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	
`project_id`	A unique identifier for the proposed project
`project_title`	Title of t • `Art Wil` •
`project_grade_category`	Grade level of students for which the project is targete • • • •

Feature	
project_subject_categories	One or more (comma-separated) subject categories f following enur • Li • Literacy & Languag
school_state	State where school is located (Two- (https://en.wikipedia.org/wiki/List_of_U.S._state_abbrevia
project_subject_subcategories	One or more (comma-separated) subject subcate • Literature & Writing
project_resource_summary	An explanation of the resources needed for t • My students need hands on literacy mat sen
project_essay_1	F
project_essay_2	Sec
project_essay_3	Tl
project_essay_4	Fou
project_submitted_datetime	Datetime when project application was submitted. **Exa**
teacher_id	A unique identifier for the teacher of the propos bdf8baa8fedef6b
teacher_prefix	Teacher's title. One of the following
teacher_number_of_previously_posted_projects	Number of project applications previously submitted

* 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."
- __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 [1]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

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

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

import re
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from tqdm import tqdm
import os


from collections import Counter
```

Reading Data

In [2]:
```
project_data = pd.read_csv('train_data.csv',nrows=70000)
resource_data = pd.read_csv('resources.csv')
```

In [3]:
```
project_data.isnull().sum()
```

Out[3]:
```
Unnamed: 0                                        0
id                                                0
teacher_id                                        0
teacher_prefix                                    3
school_state                                      0
project_submitted_datetime                        0
project_grade_category                            0
project_subject_categories                        0
project_subject_subcategories                     0
project_title                                     0
project_essay_1                                   0
project_essay_2                                   0
project_essay_3                               67612
project_essay_4                               67612
project_resource_summary                          0
teacher_number_of_previously_posted_projects      0
project_is_approved                               0
dtype: int64
```

In [4]:
```
project_data.dropna(subset = ['teacher_prefix'], inplace=True)
```

In [5]:
```
project_data.isnull().sum()
```

Out[5]:
```
Unnamed: 0                                        0
id                                                0
teacher_id                                        0
teacher_prefix                                    0
school_state                                      0
project_submitted_datetime                        0
project_grade_category                            0
project_subject_categories                        0
project_subject_subcategories                     0
project_title                                     0
project_essay_1                                   0
project_essay_2                                   0
project_essay_3                               67610
project_essay_4                               67610
project_resource_summary                          0
teacher_number_of_previously_posted_projects      0
project_is_approved                               0
dtype: int64
```

In [6]:
```
y = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)
```

In [7]:
```
print("Number of data points in entire data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in entire data (69997, 16)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'scho
ol_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']
```

In [8]:
```
print("Number of data points in entire data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

Out[8]:

	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

Preprocessing of `project_subject_categories`

In [9]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.co

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-
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",
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trail
        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]))
```

Preprocessing of project_subject_subcategories

In [10]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.co

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

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",
        if 'The' in j.split(): # this will split each of the catogory based on sp
            j=j.replace('The','') # if we have the words "The" we are going to re
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty)
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trail
        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/22898595/4
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]))
```

Text preprocessing

In [11]:
```
# 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 [12]:
```
# Dropping the other 4 columns related in project essay
project_data.drop(['project_essay_1', 'project_essay_2', 'project_essay_3', 'proj
```

In [13]:
```
project_data.head(2)
```

Out[13]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_sul
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	20
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	20

In [14]:
```
# 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[29500])
print("="*50)
```

```
My students are English learners that are working on English as their second or
third languages. We are a melting pot of refugees, immigrants, and native-born
Americans bringing the gift of language to our school. \r\n\r\n We have over 24
languages represented in our English Learner program with students at every lev
el of mastery.  We also have over 40 countries represented with the families wi
thin our school.  Each student brings a wealth of knowledge and experiences to
us that open our eyes to new cultures, beliefs, and respect.\"The limits of you
r language are the limits of your world.\"-Ludwig Wittgenstein  Our English lea
rner's have a strong support system at home that begs for more resources.  Many
times our parents are learning to read and speak English along side of their ch
ildren.  Sometimes this creates barriers for parents to be able to help their c
hild learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy p
roviding these dvd's and players, students are able to continue their mastery o
f the English language even if no one at home is able to assist.  All families
with students within the Level 1 proficiency status, will be a offered to be a
part of this program.  These educational videos will be specially chosen by the
English Learner Teacher and will be sent home regularly to watch.  The videos a
re to help the child develop early reading skills.\r\n\r\nParents that do not h
ave access to a dvd player will have the opportunity to check out a dvd player
to use for the year.  The plan is to use these videos and educational dvd's for
the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all
love learning, at least most of the time. At our school, 97.3% of the students
receive free or reduced price lunch. Of the 560 students, 97.3% are minority st
udents. \r\nThe school has a vibrant community that loves to get together and c
elebrate. Around Halloween there is a whole school parade to show off the beaut
iful costumes that students wear. On Cinco de Mayo we put on a big festival wit
h crafts made by the students, dances, and games. At the end of the year the sc
hool hosts a carnival to celebrate the hard work put in during the school year,
with a dunk tank being the most popular activity.My students will use these fiv
e brightly colored Hokki stools in place of regular, stationary, 4-legged chair
s. As I will only have a total of ten in the classroom and not enough for each
student to have an individual one, they will be used in a variety of ways. Duri
ng independent reading time they will be used as special chairs students will e
ach use on occasion. I will utilize them in place of chairs at my small group t
ables during math and reading times. The rest of the day they will be used by t
he students who need the highest amount of movement in their life in order to s
tay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my
students always say more Hokki Stools. They can't get their fill of the 5 stool
s we already have. When the students are sitting in group with me on the Hokki
Stools, they are always moving, but at the same time doing their work. Anytime
the students get to pick where they can sit, the Hokki Stools are the first to
be taken. There are always students who head over to the kidney table to get on
```

e of the stools who are disappointed as there are not enough of them. \r\n\r\nW
e ask a lot of students to sit for 7 hours a day. The Hokki stools will be a co
mpromise that allow my students to do desk work and move at the same time. Thes
e stools will help students to meet their 60 minutes a day of movement by allow
ing them to activate their core muscles for balance while they sit. For many of
my students, these chairs will take away the barrier that exists in schools for
a child who can't sit still.nannan
==========
How do you remember your days of school? Was it in a sterile environment with p
lain walls, rows of desks, and a teacher in front of the room? A typical day in
our room is nothing like that. I work hard to create a warm inviting themed roo
m for my students look forward to coming to each day.\r\n\r\nMy class is made u
p of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey a
ttend a Title I school, which means there is a high enough percentage of free a
nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept,
which is very unique as there are no walls separating the classrooms. These 9 a
nd 10 year-old students are very eager learners; they are like sponges, absorbi
ng all the information and experiences and keep on wanting more.With these reso
urces such as the comfy red throw pillows and the whimsical nautical hanging de
cor and the blue fish nets, I will be able to help create the mood in our class
room setting to be one of a themed nautical environment. Creating a classroom e
nvironment is very important in the success in each and every child's educatio
n. The nautical photo props will be used with each child as they step foot into
our classroom for the first time on Meet the Teacher evening. I'll take picture
s of each child with them, have them developed, and then hung in our classroom
ready for their first day of 4th grade. This kind gesture will set the tone be
fore even the first day of school! The nautical thank you cards will be used th
roughout the year by the students as they create thank you cards to their team
groups.\r\n\r\nYour generous donations will help me to help make our classroom
a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of mon
ey out of my own pocket on resources to get our classroom ready. Please conside
r helping with this project to make our new school year a very successful one.
Thank you!nannan
==========
My wonderful students are 3, 4, and 5 years old. We are located in a small tow
n outside of Charlotte, NC. All of my 22 students are children of school distr
ict employees.\r\nMy students are bright, energetic, and they love to learn! T
hey love hands-on activities that get them moving. Like most preschoolers, the
y enjoy music and creating different things. \r\nAll of my students come from w
onderful families that are very supportive of our classroom. Our parents enjoy
watching their children's growth as much as we do!These materials will help me
teach my students all about the life cycle of a butterfly. We will watch as th
e Painted Lady caterpillars grow bigger and build their chrysalis. After a few
weeks they will emerge from the chrysalis as beautiful butterflies! We already
have a net for the chrysalises, but we still need the caterpillars and feeding
station.\r\nThis will be an unforgettable experience for my students. My stude
nt absolutely love hands-on materials. They learn so much from getting to touc
h and manipulate different things. The supporting materials I have selected wi
ll help my students understand the life cycle through exploration.nannan
==========

My students are an amazing group of eclectic children, coming from all walks
of life. Many are from socioeconomically challenged homes, many from migrant
families. The city is small so that most students who are permanent residents
have known each other forever. It is a 'large family' of sorts. They all supp
ort each other and strive everyday to be successful. And they are! \r\nAs sec
ond language learners, many struggle day to day to learn in the classroom but

```
excel in physical activity!Most students think of exercise during the day as
their recess time. By teaching them how to purposefully exercise, how to keep
track of their exercise, as well as hypothesize results, students will create
a lifelong love of exercise and health. My students told me how much they enj
oy Physical Education outdoors. They have asked for field cones and activitie
s such as fitness dice and foam rings to organize meaningful activities. Thes
e journals will be used to chart patterns and see growth. My students showed
interest in my personal fitness tracker I wear. My students asked me to get t
hem a set to track their fitness and give them data to chart for their math j
ournals. \r\n\r\nPurposeful exercise not only creates a healthier body, but a
lso instills a healthier mindset about exercise and lifelong health.nannan
==================================================
```

In [15]:
```
# 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)
    phrase = re.sub(r"%", " percent", phrase)
    phrase = re.sub("nannan",' ', phrase)# Found this pattern in some essays whi
    return phrase
```

In [16]:
```
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My wonderful students are 3, 4, and 5 years old.  We are located in a small tow
n outside of Charlotte, NC.  All of my 22 students are children of school distr
ict employees.\r\nMy students are bright, energetic, and they love to learn!  T
hey love hands-on activities that get them moving.  Like most preschoolers, the
y enjoy music and creating different things. \r\nAll of my students come from w
onderful families that are very supportive of our classroom.  Our parents enjoy
watching their children is growth as much as we do!These materials will help me
teach my students all about the life cycle of a butterfly.  We will watch as th
e Painted Lady caterpillars grow bigger and build their chrysalis.  After a few
weeks they will emerge from the chrysalis as beautiful butterflies!  We already
have a net for the chrysalises, but we still need the caterpillars and feeding
station.\r\nThis will be an unforgettable experience for my students.  My stude
nt absolutely love hands-on materials.  They learn so much from getting to touc
h and manipulate different things.  The supporting materials I have selected wi
ll help my students understand the life cycle through exploration.
==================================================
```

In [17]:
```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-bre
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My wonderful students are 3, 4, and 5 years old.  We are located in a small tow
n outside of Charlotte, NC.  All of my 22 students are children of school distr
ict employees.  My students are bright, energetic, and they love to learn!  The
y love hands-on activities that get them moving.  Like most preschoolers, they
enjoy music and creating different things.   All of my students come from wonde
rful families that are very supportive of our classroom.  Our parents enjoy wat
ching their children is growth as much as we do!These materials will help me te
ach my students all about the life cycle of a butterfly.  We will watch as the
Painted Lady caterpillars grow bigger and build their chrysalis.  After a few w
eeks they will emerge from the chrysalis as beautiful butterflies!  We already
have a net for the chrysalises, but we still need the caterpillars and feeding
station.  This will be an unforgettable experience for my students.  My student
absolutely love hands-on materials.  They learn so much from getting to touch a
nd manipulate different things.  The supporting materials I have selected will
help my students understand the life cycle through exploration.
```

In [18]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My wonderful students are 3 4 and 5 years old We are located in a small town ou
tside of Charlotte NC All of my 22 students are children of school district emp
loyees My students are bright energetic and they love to learn They love hands
on activities that get them moving Like most preschoolers they enjoy music and
creating different things All of my students come from wonderful families that
are very supportive of our classroom Our parents enjoy watching their children
is growth as much as we do These materials will help me teach my students all a
bout the life cycle of a butterfly We will watch as the Painted Lady caterpilla
rs grow bigger and build their chrysalis After a few weeks they will emerge fro
m the chrysalis as beautiful butterflies We already have a net for the chrysali
ses but we still need the caterpillars and feeding station This will be an unfo
rgettable experience for my students My student absolutely love hands on materi
als They learn so much from getting to touch and manipulate different things Th
e supporting materials I have selected will help my students understand the lif
e cycle through exploration
```

In [19]:
```
project_data.shape
```

Out[19]:
```
(69997, 13)
```

In [20]:
```
# 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'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itse
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'tha
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'ha
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 't
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'of
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than'
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should'v
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "d
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma'
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn
            'won', "won't", 'wouldn', "wouldn't"]
```

In [21]:
```
# Combining all the above snippets
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentence in tqdm(project_data['essay'].values):
    sent = decontracted(sentence)
    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.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████
| 69997/69997 [00:57<00:00, 1216.99it/s]
```

In [22]:
```
# after preprocesing
preprocessed_essays[20000]
```

Out[22]:
```
'wonderful students 3 4 5 years old located small town outside charlotte nc 22
students children school district employees students bright energetic love lear
n love hands activities get moving like preschoolers enjoy music creating diffe
rent things students come wonderful families supportive classroom parents enjoy
watching children growth much materials help teach students life cycle butterfl
y watch painted lady caterpillars grow bigger build chrysalis weeks emerge chry
salis beautiful butterflies already net chrysalises still need caterpillars fee
ding station unforgettable experience students student absolutely love hands ma
terials learn much getting touch manipulate different things supporting materia
ls selected help students understand life cycle exploration'
```

Preprocessing of `project_title`

In [23]:
```
# similarly preprocessing the titles also
preprocessed_title = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_title.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████████|
69997/69997 [00:02<00:00, 26703.09it/s]
```

In [24]:
```
project_data['project_title'] = preprocessed_title
```

In [25]:
```
#Removing '.' from teacher prefix(as a process of text preprocessing)
project_data['teacher_prefix']=project_data['teacher_prefix'].str.replace('\.','
```

In [26]:
```
project_data['teacher_prefix'].isna().any()
```

Out[26]:
```
False
```

In [27]:
```
project_data['teacher_prefix'].value_counts()
```

Out[27]:
```
Mrs        36529
Ms         25150
Mr          6828
Teacher     1485
Dr             5
Name: teacher_prefix, dtype: int64
```

In [28]:
```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).
price_data.head(2)
```

Out[28]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [29]:
```
# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [30]:
```
project_data['price'].isnull().any()
```

Out[30]:
```
False
```

In [31]:
```
#Removing '-' from teacher prefix(as a process of text preprocessing)
project_data['project_grade_category'] = project_data['project_grade_category'].
project_data['project_grade_category'] = project_data['project_grade_category'].
```

In [32]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
m = []
def senti(i):
    l = []
    sid = SentimentIntensityAnalyzer()
    ss = sid.polarity_scores(i)
    for k in ss:
        l.append(ss[k])
    return l
```

In [33]:
```
project_data['text'] = pd.DataFrame(preprocessed_essays)
```

In [34]:
```
# Googled for this
import swifter
df2 = project_data['text'].swifter.apply(lambda x : senti(x))
```

Pandas Apply 100% 69997/69997 [15:13<00:00, 76.61it/s]

In [35]:
```
senti_score_essay = pd.DataFrame(df2.values.tolist(), columns=['neg','neu','pos'
```

In [36]:
```
#https://stackoverflow.com/questions/23891575/how-to-merge-two-dataframes-side-by
project_data = pd.concat([project_data, senti_score_essay], axis=1)
```

In [38]:
```
#https://stackoverflow.com/questions/34962104/pandas-how-can-i-use-the-apply-func
a=project_data['project_title'].apply(lambda x : len(x))
```

In [39]:
```
project_data['now_title'] = pd.DataFrame(a)
```

In [40]:
```
#https://stackoverflow.com/questions/34962104/pandas-how-can-i-use-the-apply-func
b=project_data['text'].apply(lambda x : len(x))
```

In [41]:
```
project_data['now_text'] = pd.DataFrame(b)
```

Preparing data for models

In [42]:
```
project_data.columns
```

Out[42]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'clean_categories',
       'clean_subcategories', 'essay', 'price', 'quantity', 'text', 'neg',
       'neu', 'pos', 'compound', 'now_title', 'now_text'],
      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 (optional)

- quantity : numerical (optional)
- teacher_number_of_previously_posted_projects : numerical
- price : numerical

In [43]:
```
final_features = ['school_state', 'clean_categories', 'clean_subcategories', 'te
```

In [44]:
```
project_data1 = project_data[final_features].copy()
```

In [45]:
```
project_data1.columns
```

Out[45]:
```
Index(['school_state', 'clean_categories', 'clean_subcategories', 'text',
       'project_grade_category', 'teacher_prefix', 'project_title',
       'teacher_number_of_previously_posted_projects', 'price', 'quantity',
       'now_title', 'now_text', 'neg', 'neu', 'pos', 'compound'],
      dtype='object')
```

In [46]:
```
X = project_data1.copy()
```

In [47]:
```
# train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, strati
X_train,X_cv,y_train,y_cv=train_test_split(X_train,y_train,test_size=0.33,strati
```

In [48]:
```
print("Shape of X_train",X_train.shape)
print("Shape of y_train",y_train.shape)
print('\n')
print("Shape of X_cv",X_cv.shape)
print("Shape of y_cv",y_cv.shape)
print('\n')
print("Shape of X_test",X_test.shape)
print("Shape of y_test",y_test.shape)
```

```
Shape of X_train (31420, 16)
Shape of y_train (31420,)


Shape of X_cv (15477, 16)
Shape of y_cv (15477,)


Shape of X_test (23100, 16)
Shape of y_test (23100,)
```

Vectorizing Categorical data

Encoding categorical features: school_state

In [49]:
```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values) # fit has to happen only on train

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer.transform(X_test['school_state'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(31420, 51) (31420,)
(15477, 51) (15477,)
(23100, 51) (23100,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia',
'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms',
'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'ok', 'or', 'pa',
'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
====================================================================================
====================
```

Encoding categorical features: teacher_prefix

In [50]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values) # fit has to happen only on tra

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer.transform(X_test['teacher_prefix'].values.astype

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

```
After vectorizations
(31420, 5) (31420,)
(15477, 5) (15477,)
(23100, 5) (23100,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================
====================
```

Encoding categorical features: project_grade_category

In [51]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values) # fit has to happen only

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer.transform(X_train['project_grade_category'].values
X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer.transform(X_test['project_grade_category'].values)

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(31420, 4) (31420,)
(15477, 4) (15477,)
(23100, 4) (23100,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
====================================================================================
====================
```

Encoding categorical features: clean_subcategories

In [52]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values) # fit has to happen only o

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_subcat_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_subcat_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_subcat_ohe.shape, y_train.shape)
print(X_cv_subcat_ohe.shape, y_cv.shape)
print(X_test_subcat_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(31420, 30) (31420,)
(15477, 30) (15477,)
(23100, 30) (23100,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'env
ironmentalscience', 'esl', 'extracurricular', 'financialliteracy', 'foreignlang
uages', 'gym_fitness', 'health_lifescience', 'health_wellness', 'history_geogra
phy', 'literacy', 'literature_writing', 'mathematics', 'music', 'nutritioneduca
tion', 'other', 'parentinvolvement', 'performingarts', 'socialsciences', 'speci
alneeds', 'teamsports', 'visualarts', 'warmth']
====================================================================================
====================
```

Encoding categorical features: clean_categories

In [53]:
```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values) # fit has to happen only on t

# we use the fitted CountVectorizer to convert the text to vector
X_train_cat_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_cat_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_cat_ohe = vectorizer.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_cat_ohe.shape, y_train.shape)
print(X_cv_cat_ohe.shape, y_cv.shape)
print(X_test_cat_ohe.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(31420, 9) (31420,)
(15477, 9) (15477,)
(23100, 9) (23100,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy
_language', 'math_science', 'music_arts', 'specialneeds', 'warmth']
====================================================================================
====================
```

Encoding numerical features: Price

In [54]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['price'].values.reshape(1,-1))

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

X_train_price_norm = X_train_price_norm.reshape(-1,1)
X_cv_price_norm = X_cv_price_norm.reshape(-1,1)
X_test_price_norm = X_test_price_norm.reshape(-1,1)

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

```
After vectorizations
(31420, 1) (31420,)
(15477, 1) (15477,)
(23100, 1) (23100,)
====================================================================================================
```

Encoding numerical features: Quantity

In [55]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['quantity'].values.reshape(1,-1))

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

X_train_quan_norm = X_train_quan_norm.reshape(-1,1)
X_cv_quan_norm = X_cv_quan_norm.reshape(-1,1)
X_test_quan_norm = X_test_quan_norm.reshape(-1,1)

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

```
After vectorizations
(31420, 1) (31420,)
(15477, 1) (15477,)
(23100, 1) (23100,)
====================================================================================
====================
```

In [56]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['now_title'].values.reshape(1,-1))

X_train_now_title_norm = normalizer.transform(X_train['now_title'].values.reshape
X_cv_now_title_norm = normalizer.transform(X_cv['now_title'].values.reshape(1,-1
X_test_now_title_norm = normalizer.transform(X_test['now_title'].values.reshape(1

X_train_now_title_norm = X_train_now_title_norm.reshape(-1,1)
X_cv_now_title_norm = X_cv_now_title_norm.reshape(-1,1)
X_test_now_title_norm = X_test_now_title_norm.reshape(-1,1)

print("After vectorizations")
print(X_train_now_title_norm.shape, y_train.shape)
print(X_cv_now_title_norm.shape, y_cv.shape)
print(X_test_now_title_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(31420, 1) (31420,)
(15477, 1) (15477,)
(23100, 1) (23100,)
====================================================================================
====================
```

In [57]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['now_text'].values.reshape(1,-1))

X_train_now_text_norm = normalizer.transform(X_train['now_text'].values.reshape(
X_cv_now_text_norm = normalizer.transform(X_cv['now_text'].values.reshape(1,-1))
X_test_now_text_norm = normalizer.transform(X_test['now_text'].values.reshape(1,

X_train_now_text_norm = X_train_now_text_norm.reshape(-1,1)
X_cv_now_text_norm = X_cv_now_text_norm.reshape(-1,1)
X_test_now_text_norm = X_test_now_text_norm.reshape(-1,1)

print("After vectorizations")
print(X_train_now_text_norm.shape, y_train.shape)
print(X_cv_now_text_norm.shape, y_cv.shape)
print(X_test_now_text_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(31420, 1) (31420,)
(15477, 1) (15477,)
(23100, 1) (23100,)
====================================================================================
====================
```

In [58]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['neg'].values.reshape(1,-1))

X_train_neg_norm = normalizer.transform(X_train['neg'].values.reshape(1,-1))
X_cv_neg_norm = normalizer.transform(X_cv['neg'].values.reshape(1,-1))
X_test_neg_norm = normalizer.transform(X_test['neg'].values.reshape(1,-1))

X_train_neg_norm = X_train_neg_norm.reshape(-1,1)
X_cv_neg_norm = X_cv_neg_norm.reshape(-1,1)
X_test_neg_norm = X_test_neg_norm.reshape(-1,1)

print("After vectorizations")
print(X_train_neg_norm.shape, y_train.shape)
print(X_test_neg_norm.shape, y_cv.shape)
print(X_cv_neg_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(31420, 1) (31420,)
(23100, 1) (15477,)
(15477, 1) (23100,)
====================================================================================
====================
```

In [59]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['pos'].values.reshape(1,-1))

X_train_pos_norm = normalizer.transform(X_train['pos'].values.reshape(1,-1))
X_cv_pos_norm = normalizer.transform(X_cv['pos'].values.reshape(1,-1))
X_test_pos_norm = normalizer.transform(X_test['pos'].values.reshape(1,-1))

X_train_pos_norm = X_train_pos_norm.reshape(-1,1)
X_cv_pos_norm = X_cv_pos_norm.reshape(-1,1)
X_test_pos_norm = X_test_pos_norm.reshape(-1,1)

print("After vectorizations")
print(X_train_pos_norm.shape, y_train.shape)
print(X_test_pos_norm.shape, y_cv.shape)
print(X_cv_pos_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(31420, 1) (31420,)
(23100, 1) (15477,)
(15477, 1) (23100,)
====================================================================================================
```

In [60]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['neg'].values.reshape(1,-1))

X_train_neu_norm = normalizer.transform(X_train['neu'].values.reshape(1,-1))
X_cv_neu_norm = normalizer.transform(X_cv['neu'].values.reshape(1,-1))
X_test_neu_norm = normalizer.transform(X_test['neu'].values.reshape(1,-1))

X_train_neu_norm = X_train_neu_norm.reshape(-1,1)
X_cv_neu_norm = X_cv_neu_norm.reshape(-1,1)
X_test_neu_norm = X_test_neu_norm.reshape(-1,1)

print("After vectorizations")
print(X_train_neu_norm.shape, y_train.shape)
print(X_cv_neu_norm.shape, y_cv.shape)
print(X_test_neu_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(31420, 1) (31420,)
(15477, 1) (15477,)
(23100, 1) (23100,)
====================================================================================================
```

In [61]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['compound'].values.reshape(1,-1))

X_train_com_norm = normalizer.transform(X_train['compound'].values.reshape(1,-1)
X_cv_com_norm = normalizer.transform(X_cv['compound'].values.reshape(1,-1))
X_test_com_norm = normalizer.transform(X_test['compound'].values.reshape(1,-1))

X_train_com_norm = X_train_com_norm.reshape(-1,1)
X_cv_com_norm = X_cv_com_norm.reshape(-1,1)
X_test_com_norm = X_test_com_norm.reshape(-1,1)

print("After vectorizations")
print(X_train_com_norm.shape, y_train.shape)
print(X_test_com_norm.shape, y_cv.shape)
print(X_cv_com_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(31420, 1) (31420,)
(23100, 1) (15477,)
(15477, 1) (23100,)
====================================================================================
====================
```

Encoding numerical features: teacher_number_of_projects

In [62]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.re

X_train_teacher_number_of_previously_posted_projects_norm = normalizer.transform
X_cv_teacher_number_of_previously_posted_projects_norm = normalizer.transform(X_
X_test_teacher_number_of_previously_posted_projects_norm = normalizer.transform(

X_train_teacher_number_of_previously_posted_projects_norm = X_train_teacher_numb
X_cv_teacher_number_of_previously_posted_projects_norm = X_cv_teacher_number_of_
X_test_teacher_number_of_previously_posted_projects_norm = X_test_teacher_number_

print("After vectorizations")
print(X_train_teacher_number_of_previously_posted_projects_norm.shape, y_train.sh
print(X_cv_teacher_number_of_previously_posted_projects_norm.shape, y_cv.shape)
print(X_test_teacher_number_of_previously_posted_projects_norm.shape, y_test.shap
print("="*100)
```

```
After vectorizations
(31420, 1) (31420,)
(15477, 1) (15477,)
(23100, 1) (23100,)
====================================================================================
====================
```

Vectorizing Text data

Bag of words

In [63]:
```
vectorizer = CountVectorizer(min_df=10, ngram_range=(2,3), max_features = 5000)
vectorizer.fit(X_train['text'].values)

# we use the fitted CountVectorizer to convert the text to vector
X_train_text_bow = vectorizer.transform(X_train['text'].values)
X_cv_text_bow = vectorizer.transform(X_cv['text'].values)
X_test_text_bow = vectorizer.transform(X_test['text'].values)

print("After vectorizations")
print(X_train_text_bow.shape, y_train.shape)
print(X_cv_text_bow.shape, y_cv.shape)
print(X_test_text_bow.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(31420, 5000) (31420,)
(15477, 5000) (15477,)
(23100, 5000) (23100,)
```

In [64]:
```
vectorizer = CountVectorizer(min_df = 5, ngram_range=(2,2), max_features=5000)
vectorizer.fit(X_train['project_title'].values.astype('U')) # fit has to happen o

# we use the fitted CountVectorizer to convert the text to vector

X_train_title_bow = vectorizer.transform(X_train['project_title'].values.astype(
X_cv_title_bow = vectorizer.transform(X_cv['project_title'].values.astype('U'))
X_test_title_bow = vectorizer.transform(X_test['project_title'].values.astype('U

print("After vectorizations")
print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(31420, 2576) (31420,)
(15477, 2576) (15477,)
(23100, 2576) (23100,)
```

TFIDF vectorizer

In [65]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['text'].values) # fit has to happen only on train data

# we use the fitted tfidfVectorizer to convert the text to vector
X_train_text_tfidf = vectorizer.transform(X_train['text'].values)
X_cv_text_tfidf = vectorizer.transform(X_cv['text'].values)
X_test_text_tfidf = vectorizer.transform(X_test['text'].values)

print("After vectorizations")
print(X_train_text_tfidf.shape, y_train.shape)
print(X_cv_text_tfidf.shape, y_cv.shape)
print(X_test_text_tfidf.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
al', 'additionally', 'additions', 'address', 'addressed', 'addresses', 'addre
ssing', 'adds', 'adept', 'adequate', 'adequately', 'adhd', 'adhere', 'adhesiv
e', 'adjacent', 'adjectives', 'adjust', 'adjustable', 'adjusted', 'adjustin
g', 'adjustment', 'adjustments', 'administered', 'administration', 'administr
ative', 'administrator', 'administrators', 'admirable', 'admire', 'admissio
n', 'admit', 'admitted', 'adobe', 'adolescence', 'adolescent', 'adolescents',
'adopt', 'adopted', 'adopting', 'adoption', 'adorable', 'adore', 'adult', 'ad
ulthood', 'adults', 'advance', 'advanced', 'advancement', 'advancements', 'ad
vances', 'advancing', 'advantage', 'advantaged', 'advantages', 'adventure',
'adventures', 'adventurous', 'adverse', 'adversely', 'adversities', 'adversit
y', 'advertise', 'advertisements', 'advertising', 'advice', 'advise', 'adviso
r', 'advisory', 'advocacy', 'advocate', 'advocates', 'advocating', 'aerobic',
'aesthetic', 'aesthetically', 'aesthetics', 'affect', 'affected', 'affectin
g', 'affection', 'affectionate', 'affective', 'affects', 'affiliated', 'affir
m', 'affluent', 'afford', 'affordable', 'afforded', 'affording', 'affords',
'afghanistan', 'afloat', 'aforementioned', 'afraid', 'africa', 'african', 'af
ternoon', 'afternoons', 'afterschool', 'afterward', 'afterwards', 'age', 'age
d', 'agencies', 'agency', 'agenda', 'agents', 'ages', 'aggression', 'aggressi
ve', 'agility', 'aging', 'ago', 'agree', 'agreed', 'agreement', 'agricultura
l', 'agriculture', 'ah', 'aha', 'ahead', 'aid', 'aide', 'aided', 'aides', 'ai
```

In [66]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['project_title'].values.astype('U')) # fit has to happen o

# we use the fitted tfidfVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer.transform(X_train['project_title'].values.astype
X_cv_title_tfidf = vectorizer.transform(X_cv['project_title'].values.astype('U'))
X_test_title_tfidf = vectorizer.transform(X_test['project_title'].values.astype(

print("After vectorizations")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
print(X_test_title_tfidf.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations
(31420, 1577) (31420,)
(15477, 1577) (15477,)
(23100, 1577) (23100,)
```

Using gensim for doing word2vec

Applying word2vec on project title

In [67]:
```
list_of_sentance_train=[]
for sentance in (X_train['project_title'].values):
    list_of_sentance_train.append(sentance.split())
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
w2v_model=Word2Vec(list_of_sentance_train,min_count=5,size=50, workers=4)
w2v_words = list(w2v_model.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words))
print("sample words ", w2v_words[0:50])
```

```
C:\Users\mani\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning: de
tected Windows; aliasing chunkize to chunkize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")

number of words that occured minimum 5 times  2612
sample words  ['uke', 'n', 'do', 'it', 'a', 'printer', 'ink', 'please', 'keep',
'moving', 'flexible', 'seating', 'engaged', 'learners', 'technology', 'in', 'm
y', 'hand', 'history', 'literature', 'promote', 'walking', '4th', 'graders', 'c
reate', 'collaborate', 'chromebooks', 'part', '16', '17', 'portable', 'magic',
'kindle', 'fires', 'we', 'got', 'the', 'write', 'stuff', 'colorful', 'mindset',
'cozy', 'up', 'read', 'science', 'exploration', 'creating', 'positive', 'schoo
l', 'culture']
```

In [68]:
```
from tqdm import tqdm
import numpy as np
sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sent in tqdm(list_of_sentance_train): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might ne
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
X_train_title_avgw2v = np.array(sent_vectors_train)
print(X_train_title_avgw2v.shape)
print(X_train_title_avgw2v[0])
```

```
100%|██████████████████████████████████████████████████████████████████████████|
31420/31420 [00:02<00:00, 10650.79it/s]

(31420, 50)
[-5.08816745e-02  1.45154527e-01  3.56130388e-01 -1.03055507e+00
  6.97106495e-03  6.39888983e-01  3.40124920e-01 -3.67200351e-03
 -5.18271670e-01 -4.07143432e-01 -5.24845172e-01  4.94243111e-02
  2.68066887e-01 -2.61641080e-01 -6.41805194e-02  3.33234136e-01
  6.95195869e-01  1.85921886e-01 -1.92988122e-01 -5.91347188e-01
  6.32075202e-02 -1.19326448e+00  4.92527032e-01  5.38565852e-01
  1.64447869e-01 -8.38620793e-01 -6.04664123e-01  6.13397004e-01
  2.88028029e-01  3.09706559e-01  4.39725508e-01 -2.70378822e-02
  3.25252302e-04 -1.61965269e-01  4.34887245e-01  1.59882893e-01
 -4.13327608e-01  9.91029246e-02 -6.04767960e-01 -3.30887170e-01
 -2.71422556e-02 -6.98236357e-02 -9.69100385e-02 -4.27630052e-01
 -7.85200978e-02  4.02326251e-02  4.28771041e-02  2.93610421e-01
  1.40351940e-01 -5.09939827e-02]
```

In [69]:
```
list_of_sentance_train=[]
for sentance in (X_cv['project_title'].values):
    list_of_sentance_train.append(sentance.split())
from tqdm import tqdm
import numpy as np
sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sent in tqdm(list_of_sentance_train): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might ne
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
X_cv_title_avgw2v = np.array(sent_vectors_train)
print(X_cv_title_avgw2v.shape)
print(X_cv_title_avgw2v[0])
```

```
100%|██████████████████████████████████████████████████████████████████████████████|
15477/15477 [00:01<00:00, 11256.45it/s]

(15477, 50)
[ 3.67703132e-01  5.10731577e-01  1.85832135e-01 -9.63744126e-01
 -3.74046497e-01  7.65606057e-01  6.80749662e-01  1.01115555e-03
 -6.54787532e-01 -2.34114075e-01 -6.04289506e-01 -2.11643644e-01
 -9.44414334e-02 -2.05941750e-01  8.96879062e-02  2.90581442e-01
  7.58801520e-01 -2.18413138e-02 -1.99453676e-01 -2.63970993e-01
 -2.14429351e-01 -1.42165713e+00  5.11424735e-01  9.68710959e-01
  1.69018681e-01 -5.17017230e-01  2.05646504e-01  2.40451606e-01
  4.26270034e-01  6.41157255e-02 -9.20658391e-02 -2.93228306e-01
 -3.60374809e-01 -2.29646552e-01  2.75285462e-01  3.31047680e-01
 -1.04467613e+00 -1.89409804e-01 -3.31501551e-01  4.18751065e-01
 -2.00909747e-01  1.04930915e-01 -3.42336707e-02 -3.26252565e-01
 -1.40244059e-01 -2.97310825e-01  1.34530306e-01  4.14027862e-01
  1.56419855e-01 -1.22554693e-01]
```

In [70]:
```
list_of_sentance_train=[]
for sentance in (X_test['project_title'].values):
    list_of_sentance_train.append(sentance.split())
from tqdm import tqdm
import numpy as np
sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sent in tqdm(list_of_sentance_train): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might ne
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
X_test_title_avgw2v = np.array(sent_vectors_train)
print(X_test_title_avgw2v.shape)
print(X_test_title_avgw2v[0])
```

```
100%|██████████████████████████████████████████████████████████████████████████████|
23100/23100 [00:02<00:00, 11070.52it/s]

(23100, 50)
[ 1.60020858e-01  5.76510712e-02  4.34399708e-01 -5.62790441e-01
 -3.53790683e-01  3.64384854e-01  2.63641582e-01 -1.91898116e-01
 -4.72982532e-02 -1.05507281e-01 -2.56424318e-01  2.95911440e-01
  6.56699887e-02 -2.03353104e-01  2.32223336e-01  1.46446767e-01
  4.96448817e-01  4.43469610e-02  9.91963052e-02 -4.52972279e-01
  1.37884803e-01 -7.76379051e-01  1.85170905e-01  6.26554452e-01
 -2.79808204e-03 -5.32119550e-01 -2.68106870e-01  1.62136688e-01
  1.92824632e-02  2.93994902e-01  1.54862713e-01 -7.87406680e-02
  6.56865925e-04 -4.58303098e-02  1.56320330e-01  2.81844499e-01
 -5.47707578e-01 -6.62067103e-02 -5.33916799e-01  1.38407283e-01
  4.68855975e-02 -2.47927590e-01  5.79056855e-02 -3.63613057e-01
  1.40693124e-01  1.85042507e-02  2.59669105e-01 -3.41643634e-02
 -1.93844660e-01  5.40444668e-02]
```

Applying avg word2vec on project_essay

In [71]:
```
list_of_sentance_train_essay=[]
for sentance in (X_train['text'].values):
    list_of_sentance_train_essay.append(sentance.split())
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
w2v_model1=Word2Vec(list_of_sentance_train_essay,min_count=5,size=50, workers=4)
w2v_words1 = list(w2v_model1.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words1))
print("sample words ", w2v_words1[0:50])
```

```
number of words that occured minimum 5 times  14319
sample words  ['general', 'music', 'program', 'prides', 'diversified', 'meet',
'needs', 'student', 'population', 'students', 'always', 'strive', 'making', 'le
sson', 'truly', 'artful', 'joyful', 'experience', 'every', 'day', 'make', 'lear
ning', 'target', 'goals', 'aim', 'achieve', 'excellence', 'behavior', 'academic
s', 'community', 'heavily', 'supports', 'physical', 'presence', 'low', 'socioec
onomically', 'ability', 'purchase', 'classroom', 'materials', 'sometimes', 'cha
llenge', 'child', 'deserves', 'quality', 'education', 'instance', 'project', 'h
elp', 'us']
```

In [72]:
```
from tqdm import tqdm
import numpy as np
sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sent in tqdm(list_of_sentance_train_essay): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might ne
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words1:
            vec = w2v_model1.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
X_train_text_avgw2v = np.array(sent_vectors_train)
print(X_train_text_avgw2v.shape)
print(X_train_text_avgw2v[0])
```

```
100%|██████████████████████████████████████████████████████████████████████
██| 31420/31420 [02:28<00:00, 211.47it/s]

(31420, 50)
[ 0.16773694  0.5519373  -0.27245526  0.10899999  0.02049001 -0.41106746
  0.15320979  0.20633077  0.23867219  0.24645881  0.20712612 -0.28103144
  0.20935603 -0.16107841 -0.41510981  0.1040164  -0.11247526 -0.19122567
  0.63370098 -0.00148285  0.55683751  0.34380824 -0.66137135 -0.55333744
  0.45918834 -1.07003462  0.61452636 -0.45047458 -0.21282746  0.2842797
 -0.50638323  0.17299777 -0.16235106  0.55577988 -0.12084827 -1.11540053
 -0.45256541 -0.35865587  0.80633763  0.19526129 -0.17205287  0.50529664
 -0.03596414 -0.02251347 -0.3917578  -0.07259219 -0.04125445  0.32382086
  0.81727489 -0.07165378]
```

In [73]:
```
list_of_sentance_train_essay=[]
for sentance in (X_cv['text'].values):
    list_of_sentance_train_essay.append(sentance.split())
from tqdm import tqdm
import numpy as np
sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sent in tqdm(list_of_sentance_train_essay): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might ne
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words1:
            vec = w2v_model1.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
X_cv_text_avgw2v = np.array(sent_vectors_train)
print(X_cv_text_avgw2v.shape)
print(X_cv_text_avgw2v[0])
```

```
100%|██████████████████████████████████████████████████████████████████████
██| 15477/15477 [01:12<00:00, 214.42it/s]

(15477, 50)
[-0.1763068   0.67454959 -0.60015911 -0.16678693  1.08838312  0.2149597
 -1.09742635  0.62660087 -0.75117965  0.11419798  0.69178108 -1.27549019
 -0.4479332   0.07594612 -0.17326729 -0.03119926  0.03418931 -0.25014131
  1.16904     0.2411044  -0.36113036 -0.31390842  0.03453187 -0.16293345
  0.09319696 -0.4777821  -0.01899333  0.54204476 -1.14464374 -0.00889887
 -1.12334884  0.4787931  -0.11568212  0.30197728 -0.45771776 -1.72044073
 -0.01175558  0.5841343   0.73944733  0.42129181 -0.31349146  0.05749818
  0.09362039  0.71220779 -0.7687342  -0.39816664 -0.52839447  0.90291894
  1.16781764 -0.73753625]
```

In [74]:
```
list_of_sentance_train_essay=[]
for sentance in (X_test['text'].values):
    list_of_sentance_train_essay.append(sentance.split())
from tqdm import tqdm
import numpy as np
sent_vectors_train = []; # the avg-w2v for each sentence/review is stored in this
for sent in tqdm(list_of_sentance_train_essay): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, you might ne
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words1:
            vec = w2v_model1.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors_train.append(sent_vec)
X_test_text_avgw2v = np.array(sent_vectors_train)
print(X_test_text_avgw2v.shape)
print(X_test_text_avgw2v[0])
```

```
100%|██████████████████████████████████████████████████████████████████████
██| 23100/23100 [01:48<00:00, 212.53it/s]

(23100, 50)
[ 0.13527144  0.67269634 -0.71187643  0.25965736  0.94412077 -0.46405309
  0.12656477  0.47393178 -0.03551417 -0.12821306 -0.23572855 -0.31189701
 -0.01463286  0.05955699 -0.20850719 -0.46933518  0.03050863 -0.12465264
  0.54406417  0.35161125  0.12215677  0.25617235 -0.79591037  0.01475795
  0.5024552  -0.52610819  0.58941086 -0.25665215 -0.63223653  0.0128607
  0.07969137  0.47907509  0.12222531  0.17043591 -0.31626349 -1.02820238
  0.00580846  0.49404507  0.74782905  0.13171954 -0.21154851  0.35826682
  0.01862422 -0.03163691 -0.434713    0.05465849 -0.0938182   0.52452334
  0.63219388 -0.03617716]
```

Applying tfidf w2v on project_title

In [75]:
```
tfidf_model1 = TfidfVectorizer()
tfidf_model1.fit(X_train['project_title'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model1.get_feature_names(), list(tfidf_model1.idf_)))
tfidf_words1 = set(tfidf_model1.get_feature_names())
```

In [76]:
```
X_train_title_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored i
for sentence in tqdm(X_train['project_title'].values): # for each review/sentenc
    vector = np.zeros(50) # 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 w2v_words) and (word in tfidf_words1):
            vec = w2v_model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    X_train_title_tfidf_w2v.append(vector)
print(len(X_train_title_tfidf_w2v))
print(len(X_train_title_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████
| 31420/31420 [00:04<00:00, 6737.64it/s]

31420
50
```

In [77]:
```
X_cv_title_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in th
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(50) # 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 w2v_words) and (word in tfidf_words1):
            vec = w2v_model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    X_cv_title_tfidf_w2v.append(vector)
print(len(X_cv_title_tfidf_w2v))
print(len(X_cv_title_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████
| 15477/15477 [00:02<00:00, 6725.50it/s]

15477
50
```

In [78]:
```
X_test_title_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(50) # 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 w2v_words) and (word in tfidf_words1):
            vec = w2v_model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    X_test_title_tfidf_w2v.append(vector)
print(len(X_test_title_tfidf_w2v))
print(len(X_test_title_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████
| 23100/23100 [00:03<00:00, 6072.93it/s]

23100
50
```

Applying tfidf w2v on project_text

In [79]:
```
tfidf_model1 = TfidfVectorizer()
tfidf_model1.fit(X_train['text'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model1.get_feature_names(), list(tfidf_model1.idf_)))
tfidf_words1 = set(tfidf_model1.get_feature_names())
```

In [80]:
```
X_train_text_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in
for sentence in tqdm(X_train['text'].values): # for each review/sentence
    vector = np.zeros(50) # 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 w2v_words1) and (word in tfidf_words1):
            vec = w2v_model1[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    X_train_text_tfidf_w2v.append(vector)
print(len(X_train_text_tfidf_w2v))
print(len(X_train_text_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████
| 31420/31420 [04:31<00:00, 115.79it/s]

31420
50
```

In [81]:
```
X_cv_text_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in th
for sentence in tqdm(X_cv['text'].values): # for each review/sentence
    vector = np.zeros(50) # 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 w2v_words1) and (word in tfidf_words1):
            vec = w2v_model1[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    X_cv_text_tfidf_w2v.append(vector)
print(len(X_cv_text_tfidf_w2v))
print(len(X_cv_text_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████
| 15477/15477 [02:16<00:00, 113.18it/s]

15477
50
```

In [82]:
```
X_test_text_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in t
for sentence in tqdm(X_test['text'].values): # for each review/sentence
    vector = np.zeros(50) # 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 w2v_words1) and (word in tfidf_words1):
            vec = w2v_model1[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf valu
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    X_test_text_tfidf_w2v.append(vector)
print(len(X_test_text_tfidf_w2v))
print(len(X_test_text_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████
| 23100/23100 [03:20<00:00, 115.25it/s]

23100
50
```

Assignment 5 : Logistic regression

1. **[Task-1] Logistic Regression(either SGDClassifier with log loss, or LogisticRegression) on these feature sets**

    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (`BOW with bi-grams` with `min_df=10` and `max_features=5000`)

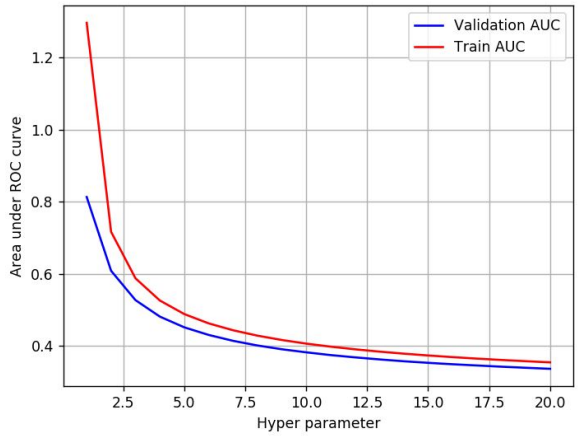
- Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (`TFIDF with bi-grams` with `min_df=10` and `max_features=5000`)
- Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
- Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

2. **Hyper paramter tuning (find best hyper parameters corresponding the algorithm that you choose)**

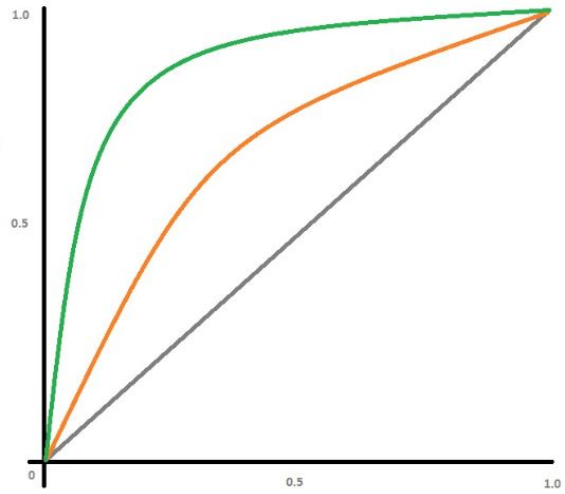
   - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
   - Find the best hyper paramter using k-fold cross validation or simple cross validation data
   - 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 (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-

matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points. Please visualize your confusion matrices using seaborn heatmaps.

	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

(https://seaborn.pydata.org/generated/seaborn.heatmap.html)

4. **[Task-2] Apply Logistic Regression on the below feature set Set 5 by finding the best hyper parameter as suggested in step 2 and step 3.**
5. 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

   And apply the Logistic regression on these features by finding the best hyper paramter as suggested in step 2 and step 3

6. **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 (http://zetcode.com/python/prettytable/)

Vectorizer	Model	Hyper parameter	AUC
BOW	Brute	7	0.78
TFIDF	Brute	12	0.79
W2V	Brute	10	0.78
TFIDFW2V	Brute	6	0.78

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.

2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link. (https://soundcloud.com/applied-ai-course/leakage-bow-and-tfidf)

Logistic regression

Applying Logistic regression on BOW, SET 1

Merging all the above features

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

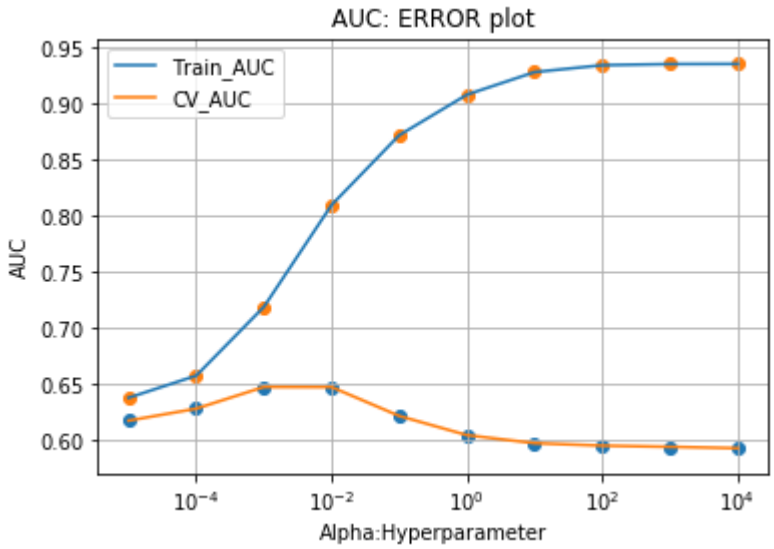
In [83]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_state_ohe,X_train_teacher_ohe,X_train_grade_ohe,X_train_su
               X_train_cat_ohe,X_train_price_norm,X_train_teacher_number_of_previ
               X_train_text_bow,X_train_title_bow)).tocsr()

X_cr = hstack((X_cv_state_ohe,X_cv_teacher_ohe,X_cv_grade_ohe,X_cv_subcat_ohe,
               X_cv_cat_ohe,X_cv_price_norm,X_cv_teacher_number_of_previously_pos
               X_cv_text_bow,X_cv_title_bow)).tocsr()

X_te = hstack((X_test_state_ohe,X_test_teacher_ohe,X_test_grade_ohe,X_test_subcat
               X_test_cat_ohe,X_test_price_norm,X_test_teacher_number_of_previous
               X_test_text_bow,X_test_title_bow)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(31420, 7677) (31420,)
(15477, 7677) (15477,)
(23100, 7677) (23100,)
====================================================================================
====================
```

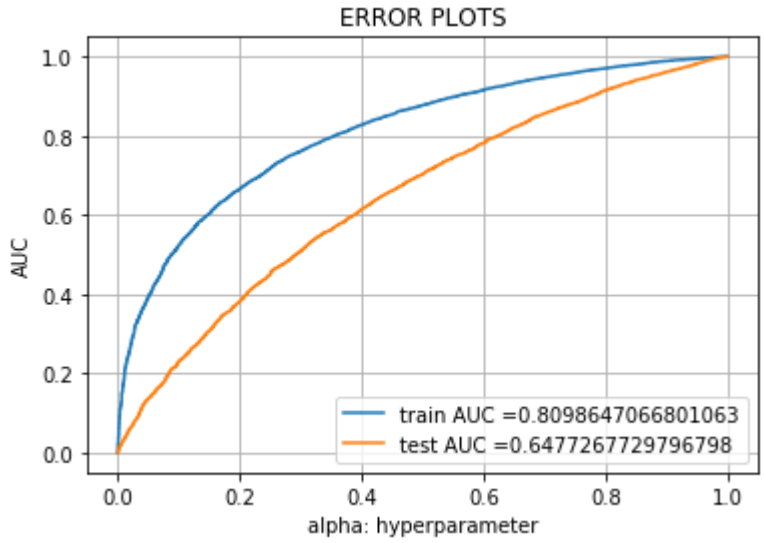
In [84]:
```
def batch_predict(clf,data):
    y_pred=[]
    dl=data.shape[0]-data.shape[0]%1000

    for i in range(0,dl,1000):
        y_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])

    y_pred.extend(clf.predict_proba(data[dl:])[:,1])

    return y_pred
```

In [85]:
```
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score

train_auc=[]
cv_auc=[]
alpha= [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
b=[]
for i in tqdm(alpha):
    mb=LogisticRegression(penalty='l2',C=i,class_weight='balanced')
    mb.fit(X_tr,y_train)

    y_train_pred=batch_predict(mb,X_tr)
    y_cv_pred=batch_predict(mb,X_cr)

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv,y_cv_pred))

max_auc_ind_train=train_auc.index(max(train_auc))
alpha_max_auc_train=alpha[max_auc_ind_train]

print("max auc in train data:",max(train_auc))
print("alpha value for maximum AUC:",alpha_max_auc_train)
max_auc_ind_cv=cv_auc.index(max(cv_auc))
alpha_max_auc_cv=alpha[max_auc_ind_cv]
print("max auc  in cv data:",max(cv_auc))
print("alpha value for maximum AUC:",alpha_max_auc_cv)

plt.plot(alpha,train_auc,label='Train_AUC')
plt.plot(alpha,cv_auc,label='CV_AUC')
plt.scatter(alpha,cv_auc)
plt.scatter(alpha,train_auc)
#https://matplotlib.org/3.1.1/api/_as_gen/matplotlib.pyplot.xscale.html
plt.xscale('log')
plt.title("AUC: ERROR plot")
plt.ylabel('AUC')
plt.xlabel('Alpha:Hyperparameter')
plt.legend()
plt.grid(1)
```

```
100%|██████████| 10/10 [03:22<00:00, 48.23s/it]

max auc in train data: 0.9356183466678004
alpha value for maximum AUC: 10000
max auc  in cv data: 0.6476445274890309
alpha value for maximum AUC: 0.001
```


AUC: ERROR plot
Train_AUC
CV_AUC
AUC
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
Alpha:Hyperparameter

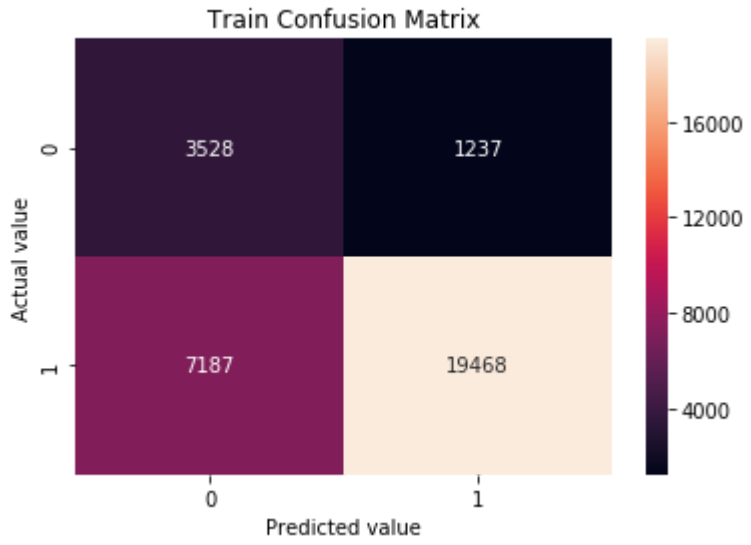
In [86]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htr
from sklearn.metrics import roc_curve, auc

nb = LogisticRegression(C=0.01,class_weight='balanced',penalty='l2')
nb.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
# not the predicted outputs

y_train_pred = nb.predict_proba(X_tr)[:,1]
y_test_pred = nb.predict_proba(X_te)[:,1]

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr )))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [87]:
```
#we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predict(proba,threshold,fpr,tpr):
    t=threshold[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)",max(tpr*(1-fpr)))
    print("Threshold:",np.round(t,3))
    prediction=[]
    for i in proba:
        if i>=t:
            prediction.append(1)
        else:
            prediction.append(0)

    return prediction
```

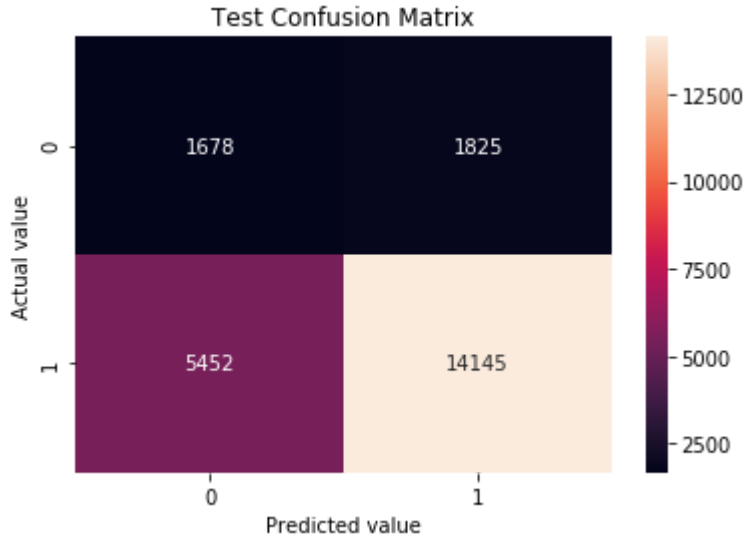
In [88]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_tr=confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,train_fpr,tra

sns.heatmap(con_tr,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Train Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.5407646852843344
Threshold: 0.491
```



In [89]:
```
#https://stackoverflow.com/a/33158941/10967428
con_te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, te

sns.heatmap(con_te,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Test Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.3690463321220917
Threshold: 0.478
```



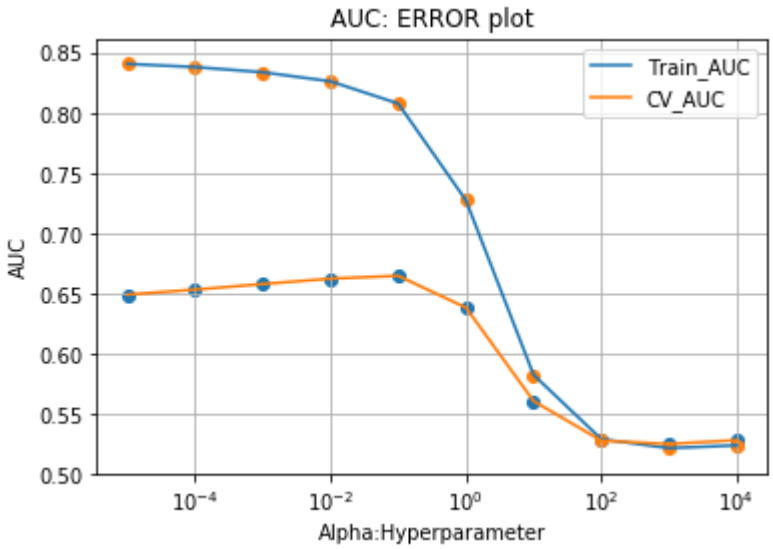
2.4.2 Applying Logistic regression on TFIDF, SET 2

In [90]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_state_ohe,X_train_teacher_ohe,X_train_grade_ohe,X_train_su
               X_train_cat_ohe,X_train_price_norm,X_train_teacher_number_of_previ
               X_train_text_tfidf,X_train_title_tfidf)).tocsr()

X_cr = hstack((X_cv_state_ohe,X_cv_teacher_ohe,X_cv_grade_ohe,X_cv_subcat_ohe,
               X_cv_cat_ohe,X_cv_price_norm,X_cv_teacher_number_of_previously_pos
               X_cv_text_tfidf,X_cv_title_tfidf)).tocsr()

X_te = hstack((X_test_state_ohe,X_test_teacher_ohe,X_test_grade_ohe,X_test_subcat
               X_test_cat_ohe,X_test_price_norm,X_test_teacher_number_of_previous
               X_test_text_tfidf,X_test_title_tfidf)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

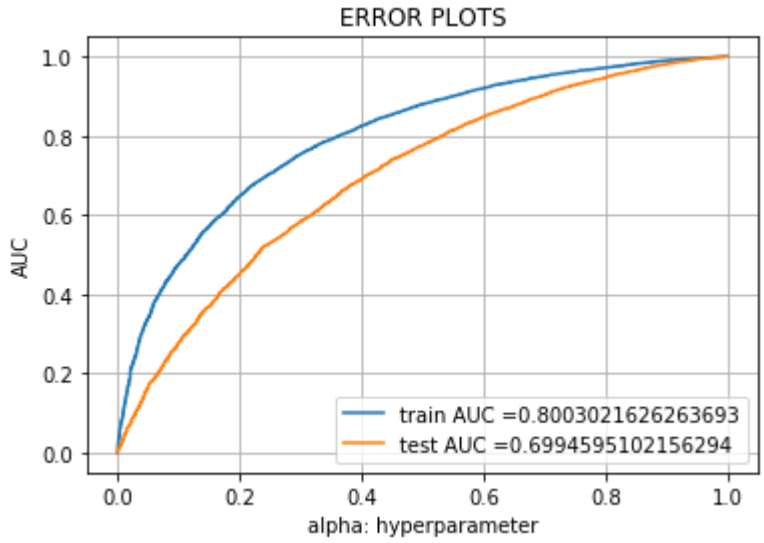
```
Final Data matrix
(31420, 11759) (31420,)
(15477, 11759) (15477,)
(23100, 11759) (23100,)
====================================================================================
====================
```

In [91]:
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score

train_auc=[]
cv_auc=[]
alpha= [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
b=[]
for i in tqdm(alpha):
    mb=MultinomialNB(alpha=i)
    mb.fit(X_tr,y_train)

    y_train_pred=batch_predict(mb,X_tr)
    y_cv_pred=batch_predict(mb,X_cr)

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv,y_cv_pred))

max_auc_ind_train=train_auc.index(max(train_auc))
alpha_max_auc_train=alpha[max_auc_ind_train]

print("max auc in train data:",max(train_auc))
print("alpha value for maximum AUC:",alpha_max_auc_train)
max_auc_ind_cv=cv_auc.index(max(cv_auc))
alpha_max_auc_cv=alpha[max_auc_ind_cv]
print("max auc  in cv data:",max(cv_auc))
print("alpha value for maximum AUC:",alpha_max_auc_cv)

plt.plot(alpha,train_auc,label='Train_AUC')
plt.plot(alpha,cv_auc,label='CV_AUC')
plt.scatter(alpha,cv_auc)
plt.scatter(alpha,train_auc)
#https://matplotlib.org/3.1.1/api/_as_gen/matplotlib.pyplot.xscale.html
plt.xscale('log')
plt.title("AUC: ERROR plot")
plt.ylabel('AUC')
plt.xlabel('Alpha:Hyperparameter')
plt.legend()
plt.grid(1)
```

```
100%|██████████| 10/10 [00:01<00:00,  7.14it/s]

max auc in train data: 0.8406841293170694
alpha value for maximum AUC: 1e-05
max auc  in cv data: 0.6650090488384159
alpha value for maximum AUC: 0.1
```

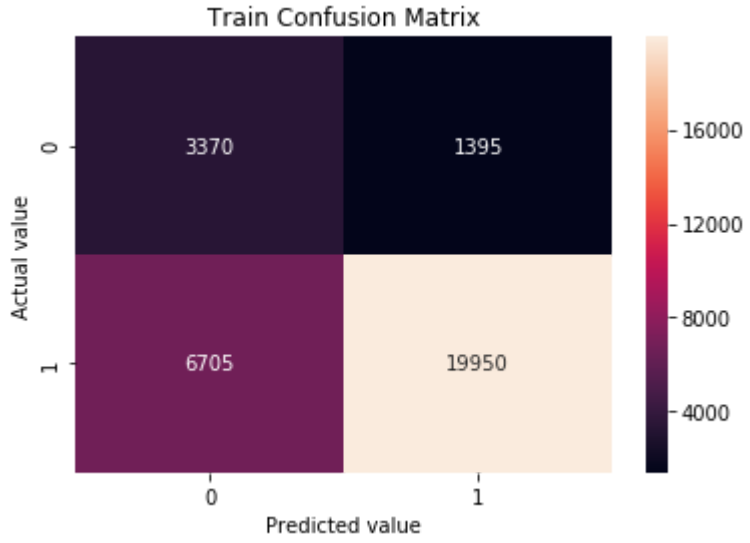

AUC: ERROR plot
Train_AUC
CV_AUC
AUC
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
Alpha:Hyperparameter

In [92]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htr
from sklearn.metrics import roc_curve, auc

nb = LogisticRegression(C=0.1,class_weight='balanced',penalty='l2')
nb.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
# not the predicted outputs

y_train_pred = nb.predict_proba(X_tr)[:,1]
y_test_pred = nb.predict_proba(X_te)[:,1]

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr )))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



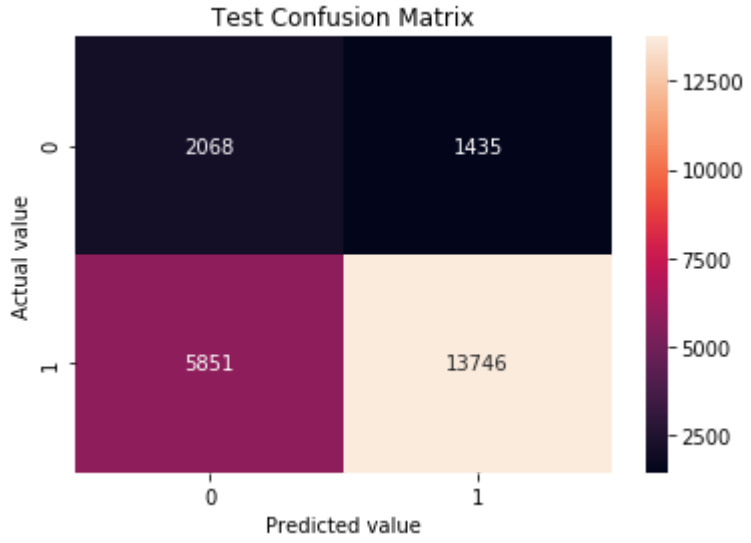
In [93]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_tr=confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,train_fpr,tra

sns.heatmap(con_tr,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Train Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.5293357291873956
Threshold: 0.487
```



In [94]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, te

sns.heatmap(con_te,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Test Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.41824799396681267
Threshold: 0.497
```



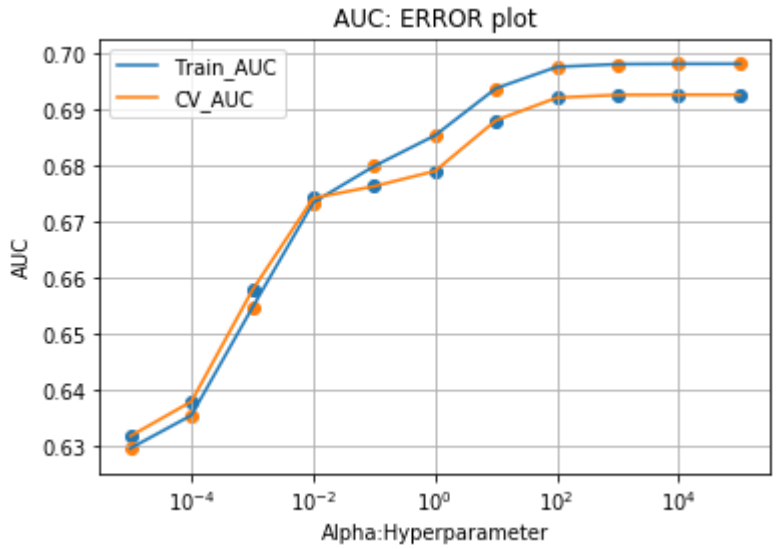
2.4.2 Applying Logistic regression on avgw2v, SET 3

In [95]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_state_ohe,X_train_teacher_ohe,X_train_grade_ohe,X_train_su
               X_train_cat_ohe,X_train_price_norm,X_train_teacher_number_of_previ
               X_train_text_avgw2v,X_train_title_avgw2v)).tocsr()

X_cr = hstack((X_cv_state_ohe,X_cv_teacher_ohe,X_cv_grade_ohe,X_cv_subcat_ohe,
               X_cv_cat_ohe,X_cv_price_norm,X_cv_teacher_number_of_previously_pos
               X_cv_text_avgw2v,X_cv_title_avgw2v)).tocsr()

X_te = hstack((X_test_state_ohe,X_test_teacher_ohe,X_test_grade_ohe,X_test_subcat
               X_test_cat_ohe,X_test_price_norm,X_test_teacher_number_of_previous
               X_test_text_avgw2v,X_test_title_avgw2v)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

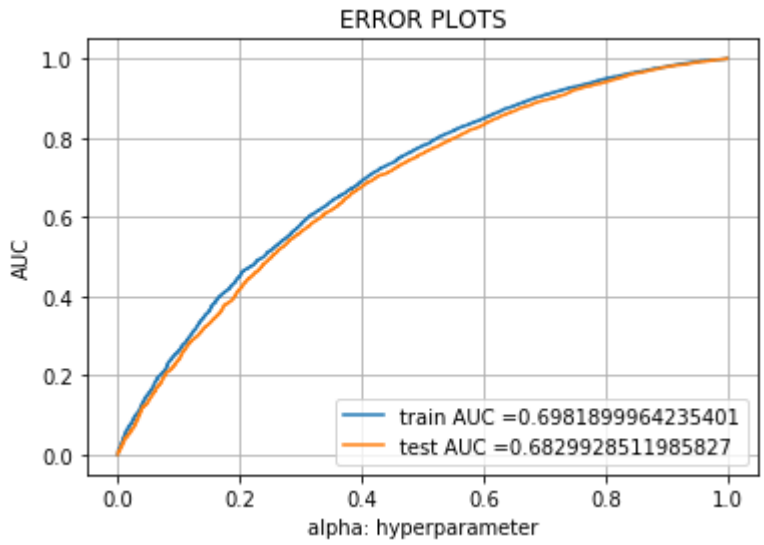
```
Final Data matrix
(31420, 201) (31420,)
(15477, 201) (15477,)
(23100, 201) (23100,)
====================================================================================
====================
```

In [96]:
```
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score

train_auc=[]
cv_auc=[]
alpha= [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 10**5]
b=[]
for i in tqdm(alpha):
    mb=LogisticRegression(penalty='l2',C=i,class_weight='balanced')
    mb.fit(X_tr,y_train)

    y_train_pred=batch_predict(mb,X_tr)
    y_cv_pred=batch_predict(mb,X_cr)

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv,y_cv_pred))

max_auc_ind_train=train_auc.index(max(train_auc))
alpha_max_auc_train=alpha[max_auc_ind_train]

print("max auc in train data:",max(train_auc))
print("alpha value for maximum AUC:",alpha_max_auc_train)
max_auc_ind_cv=cv_auc.index(max(cv_auc))
alpha_max_auc_cv=alpha[max_auc_ind_cv]
print("max auc  in cv data:",max(cv_auc))
print("alpha value for maximum AUC:",alpha_max_auc_cv)

plt.plot(alpha,train_auc,label='Train_AUC')
plt.plot(alpha,cv_auc,label='CV_AUC')
plt.scatter(alpha,cv_auc)
plt.scatter(alpha,train_auc)
#https://matplotlib.org/3.1.1/api/_as_gen/matplotlib.pyplot.xscale.html
plt.xscale('log')
plt.title("AUC: ERROR plot")
plt.ylabel('AUC')
plt.xlabel('Alpha:Hyperparameter')
plt.legend()
plt.grid(1)
```

```
100%|██████████| 11/11 [01:40<00:00, 16.17s/it]

max auc in train data: 0.6981899964235401
alpha value for maximum AUC: 100000
max auc  in cv data: 0.6926902519493862
alpha value for maximum AUC: 100000
```

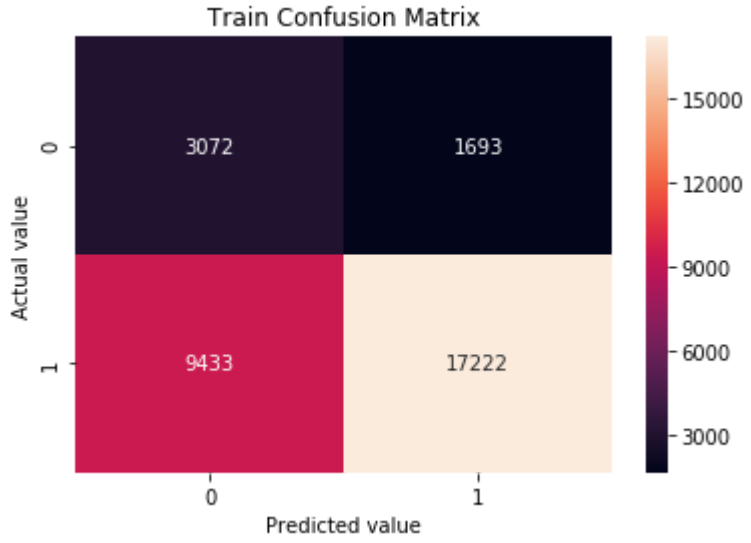

AUC: ERROR plot
Train_AUC
CV_AUC
AUC
0.70
0.69
0.68
0.67
0.66
0.65
0.64
0.63
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
Alpha:Hyperparameter

In [97]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htr
from sklearn.metrics import roc_curve, auc

nb = LogisticRegression(C=10**5,class_weight='balanced',penalty='l2')
nb.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
# not the predicted outputs

y_train_pred = nb.predict_proba(X_tr)[:,1]
y_test_pred = nb.predict_proba(X_te)[:,1]

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr )))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



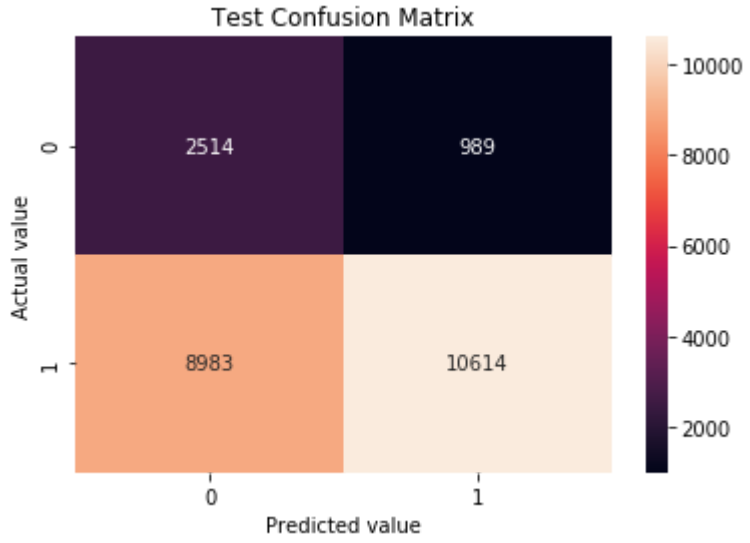
In [98]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_tr=confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,train_fpr,tra

sns.heatmap(con_tr,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Train Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.41654622638222694
Threshold: 0.498
```



In [99]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, te

sns.heatmap(con_te,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Test Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4072480114617857
Threshold: 0.537
```



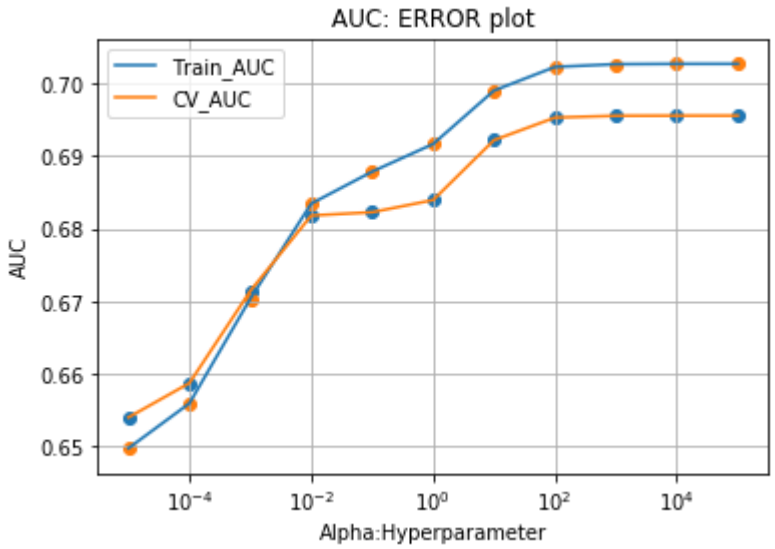
2.4.2 Applying Logistic regression on TFIDF avgw2v SET 4

In [100]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_state_ohe,X_train_teacher_ohe,X_train_grade_ohe,X_train_su
               X_train_cat_ohe,X_train_price_norm,X_train_teacher_number_of_previ
               X_train_text_tfidf_w2v,X_train_title_tfidf_w2v)).tocsr()

X_cr = hstack((X_cv_state_ohe,X_cv_teacher_ohe,X_cv_grade_ohe,X_cv_subcat_ohe,
               X_cv_cat_ohe,X_cv_price_norm,X_cv_teacher_number_of_previously_pos
               X_cv_text_tfidf_w2v,X_cv_title_tfidf_w2v)).tocsr()

X_te = hstack((X_test_state_ohe,X_test_teacher_ohe,X_test_grade_ohe,X_test_subcat
               X_test_cat_ohe,X_test_price_norm,X_test_teacher_number_of_previous
               X_test_text_tfidf_w2v,X_test_title_tfidf_w2v)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

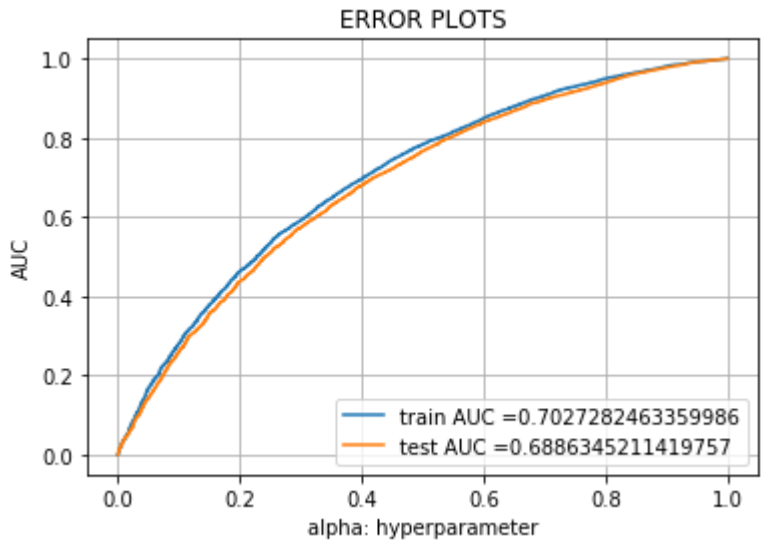
```
Final Data matrix
(31420, 201) (31420,)
(15477, 201) (15477,)
(23100, 201) (23100,)
====================================================================================
====================
```

In [101]:
```
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score

train_auc=[]
cv_auc=[]
alpha= [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 10**5]
b=[]
for i in tqdm(alpha):
    mb=LogisticRegression(penalty='l2',C=i,class_weight='balanced')
    mb.fit(X_tr,y_train)

    y_train_pred=batch_predict(mb,X_tr)
    y_cv_pred=batch_predict(mb,X_cr)

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv,y_cv_pred))

max_auc_ind_train=train_auc.index(max(train_auc))
alpha_max_auc_train=alpha[max_auc_ind_train]

print("max auc in train data:",max(train_auc))
print("alpha value for maximum AUC:",alpha_max_auc_train)
max_auc_ind_cv=cv_auc.index(max(cv_auc))
alpha_max_auc_cv=alpha[max_auc_ind_cv]
print("max auc  in cv data:",max(cv_auc))
print("alpha value for maximum AUC:",alpha_max_auc_cv)

plt.plot(alpha,train_auc,label='Train_AUC')
plt.plot(alpha,cv_auc,label='CV_AUC')
plt.scatter(alpha,cv_auc)
plt.scatter(alpha,train_auc)
#https://matplotlib.org/3.1.1/api/_as_gen/matplotlib.pyplot.xscale.html
plt.xscale('log')
plt.title("AUC: ERROR plot")
plt.ylabel('AUC')
plt.xlabel('Alpha:Hyperparameter')
plt.legend()
plt.grid(1)
```

```
100%|██████████| 11/11 [01:51<00:00, 18.11s/it]

max auc in train data: 0.7027282463359986
alpha value for maximum AUC: 100000
max auc  in cv data: 0.6955988604661654
alpha value for maximum AUC: 100000
```

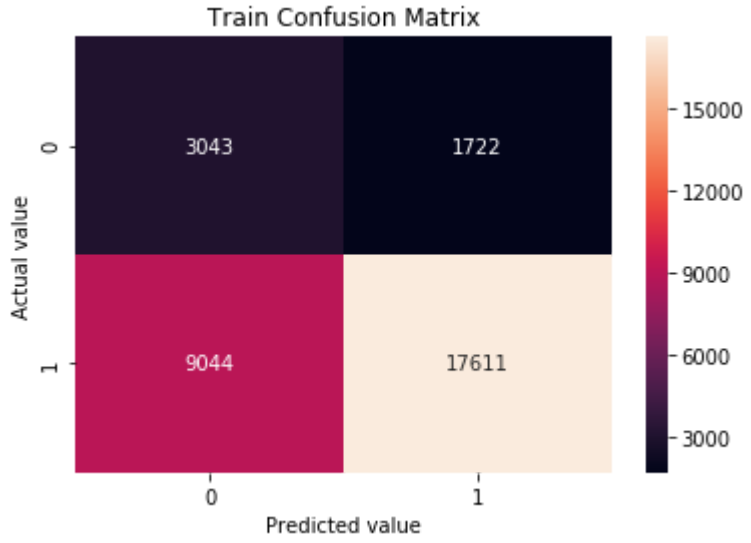

AUC: ERROR plot
Train_AUC
CV_AUC
AUC
0.70
0.69
0.68
0.67
0.66
0.65
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
Alpha:Hyperparameter

In [102]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htr
from sklearn.metrics import roc_curve, auc

nb = LogisticRegression(C=10**5,class_weight='balanced',penalty='l2')
nb.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
# not the predicted outputs

y_train_pred = nb.predict_proba(X_tr)[:,1]
y_test_pred = nb.predict_proba(X_te)[:,1]

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr )))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



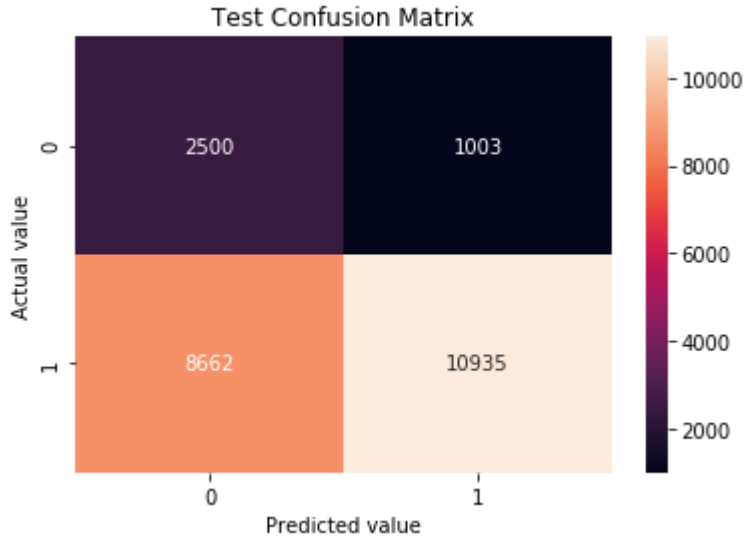
In [103]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_tr=confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,train_fpr,tra

sns.heatmap(con_tr,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Train Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4219338589174212
Threshold: 0.485
```



In [104]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, te

sns.heatmap(con_te,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Test Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4096617059265175
Threshold: 0.525
```



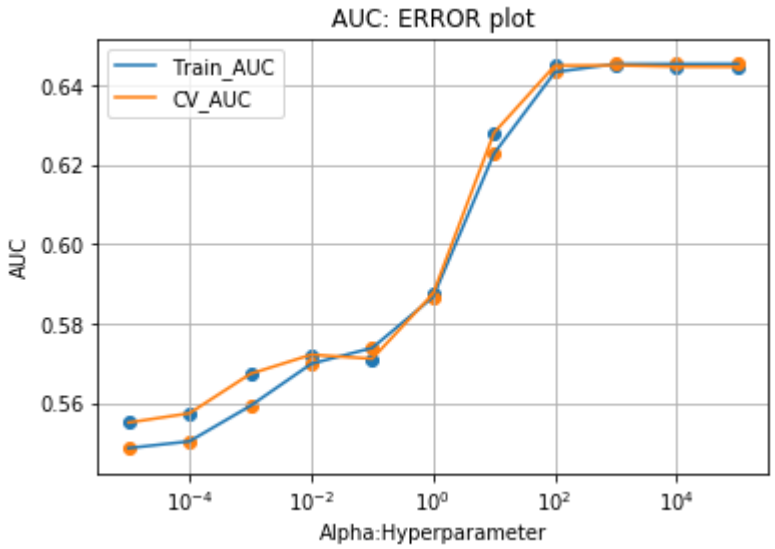
Applying Logistic regression on SET 5

In [105]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_state_ohe,X_train_teacher_ohe,X_train_grade_ohe,X_train_su
               X_train_cat_ohe,X_train_price_norm,X_train_teacher_number_of_previ
               X_train_quan_norm, X_train_now_title_norm, X_train_now_text_norm,
               X_train_pos_norm, X_train_neg_norm, X_train_neu_norm,
               X_train_com_norm)).tocsr()

X_cr = hstack((X_cv_state_ohe,X_cv_teacher_ohe,X_cv_grade_ohe,X_cv_subcat_ohe,
               X_cv_cat_ohe,X_cv_price_norm,X_cv_teacher_number_of_previously_pos
               X_cv_quan_norm,X_cv_now_title_norm, X_cv_now_text_norm,
               X_cv_pos_norm, X_cv_neg_norm, X_cv_neu_norm,
               X_cv_com_norm)).tocsr()

X_te = hstack((X_test_state_ohe,X_test_teacher_ohe,X_test_grade_ohe,X_test_subcat
               X_test_cat_ohe,X_test_price_norm,X_test_teacher_number_of_previous
               X_test_quan_norm,X_test_now_title_norm, X_test_now_text_norm,
               X_test_pos_norm, X_test_neg_norm, X_test_neu_norm,
               X_test_com_norm)).tocsr()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

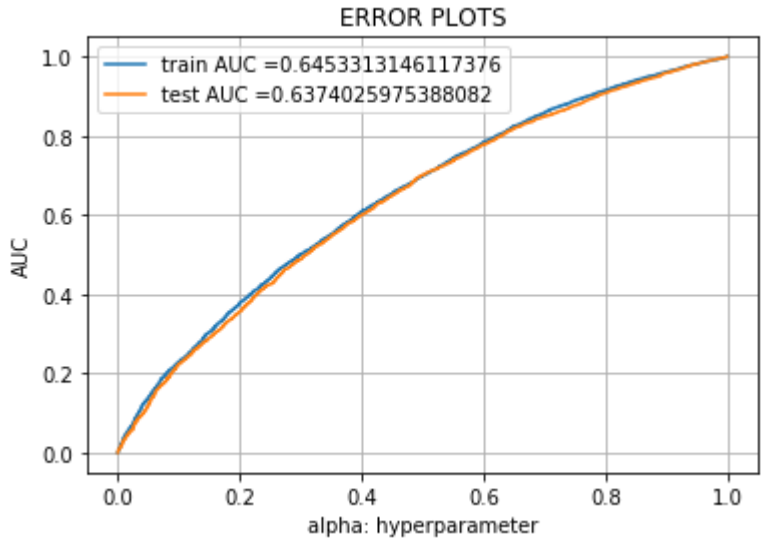
```
Final Data matrix
(31420, 108) (31420,)
(15477, 108) (15477,)
(23100, 108) (23100,)
====================================================================================
======================
```

In [106]:
```
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score

train_auc=[]
cv_auc=[]
alpha= [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000, 10**5]
b=[]
for i in tqdm(alpha):
    mb=LogisticRegression(penalty='l2',C=i,class_weight='balanced')
    mb.fit(X_tr,y_train)

    y_train_pred=batch_predict(mb,X_tr)
    y_cv_pred=batch_predict(mb,X_cr)

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv,y_cv_pred))

max_auc_ind_train=train_auc.index(max(train_auc))
alpha_max_auc_train=alpha[max_auc_ind_train]

print("max auc in train data:",max(train_auc))
print("alpha value for maximum AUC:",alpha_max_auc_train)
max_auc_ind_cv=cv_auc.index(max(cv_auc))
alpha_max_auc_cv=alpha[max_auc_ind_cv]
print("max auc  in cv data:",max(cv_auc))
print("alpha value for maximum AUC:",alpha_max_auc_cv)

plt.plot(alpha,train_auc,label='Train_AUC')
plt.plot(alpha,cv_auc,label='CV_AUC')
plt.scatter(alpha,cv_auc)
plt.scatter(alpha,train_auc)
#https://matplotlib.org/3.1.1/api/_as_gen/matplotlib.pyplot.xscale.html
plt.xscale('log')
plt.title("AUC: ERROR plot")
plt.ylabel('AUC')
plt.xlabel('Alpha:Hyperparameter')
plt.legend()
plt.grid(1)
```

```
100%|████████████████████████████████████████████████████████████████████████████████| 11/11 [00:39<00:00,  7.51s/it]

max auc in train data: 0.6453449512178367
alpha value for maximum AUC: 100000
max auc  in cv data: 0.6449834842879261
alpha value for maximum AUC: 1000
```

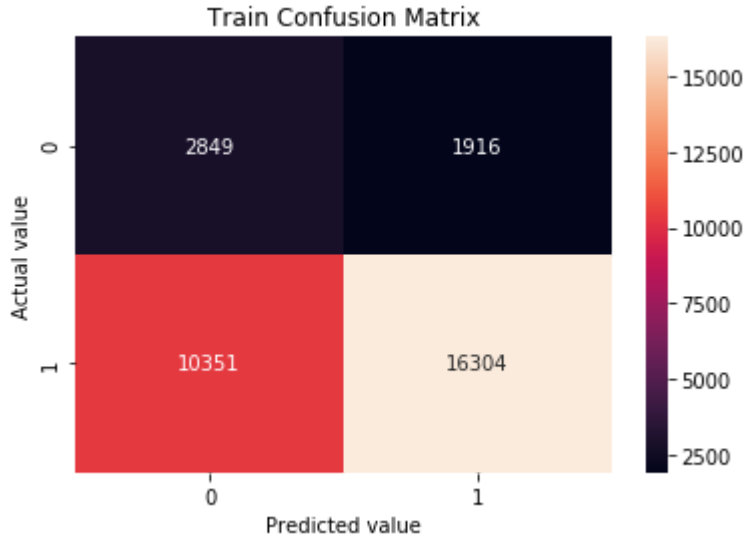

AUC: ERROR plot
Train_AUC
CV_AUC
AUC
0.64
0.62
0.60
0.58
0.56
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
Alpha:Hyperparameter

In [107]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.htr
from sklearn.metrics import roc_curve, auc

nb = LogisticRegression(C=1000,class_weight='balanced',penalty='l2')
nb.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimate
# not the predicted outputs

y_train_pred = nb.predict_proba(X_tr)[:,1]
y_test_pred = nb.predict_proba(X_te)[:,1]

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr )))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



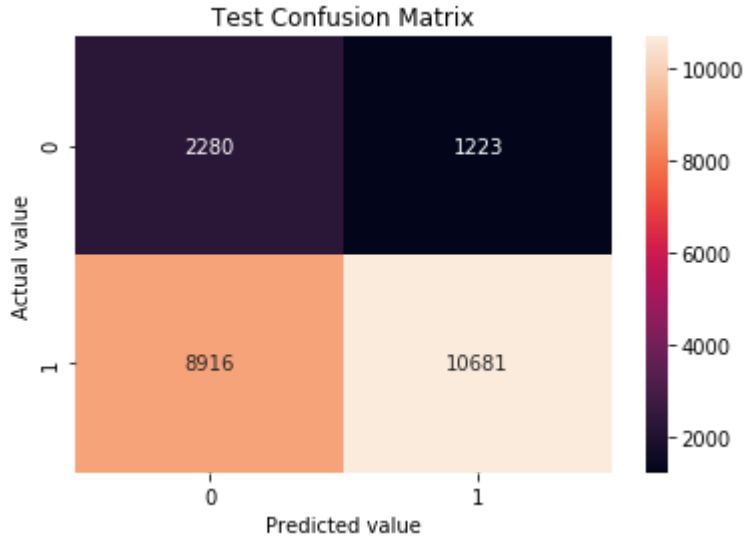
In [108]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_tr=confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,train_fpr,tra

sns.heatmap(con_tr,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Train Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.36571689516052047
Threshold: 0.498
```



In [109]:
```
import seaborn as sns
#https://stackoverflow.com/a/33158941/10967428
con_te=confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, te

sns.heatmap(con_te,annot=True,fmt='0.00f',annot_kws={'size':10})
plt.title("Test Confusion Matrix")
plt.ylabel("Actual value")
plt.xlabel("Predicted value")
plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.36074392587573667
Threshold: 0.531
```



Conclusions

In [110]:
```
# Please compare all your models using Prettytable library
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer",  "Hyper parameter", "AUC"]
x.add_row(["BOW", 1, 0.65])
x.add_row(["TFIDF", 0.1, 0.69])
x.add_row(["AVGW2V", 100000, 0.68])
x.add_row(["TFIDF W2V", 0.1, 0.68])
x.add_row(["NO TEXT", 100, 0.63])

print(x)
```

```
+------------+-----------------+------+
| Vectorizer | Hyper parameter | AUC  |
+------------+-----------------+------+
|    BOW     |        1        | 0.65 |
|   TFIDF    |       0.1       | 0.69 |
|   AVGW2V   |      100000     | 0.68 |
| TFIDF W2V  |       0.1       | 0.68 |
|  NO TEXT   |       100       | 0.63 |
+------------+-----------------+------+
```

Summary

1. On comparing both the results we see that TFIDF featurization works a bit well in terms precision and recall
2. Its very good compared to kNN in terms of execution time and in terms of accuracy and execution time.

In [ ]: