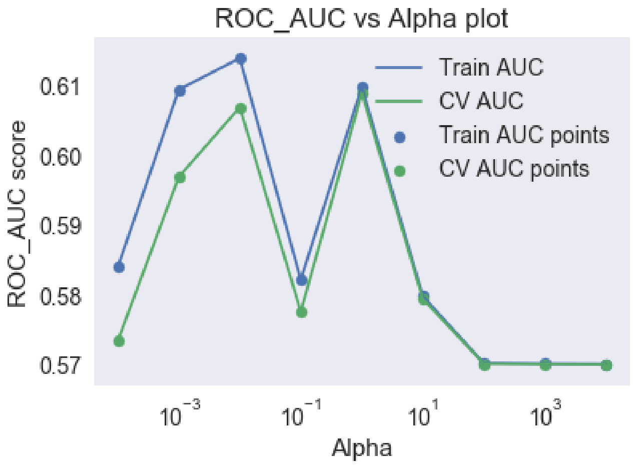
In [119]:

```
#BY USING L2 REGULARISER

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

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

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



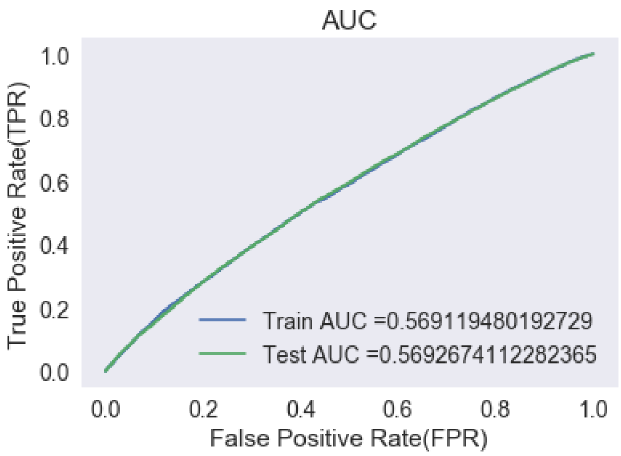
fitting_best_alpha_hyper_parameter_to_the_model

In [120]:

```
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_n = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 10**3)
Classifier_n.fit(X_tr_svd ,y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
#https://scikitlearn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html#sklearn..
r_model.SGDClassifier.decision_function
y_train_pred = Classifier_n.decision_function(X_tr_svd)
y_test_pred = Classifier_n.decision_function(X_test_svd)

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

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



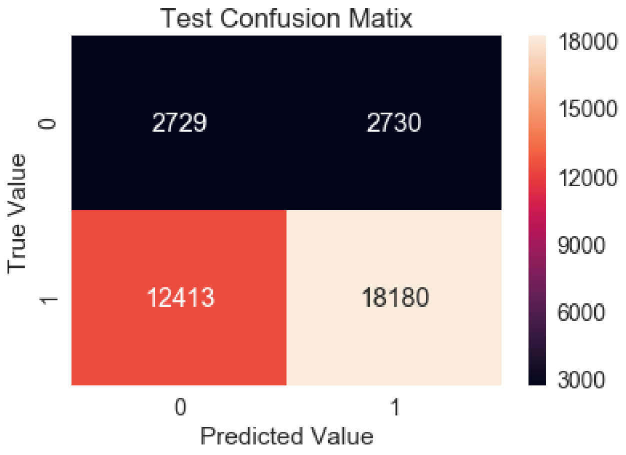
In [121]:

```
#Confusion_matrix
import seaborn as sea
test_confusion_matrix =
pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,te_thresholds,test_fpr,test_fpr)), range(2
),range(2))
sea.set(font_scale=1.4)
sea.heatmap(test_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Test Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.05
```

Out[121]:

```
Text(0.5,1,'Test Confusion Matix')
```



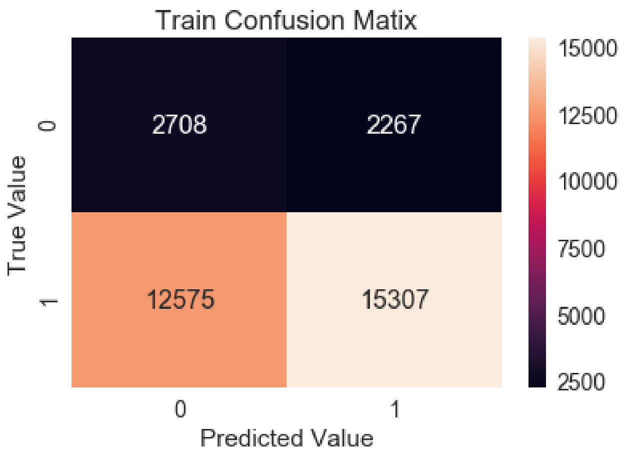
In [122]:

```
import seaborn as sea
train_confusion_matrix = pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,te_thresholds,
train_fpr,train_fpr)), range(2),range(2))
sea.set(font_scale=1.4)
sea.heatmap(train_confusion_matrix, annot = True, annot_kws={"size":16}, fmt = 'd')
plt.xlabel("Predicted Value")
plt.ylabel("True Value")
plt.title("Train Confusion Matix")
```

```
the maximum value of tpr*(1-fpr) 0.25 for threshold 1.08
```

Out[122]:

```
Text(0.5,1,'Train Confusion Matix')
```



3. Conclusion

In [124]:

```
#how to use pretty table http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
tb = PrettyTable()
tb.field_names= ("Vectorizer", " Alpha ", " Test_AUC ")
tb.add_row(["BOW ", 10,0.558])
tb.add_row(["TfIdf ", 1, 0.545])
tb.add_row(["AVG_W2V", 1, 0.473])
tb.add_row(["AVG_TfIdf", 1, 0.481])
tb.add_row(["SVD_Top_2000_Features", 10**3, 0.566])
print(tb.get_string(titles = "SVM_Observations"))
```

```
+-----------------------+---------+------------+
|       Vectorizer      |  Alpha  |  Test_AUC  |
+-----------------------+---------+------------+
|          BOW          |    10   |   0.558    |
|         TfIdf         |    1    |   0.545    |
|        AVG_W2V        |    1    |   0.473    |
|       AVG_TfIdf       |    1    |   0.481    |
| SVD_Top_2000_Features |   1000  |   0.566    |
+-----------------------+---------+------------+
```