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	De
project_id	A unique identifier for the proposed project. **Example:**
project_title	Title of the project. **E** • Art Will Make You • First Gr
project_grade_category	Grade level of students for which the project is targeted. One of the enumerate • Grades • Gra • Gra • Grad
project_subject_categories	One or more (comma-separated) subject categories for the projec following enumerated list • Applied L • Care & • Health & • History & • Literacy & L • Math & • Music & T • Specia • **Ex** • Music & T • Literacy & Language, Math &
school_state	State where school is located (Two-letter U.S. p (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Posta **Exar**
project_subject_subcategories	One or more (comma-separated) subject subcategories for th **E** • L • Literature & Writing, Social S
project_resource_summary	An explanation of the resources needed for the project. **E** • My students need hands on literacy materials to sensory
project_essay_1	First applicat
project_essay_2	Second applicat
project_essay_3	Third applicat
project_essay_4	Fourth applicat
project_submitted_datetime	Datetime when project application was submitted. **Example:** 201 12:43
teacher_id	A unique identifier for the teacher of the proposed project. bdf8baa8fedef6bfeec7ae4ff

Feature	De
`teacher_prefix`	Teacher's title. One of the following enumerate • • • • • • T
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the sam **Exa**

* 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

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 [43]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [44]:

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

In [45]:

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

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

In [46]:

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

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

Out[46]:

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

1.2 preprocessing of `project_subject_categories`

In [47]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47
301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-stri
ng
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-pyth
on
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", "Warmt
h", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "M
ath & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace
 it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"M
ath & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spa
ces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [48]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47
301924/4084039

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

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

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

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

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

1.4 preprocessing of `school_state`

In [49]:

```
my_counter = Counter()
for word in project_data['school_state'].values:
    my_counter.update(word.split())

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

In [ ]:

```

```

In [50]:

```
preproc = []
# tqdm is for printing the status bar
for sent in project_data['project_grade_category']:
    sent = sent.replace(' ', '_')
    sent = sent.replace('PreK-2', 'PreK_2')
    sent = sent.replace('6-8', '6_8')
    sent = sent.replace('3-5', '3_5')
    sent = sent.replace('9-12', '9_12')
    preproc.append(sent)
project_data['project_grade_category']=preproc
```

In [51]:

```
my_counter = Counter()
for word in project_data['project_grade_category'].values:
    my_counter.update(word.split())

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

In [ ]:

```

```

In [52]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].astype(str)
preproc = []
# tqdm is for printing the status bar
for sent in project_data['teacher_prefix']:
    sent = sent.replace('Mr.', 'Mr')
    sent = sent.replace('Mrs.', 'Mrs')
    sent = sent.replace('Dr.', 'Dr')
    sent = sent.replace('Ms.', 'Ms')
    sent = sent.replace('nan','')
    preproc.append(sent)
project_data['teacher_prefix']=preproc
```

In [53]:

```
#['Teacher', 'Mrs.', 'Dr.', 'Mr.', 'Ms.']
project_data['teacher_prefix']=project_data['teacher_prefix'].fillna('')
my_counter = Counter()
for word in project_data['teacher_prefix'].values:
    my_counter.update(word.split())

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

In [ ]:

```

```

1.3 Text preprocessing

In [54]:

```
# 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 [55]:

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

Out[55]:

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

In [56]:

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

In [57]:

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

My students are English learners that are working on English as their seco
nd or third languages. We are a melting pot of refugees, immigrants, and n
ative-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 level of mastery. We also have over 40 countries repres
ented with the families within our school. Each student brings a wealth o
f knowledge and experiences to us that open our eyes to new cultures, beli
efs, and respect.\"The limits of your language are the limits of your worl
d.\"-Ludwig Wittgenstein Our English learner's have a strong support syst
em at home that begs for more resources. Many times our parents are learn
ing to read and speak English along side of their children. Sometimes thi
s creates barriers for parents to be able to help their child learn phonet
ics, letter recognition, and other reading skills.\r\n\r\nBy providing the
se dvd's and players, students are able to continue their mastery of the E
nglish language even if no one at home is able to assist. All families wi
th 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 are to help the child develop early reading skills.\r\n\r\nPare
nts that do not have access to a dvd player will have the opportunity to c
heck out a dvd player to use for the year. The plan is to use these video
s and educational dvd's for the years to come for other EL students.\r\nna
nnan

==

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% a
re minority students. \r\nThe school has a vibrant community that loves to
get together and celebrate. Around Halloween there is a whole school parad
e to show off the beautiful costumes that students wear. On Cinco de Mayo
we put on a big festival with crafts made by the students, dances, and gam
es. At the end of the year the school hosts a carnival to celebrate the ha
rd work put in during the school year, with a dunk tank being the most pop
ular activity.My students will use these five brightly colored Hokki stool
s in place of regular, stationary, 4-legged chairs. As I will only have a
total of ten in the classroom and not enough for each student to have an i
ndividual one, they will be used in a variety of ways. During independent
reading time they will be used as special chairs students will each use on
occasion. I will utilize them in place of chairs at my small group tables
during math and reading times. The rest of the day they will be used by th
e students who need the highest amount of movement in their life in order
to stay focused on school.\r\n\r\nWhenever asked what the classroom is mis
sing, my students always say more Hokki Stools. They can't get their fill
of the 5 stools we already have. When the students are sitting in group wi
th me on the Hokki Stools, they are always moving, but at the same time do
ing their work. Anytime the students get to pick where they can sit, the H
okki Stools are the first to be taken. There are always students who head
over to the kidney table to get one of the stools who are disappointed as
there are not enough of them. \r\n\r\nWe ask a lot of students to sit for
7 hours a day. The Hokki stools will be a compromise that allow my student
s to do desk work and move at the same time. These stools will help studen
ts to meet their 60 minutes a day of movement by allowing them to activate
their core muscles for balance while they sit. For many of my students, th
ese chairs will take away the barrier that exists in schools for a child w
ho can't sit still.nannan

==

How do you remember your days of school? Was it in a sterile environment w
ith plain walls, rows of desks, and a teacher in front of the room? A typi
cal day in our room is nothing like that. I work hard to create a warm inv
iting themed room for my students look forward to coming to each day.\r\n
\r\nMy class is made up of 28 wonderfully unique boys and girls of mixed r

aces in Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free and 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 and 10 year-old students are very eager learners; they are like sponges, absorbing all the information and experiences and keep on wanting more.With these resources such as the comfy red throw pillows and the whimsical nautical hanging decor and the blue fish nets, I will be able to help create the mood in our classroom setting to be one of a themed nautical environment. Creating a classroom environment is very important in the success in each and every child's education. The nautical photo props will be used with each child as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pictures of each child with them, have them developed, and then hung in our classroom ready for their first day of 4th grade. This kind gesture will set the tone before even the first day of school! The nautical thank you cards will be used throughout the year by the students as they create thank you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of my own pocket on resources to get our classroom ready. Please consider helping with this project to make our new school year a very successful one. Thank you!nannan

==

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

==

The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% African-American, making up the largest segment of the student body. A typical school in Dallas is made up of 23.2% African-American students. Most of the students are on free or reduced lunch. We aren't receiving doctors, lawyers, or engineers children from rich backgrounds or neighborhoods. As an educator I am inspiring minds of young children and we focus not only on academics but one smart, effective, efficient, and disciplined students with good character.In our classroom we can utilize the Bluetooth for swift transitions during class. I use a speaker which doesn't amplify the sound enough to receive the message. Due to the volume of my speaker my students can't hear videos or books clearly and it isn't making the lessons as meaningful. But with the blue tooth speaker my students will be able to hear and I can stop, pause and replay it at any time.\r\nThe cart will allow me to have more room for storage of things that are needed for the day and has an extra part to it I can use. The table top chart has all of the letter, words and pictures for students to learn about different letters and it is more accessible.nannan

==

In [58]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [59]:

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

```
My kindergarten students have varied disabilities ranging from speech and
language delays, cognitive delays, gross/fine motor delays, to autism. The
y are eager beavers and always strive to work their hardest working past t
heir limitations. \r\n\r\nThe materials we have are the ones I seek out fo
r my students. I teach in a Title I school where most of the students rece
ive free or reduced price lunch.  Despite their disabilities and limitatio
ns, my students love coming to school and come eager to learn and explore.
Have you ever felt like you had ants in your pants and you needed to groov
e and move as you were in a meeting? This is how my kids feel all the tim
e. The want to be able to move as they learn or so they say.Wobble chairs
are the answer and I love then because they develop their core, which enha
nces gross motor and in Turn fine motor skills. \r\nThey also want to lear
n through games, my kids do not want to sit and do worksheets. They want t
o learn to count by jumping and playing. Physical engagement is the key to
our success. The number toss and color and shape mats can make that happe
n. My students will forget they are doing work and just have the fun a 6 y
ear old deserves.nannan
==================================================
```

In [60]:

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

```
My kindergarten students have varied disabilities ranging from speech and
language delays, cognitive delays, gross/fine motor delays, to autism. The
y are eager beavers and always strive to work their hardest working past t
heir limitations.     The materials we have are the ones I seek out for my
students. I teach in a Title I school where most of the students receive f
ree or reduced price lunch.  Despite their disabilities and limitations, m
y students love coming to school and come eager to learn and explore.Have
you ever felt like you had ants in your pants and you needed to groove and
move as you were in a meeting? This is how my kids feel all the time. The
want to be able to move as they learn or so they say.Wobble chairs are the
answer and I love then because they develop their core, which enhances gro
ss motor and in Turn fine motor skills.   They also want to learn through
games, my kids do not want to sit and do worksheets. They want to learn to
count by jumping and playing. Physical engagement is the key to our succes
s. The number toss and color and shape mats can make that happen. My stude
nts will forget they are doing work and just have the fun a 6 year old des
erves.nannan
```

In [61]:

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

```
My kindergarten students have varied disabilities ranging from speech and
language delays cognitive delays gross fine motor delays to autism They ar
e eager beavers and always strive to work their hardest working past their
limitations The materials we have are the ones I seek out for my students
I teach in a Title I school where most of the students receive free or red
uced price lunch Despite their disabilities and limitations my students lo
ve coming to school and come eager to learn and explore Have you ever felt
like you had ants in your pants and you needed to groove and move as you w
ere in a meeting This is how my kids feel all the time The want to be able
to move as they learn or so they say Wobble chairs are the answer and I lo
ve then because they develop their core which enhances gross motor and in
Turn fine motor skills They also want to learn through games my kids do no
t want to sit and do worksheets They want to learn to count by jumping and
playing Physical engagement is the key to our success The number toss and
color and shape mats can make that happen My students will forget they are
doing work and just have the fun a 6 year old deserves nannan
```

In [62]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [63]:

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

```
100%|██████████████████████████████████████████████████████████████████████████████
████| 109248/109248 [02:11<00:00, 828.16it/s]
```

In [64]:

```
# after preprocesing
project_data['essay']=preprocessed_essays[20000]
```

1.4 Preprocessing of `project_title`

In [65]:

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

In [66]:

```
# similarly you can preprocess the titles also
preprocessed_titles = []
# tqdm is for printing the status bar
for sentence in tqdm(project_data['project_title'].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 not in stopwords)
    preprocessed_titles.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████
█| 109248/109248 [00:05<00:00, 19139.39it/s]
```

In [67]:

```
project_data['project_title']=preprocessed_titles
```

1.5 Preparing data for models

In [68]:

```
project_data.columns
```

Out[68]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_ti
tle',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approve
d',
       'clean_categories', 'clean_subcategories', 'essay'],
      dtype='object')
```

we are going to consider

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

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

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

1.5.1 Vectorizing Categorical data

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

In [69]:

```
# you can do the similar thing with state, teacher_prefix and project_grade_category al
so
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [70]:

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

Assignment 4: Naive Bayes

1. **Apply Multinomial NaiveBayes on these feature sets**

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

2. **The hyper paramter tuning(find best Alpha)**

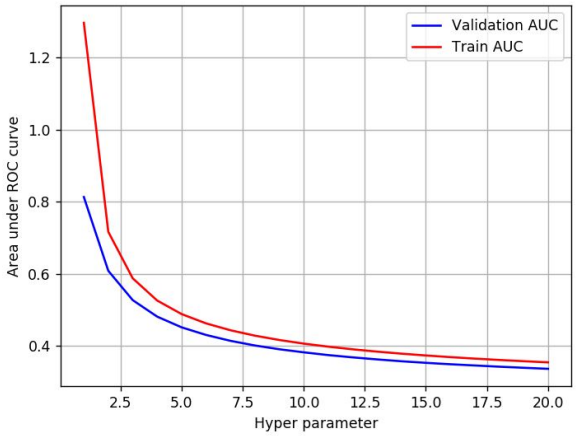
   - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
   - Consider a wide range of alpha values for hyperparameter tuning, start as low as 0.00001
   - 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. **Feature importance**

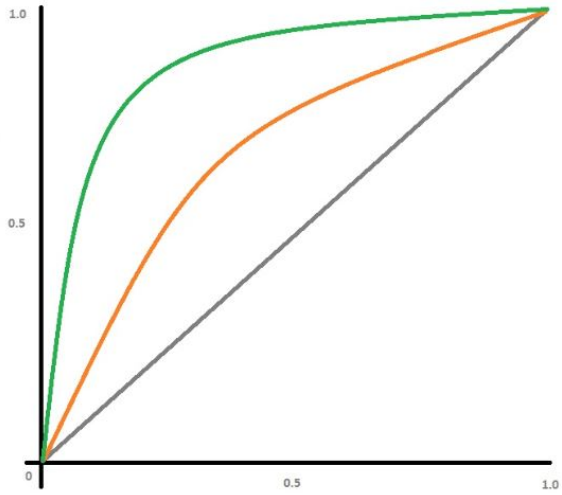
   - Find the top 10 features of positive class and top 10 features of negative class for both feature sets Set 1 and Set 2 using values of `feature_log_prob_` parameter of MultinomialNB (https://scikit-learn.org/stable/modules/generated/sklearn.naive_bayes.MultinomialNB.html) and print their corresponding feature names

4. **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. Here on X-axis you will have alpha values, since they have a wide range, just to represent those alpha values on the graph, apply log function on those alpha values.



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

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

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

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

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

2. Naive Bayes

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

In [71]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
y = project_data['project_is_approved']
print(y.shape)
```

```
(109248,)
```

In [72]:

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

In [73]:

```
X=project_data
print(X.shape)
```

```
(109248, 17)
```

In [74]:

```
#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, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, strat
ify=y_train)
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [75]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_i
ndex()
```

In [76]:

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

In [77]:

```
X_train=X_train.fillna(0)
X_cv=X_cv.fillna(0)
X_test=X_test.fillna(0)
```

In [144]:

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

X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(1,-1)).transp
ose()

X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(1,-1)).transpose()
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(1,-1)).transpos
e()

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

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

In [145]:

```
print(X_train_price_norm)
```

```
[[1.41151449e-03]
 [2.11769978e-03]
 [1.94410224e-03]
 ...
 [1.05071697e-03]
 [1.57169984e-03]
 [4.17585323e-05]]
```

In [ ]:

```

```

In [147]:

```
normalizer = Normalizer()
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1
,-1))

X_train_project_norm = normalizer.transform(X_train['teacher_number_of_previously_poste
d_projects'].values.reshape(1,-1)).transpose()
X_cv_project_norm = normalizer.transform(X_cv['teacher_number_of_previously_posted_proj
ects'].values.reshape(1,-1)).transpose()
X_test_project_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_
projects'].values.reshape(1,-1)).transpose()

print("After vectorizations")
print(X_train_project_norm.shape, y_train.shape)
print(X_cv_project_norm.shape, y_cv.shape)
print(X_test_project_norm.shape, y_test.shape)
print("="*100)
```

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

In [ ]:

In [ ]:

In [ ]:

In [80]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label

from sklearn.feature_extraction.text import CountVectorizer
```

In [81]:

```
vectorizer_grades = CountVectorizer( lowercase=False, binary=True)
vectorizer_grades.fit(X_train['project_grade_category'].values) # fit has to happen onl
y on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer_grades.transform(X_train['project_grade_category'].value
s)
X_cv_grade_ohe = vectorizer_grades.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer_grades.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_grades.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
['Grades_3_5', 'Grades_6_8', 'Grades_9_12', 'Grades_PreK_2']
====================================================================================
==========================
```

In [ ]:

```

```

In [82]:

```
vectorizer_tprefix = CountVectorizer( lowercase=False, binary=True)
vectorizer_tprefix.fit(X_train['teacher_prefix'].values) # fit has to happen only on tr
ain data

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

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

```
After vectorizations
(49041, 5) (49041,)
(24155, 5) (24155,)
(36052, 5) (36052,)
['Dr', 'Mr', 'Mrs', 'Ms', 'Teacher']
====================================================================================
==========================
```

In [83]:

```
vectorizer_state = CountVectorizer( lowercase=False, binary=True)
vectorizer_state.fit(X_train['school_state'].values) # fit has to happen only on train
 data

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer_state.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer_state.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer_state.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_state.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['AK', 'AL', 'AR', 'AZ', 'CA', 'CO', 'CT', 'DC', 'DE', 'FL', 'GA', 'HI',
'IA', 'ID', 'IL', 'IN', 'KS', 'KY', 'LA', 'MA', 'MD', 'ME', 'MI', 'MN', 'M
O', 'MS', 'MT', 'NC', 'ND', 'NE', 'NH', 'NJ', 'NM', 'NV', 'NY', 'OH', 'O
K', 'OR', 'PA', 'RI', 'SC', 'SD', 'TN', 'TX', 'UT', 'VA', 'VT', 'WA', 'W
I', 'WV', 'WY']
====================================================================
==========================
```

In [ ]:

```
```

In [84]:

```
vectorizer_ccategory = CountVectorizer( lowercase=False, binary=True)
vectorizer_ccategory.fit(X_train['clean_categories'].values) # fit has to happen only o
n train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_cat_ohe = vectorizer_ccategory.transform(X_train['clean_categories'].values)
X_cv_cat_ohe = vectorizer_ccategory.transform(X_cv['clean_categories'].values)
X_test_cat_ohe = vectorizer_ccategory.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_ccategory.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
['AppliedLearning', 'Care_Hunger', 'Health_Sports', 'History_Civics', 'Lit
eracy_Language', 'Math_Science', 'Music_Arts', 'SpecialNeeds', 'Warmth']
====================================================================================
==========================
```

In [85]:

```
vectorizer_csc = CountVectorizer( lowercase=False, binary=True)
vectorizer_csc.fit(X_train['clean_subcategories'].values) # fit has to happen only on t
rain data

# we use the fitted CountVectorizer to convert the text to vector
X_train_sub_ohe = vectorizer_csc.transform(X_train['clean_subcategories'].values)
X_cv_sub_ohe = vectorizer_csc.transform(X_cv['clean_subcategories'].values)
X_test_sub_ohe = vectorizer_csc.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_sub_ohe.shape, y_train.shape)
print(X_cv_sub_ohe.shape, y_cv.shape)
print(X_test_sub_ohe.shape, y_test.shape)
print(vectorizer_csc.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
['AppliedSciences', 'Care_Hunger', 'CharacterEducation', 'Civics_Governmen
t', 'College_CareerPrep', 'CommunityService', 'ESL', 'EarlyDevelopment',
'Economics', 'EnvironmentalScience', 'Extracurricular', 'FinancialLiterac
y', 'ForeignLanguages', 'Gym_Fitness', 'Health_LifeScience', 'Health_Welln
ess', 'History_Geography', 'Literacy', 'Literature_Writing', 'Mathematic
s', 'Music', 'NutritionEducation', 'Other', 'ParentInvolvement', 'Performi
ngArts', 'SocialSciences', 'SpecialNeeds', 'TeamSports', 'VisualArts', 'Wa
rmth']
====================================================================================
==========================
```

In [ ]:

```
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [86]:

```
from sklearn.feature_extraction.text import CountVectorizer
```

In [87]:

```
vectorizer_bow_essay = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
```

In [88]:

```
vectorizer_bow_essay.fit(X_train['essay'].values) # fit has to happen only on train dat
a
```

Out[88]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=5000, min_df=10,
        ngram_range=(1, 4), preprocessor=None, stop_words=None,
        strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
        tokenizer=None, vocabulary=None)
```

In [89]:

```
X_train_essay_bow = vectorizer_bow_essay.transform(X_train['essay'].values)
X_cv_essay_bow = vectorizer_bow_essay.transform(X_cv['essay'].values)
X_test_essay_bow = vectorizer_bow_essay.transform(X_test['essay'].values)
```

In [90]:

```
print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 447) (49041,)
(24155, 447) (24155,)
(36052, 447) (36052,)
====================================================================================
==========================
```

In [ ]:

```
```

In [91]:

```
vectorizer_bow_prtitle= CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
```

In [92]:

```
vectorizer_bow_prtitle.fit(X_train['project_title'].values) # fit has to happen only on
train data
```

Out[92]:

```
CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=5000, min_df=10,
        ngram_range=(1, 4), preprocessor=None, stop_words=None,
        strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
        tokenizer=None, vocabulary=None)
```

In [93]:

```
X_train_title_bow = vectorizer_bow_prtitle.transform(X_train['project_title'].values)
X_cv_title_bow = vectorizer_bow_prtitle.transform(X_cv['project_title'].values)
X_test_title_bow = vectorizer_bow_prtitle.transform(X_test['project_title'].values)
```

In [94]:

```
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("="*100)
```

```
After vectorizations
(49041, 4106) (49041,)
(24155, 4106) (24155,)
(36052, 4106) (36052,)
====================================================================================
==========================
```

In [95]:

```
vectorizer_tfidf_essay = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000
)
vectorizer_tfidf_essay.fit(X_train['essay'].values) # fit has to happen only on train d
ata
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer_tfidf_essay.transform(X_train['essay'].values)
X_cv_essay_tfidf = vectorizer_tfidf_essay.transform(X_cv['essay'].values)
X_test_essay_tfidf = vectorizer_tfidf_essay.transform(X_test['essay'].values)
print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 447) (49041,)
(24155, 447) (24155,)
(36052, 447) (36052,)
====================================================================================
==========================
```

In [ ]:

```
```

In [96]:

```
vectorizer_tfidf_prtitle = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=50
00)
vectorizer_tfidf_prtitle.fit(X_train['project_title'].values) # fit has to happen only
 on train data
# we use the fitted CountVectorizer to convert the text to vector
X_train_title_tfidf = vectorizer_tfidf_prtitle.transform(X_train['project_title'].value
s)
X_cv_title_tfidf = vectorizer_tfidf_prtitle.transform(X_cv['project_title'].values)
X_test_title_tfidf = vectorizer_tfidf_prtitle.transform(X_test['project_title'].values)

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("="*100)
```

```
After vectorizations
(49041, 4106) (49041,)
(24155, 4106) (24155,)
(36052, 4106) (36052,)
====================================================================================
==========================
```

In [97]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_essay_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_train.append(vector)

print(len(avg_w2v_essay_train))
print(len(avg_w2v_essay_train[0]))
print(type(avg_w2v_essay_train))
```

```
100%|████████████████████████████████████████████████████████████████████████████
██████| 49041/49041 [00:20<00:00, 2351.98it/s]

49041
300
<class 'list'>
```

In [98]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_essay_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_test.append(vector)

print(len(avg_w2v_essay_test))
print(len(avg_w2v_essay_test[0]))
print(type(avg_w2v_essay_test))
```

```
100%|████████████████████████████████████████████████████████████████████████████████| 36052/36052 [00:15<00:00, 2340.17it/s]

36052
300
<class 'list'>
```

In [99]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_essay_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essay_cv.append(vector)

print(len(avg_w2v_essay_cv))
print(len(avg_w2v_essay_cv[0]))
print(type(avg_w2v_essay_cv))
```

```
100%|████████████████████████████████████████████████████████████████████████████████| 24155/24155 [00:10<00:00, 2385.89it/s]

24155
300
<class 'list'>
```

In [ ]:

```

```

In [100]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_title_train.append(vector)

print(len(avg_w2v_title_train))
print(len(avg_w2v_title_train[0]))
print(type(avg_w2v_title_train))
```

```
100%|████████████████████████████████████████████████████████████████████
████| 49041/49041 [00:02<00:00, 23314.32it/s]

49041
300
<class 'list'>
```

In [101]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_title_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_title_test.append(vector)

print(len(avg_w2v_title_test))
print(len(avg_w2v_title_test[0]))
print(type(avg_w2v_title_test))
```

```
100%|████████████████████████████████████████████████████████████████████
████| 36052/36052 [00:01<00:00, 30150.99it/s]

36052
300
<class 'list'>
```

In [102]:

```
# average Word2Vec
# compute average word2vec for each essay.
avg_w2v_title_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_title_cv.append(vector)

print(len(avg_w2v_title_cv))
print(len(avg_w2v_title_cv[0]))
print(type(avg_w2v_title_cv))
```

```
100%|████████████████████████████████████████████████████████████████████████████
████| 24155/24155 [00:00<00:00, 28093.65it/s]

24155
300
<class 'list'>
```

In [103]:

```
tfidf_model = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
tfidf_model.fit(X_train['essay'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [104]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_train_essay = []; # the avg-w2v for each sentence/review is stored in this li
st
for sentence in tqdm(X_train['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_train_essay.append(vector)

print(len(tfidf_w2v_train_essay))
print(len(tfidf_w2v_train_essay[0]))
```

```
100%|████████████████████████████████████████████████████████████████
██████| 49041/49041 [02:51<00:00, 286.21it/s]

49041
300
```

In [105]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_test_essay = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_test['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_test_essay.append(vector)

print(len(tfidf_w2v_test_essay))
print(len(tfidf_w2v_test_essay[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████
██████| 36052/36052 [02:02<00:00, 293.41it/s]

36052
300
```

In [106]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_cv_essay = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['essay'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_cv_essay.append(vector)

print(len(tfidf_w2v_cv_essay))
print(len(tfidf_w2v_cv_essay[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████
██████| 24155/24155 [01:46<00:00, 226.93it/s]

24155
300
```

In [107]:

```
tfidf_model = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
tfidf_model.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_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [108]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_train_title = []; # the avg-w2v for each sentence/review is stored in this li
st
for sentence in tqdm(X_train['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_train_title.append(vector)

print(len(tfidf_w2v_train_title))
print(len(tfidf_w2v_train_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████
██████| 49041/49041 [00:05<00:00, 8520.73it/s]

49041
300
```

In [109]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_test_title = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in tqdm(X_test['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_test_title.append(vector)

print(len(tfidf_w2v_test_title))
print(len(tfidf_w2v_test_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████
██████| 36052/36052 [00:03<00:00, 9575.28it/s]

36052
300
```

In [110]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_cv_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['project_title'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_cv_title.append(vector)

print(len(tfidf_w2v_cv_title))
print(len(tfidf_w2v_cv_title[0]))
```

```
100%|████████████████████████████████████████████████████████████████████
████| 24155/24155 [00:02<00:00, 10160.15it/s]

24155
300
```

In [ ]:

In [ ]:

2.4 Appling NB() on different kind of featurization as mentioned in the instructions

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

2.4.1 Applying Naive Bayes on BOW, SET 1

In [148]:

```
# Please write all the code with proper documentation
# Please write all the code with proper documentation
# Please write all the code with proper documentation

# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_bow,X_train_title_bow, X_train_state_ohe, X_train_teacher_
ohe, X_train_grade_ohe,X_train_cat_ohe,X_train_sub_ohe, X_train_price_norm,X_train_proj
ect_norm)).tocsr()
X_cr = hstack((X_cv_essay_bow,X_cv_title_bow, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_gr
ade_ohe,X_cv_cat_ohe,X_cv_sub_ohe, X_cv_price_norm,X_cv_project_norm)).tocsr()
X_te = hstack((X_test_essay_bow,X_test_title_bow, X_test_state_ohe, X_test_teacher_ohe,
X_test_grade_ohe,X_test_cat_ohe,X_test_sub_ohe, X_test_price_norm,X_test_project_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
(49041, 4654) (49041,)
(24155, 4654) (24155,)
(36052, 4654) (36052,)
====================================================================================
==========================
```

2.4.1.1 Top 10 important features of positive class from SET 1

In [149]:

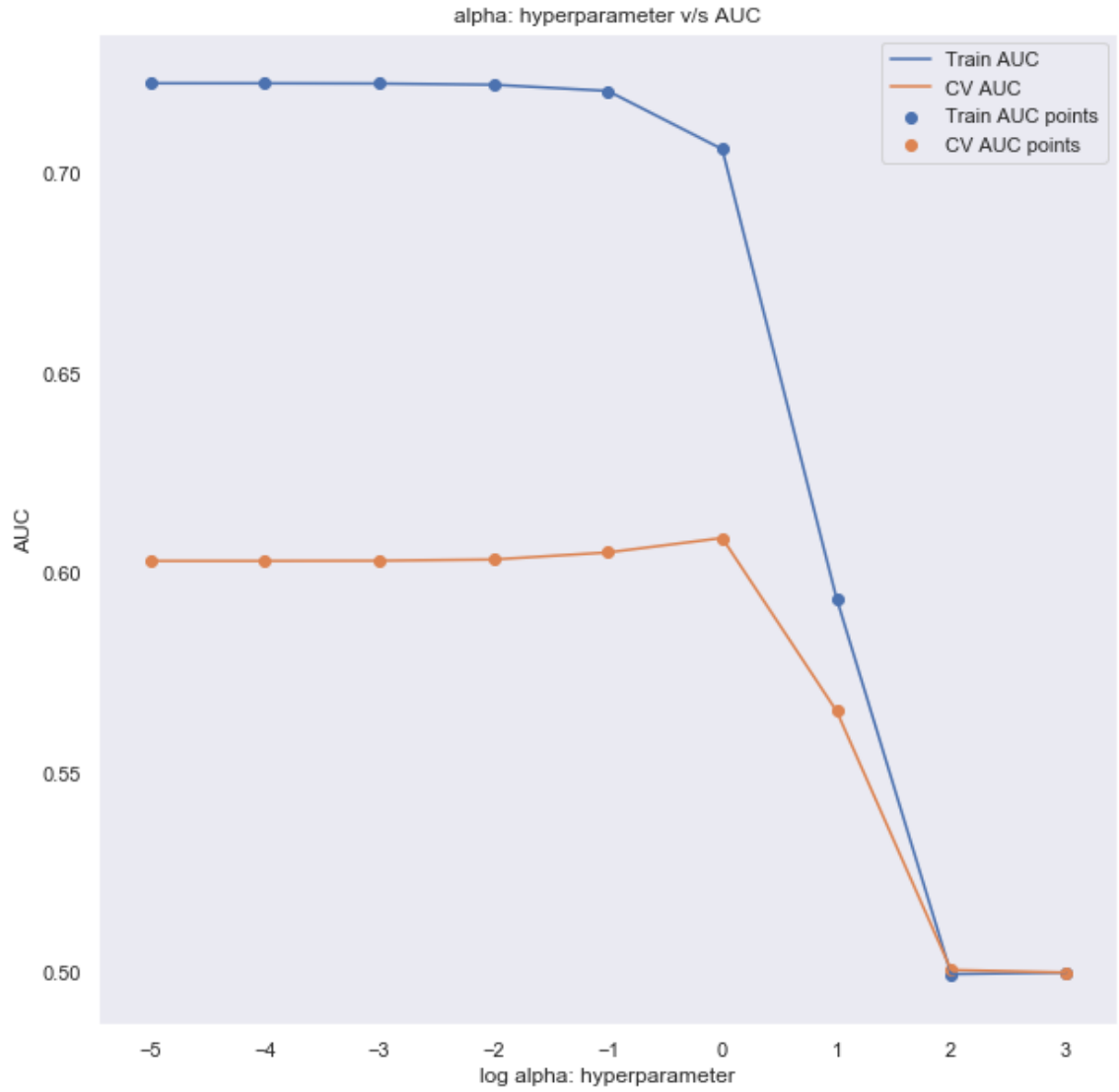
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math
train_auc = []
cv_auc = []
log_alphas = []
alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000]
for i in tqdm(alphas):
    nb = MultinomialNB(alpha = i,class_prior=[0.5,0.5])
    nb.fit(X_tr, y_train)
    y_train_pred=nb.predict_proba(X_tr[:])[:,1]
    y_cv_pred=nb.predict_proba(X_cr[:])[:,1]
   # y_train_pred = batch_predict(nb, X_tr)
    #y_cv_pred = batch_predict(nb, X_cr)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

for a in tqdm(alphas):
    b = math.log10(a)
    log_alphas.append(b)
```

```
100%|████████████████████████████████████████████████████████████
████████████| 9/9 [00:11<00:00,  1.24s/it]
100%|████████████████████████████████████████████████████████████
████████████| 9/9 [00:00<00:00, 9011.40it/s]
```

In [150]:

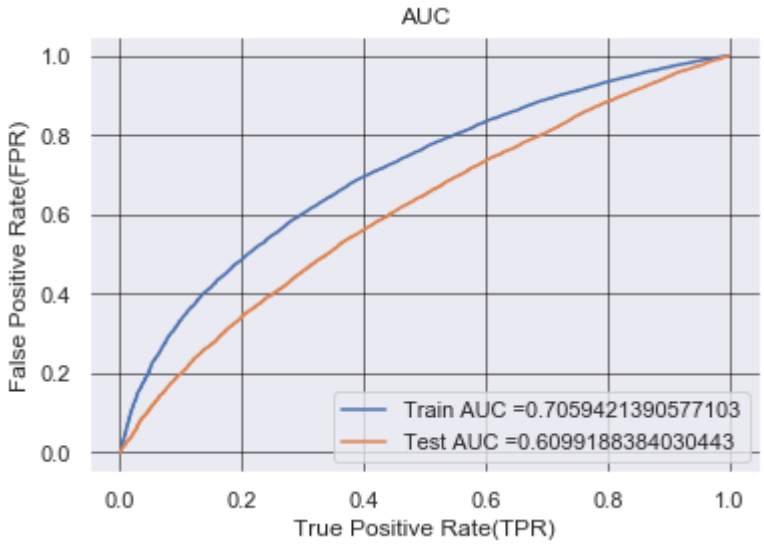
```
plt.figure(figsize=(10,10))
plt.plot(log_alphas, train_auc, label='Train AUC')
plt.plot(log_alphas, cv_auc, label='CV AUC')
plt.scatter(log_alphas, train_auc, label='Train AUC points')
plt.scatter(log_alphas, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC")
plt.grid()
plt.show()
```


alpha: hyperparameter v/s AUC
Train AUC
CV AUC
Train AUC points
CV AUC points
AUC
0.70
0.65
0.60
0.55
0.50
−5
−4
−3
−2
−1
0
1
2
3
log alpha: hyperparameter

In [ ]:

In [151]:

```
from sklearn.metrics import roc_curve, auc
nb_bow = MultinomialNB(alpha = 1,class_prior=[0.5,0.5])
nb_bow.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positiveclass
# not the predicted outputs
y_train_pred = nb_bow.predict_proba( X_tr[:])[:,1]
y_test_pred = nb_bow.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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid(color='black', linestyle='-', linewidth=0.5)
plt.show()
```



In [152]:

```
# 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, threshould, fpr, tpr):

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

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.rou
nd(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

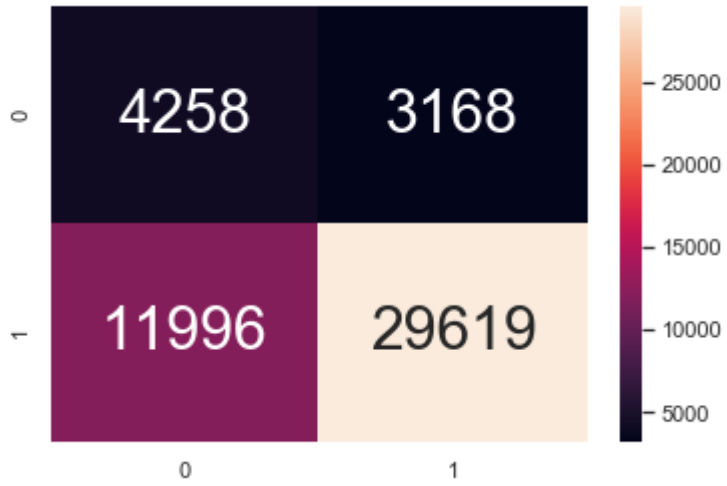
In [120]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,tr_thre
sholds,train_fpr,train_tpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4240588553345065 for threshold 0.441
```

Out[120]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1eb51cc7d68>
```



In [121]:

```
# Collecting feature names for BOW set1
# adding to end of list by concatening features
# Code snippet taken from here https://stackabuse.com/append-vs-extend-in-python-lists/
bow_features_names1 = []
```

In [122]:

```
for cnt6 in vectorizer_bow_essay.get_feature_names() :
    bow_features_names1.append(cnt6)
for cnt5 in vectorizer_bow_prtitle.get_feature_names() :
    bow_features_names1.append(cnt5)

for cnt2 in vectorizer_state.get_feature_names() :
    bow_features_names1.append(cnt2)
#i have given vectorizer of project grade category name of "states"
for cnt3 in vectorizer_grades.get_feature_names() :
    bow_features_names1.append(cnt3)
for cnt in vectorizer_ccategory.get_feature_names() :
    bow_features_names1.append(cnt)
for cnt1 in vectorizer_csc.get_feature_names() :
    bow_features_names1.append(cnt1)


for cnt4 in vectorizer_tprefix.get_feature_names() :
    bow_features_names1.append(cnt4)



bow_features_names1.append("price")
bow_features_names1.append("prev_proposed_projects")

len(bow_features_names1)
```

Out[122]:

4654

In [123]:

```
pos_class_prob_sorted = nb_bow.feature_log_prob_[1, :].argsort()[::-1][:7206]
for i in pos_class_prob_sorted[:30]:
    print(bow_features_names1[i])
```

```
students
learn
want
the
motor
they
delays
work
limitations
love
school
disabilities
gross
move
kids
want learn
eager
fine
fine motor
my
ranging speech
ranging speech language delays
ranging speech language
receive
receive free
able
ranging
price lunch despite disabilities
receive free reduced price
price lunch despite
```

2.4.1.2 Top 10 important features of negative class from SET 1

In [124]:

```
neg_class_prob_sorted = nb_bow.feature_log_prob_[0, :].argsort()[::-1][:7206]
for i in neg_class_prob_sorted[0:30]:
    print(bow_features_names1[i])
```

```
students
learn
want
the
motor
they
delays
work
limitations
love
school
disabilities
gross
move
kids
want learn
eager
fine
fine motor
my
ranging speech
ranging speech language delays
ranging speech language
receive
receive free
able
ranging
price lunch despite disabilities
receive free reduced price
price lunch despite
```

2.4.2 Applying Naive Bayes on TFIDF, SET 2

In [153]:

```
# Please write all the code with proper documentation
# Please write all the code with proper documentation
# Please write all the code with proper documentation


# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_tfidf,X_train_title_tfidf, X_train_state_ohe, X_train_teac
her_ohe, X_train_grade_ohe,X_train_cat_ohe,X_train_sub_ohe, X_train_price_norm,X_train_
project_norm)).tocsr()
X_cr = hstack((X_cv_essay_tfidf,X_cv_title_tfidf, X_cv_state_ohe, X_cv_teacher_ohe, X_c
v_grade_ohe,X_cv_cat_ohe,X_cv_sub_ohe, X_cv_price_norm,X_cv_project_norm)).tocsr()
X_te = hstack((X_test_essay_tfidf,X_test_title_tfidf, X_test_state_ohe, X_test_teacher_
ohe, X_test_grade_ohe,X_test_cat_ohe,X_test_sub_ohe, X_test_price_norm,X_test_project_n
orm)).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
(49041, 4654) (49041,)
(24155, 4654) (24155,)
(36052, 4654) (36052,)
====================================================================================
==========================
```

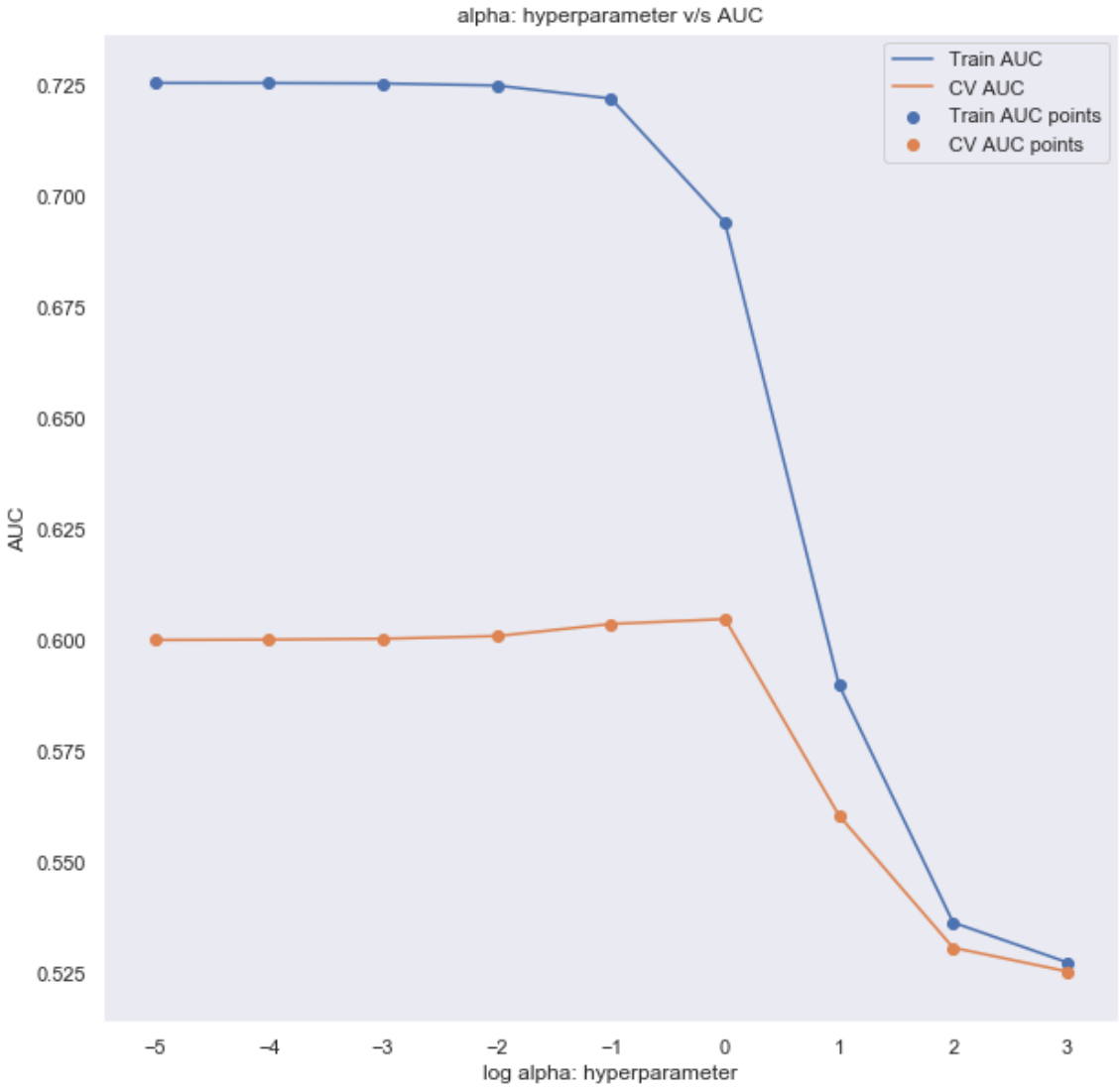
In [154]:

```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math
train_auc = []
cv_auc = []
log_alphas = []
alphas = [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000]
for i in tqdm(alphas):
    nb = MultinomialNB(alpha = i,class_prior=[0.5,0.5])
    nb.fit(X_tr, y_train)
    y_train_pred = nb.predict_proba(X_tr[:])[:,1]
    y_cv_pred = nb.predict_proba(X_cr[:])[:,1]
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positive class
# not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
for a in tqdm(alphas):
    b = math.log10(a)
    log_alphas.append(b)
```

```
100%|████████████████████████████████████████████████████████████████████
████████████| 9/9 [00:12<00:00,  1.38s/it]
100%|████████████████████████████████████████████████████████████████████
████████████| 9/9 [00:00<00:00, 8983.52it/s]
```

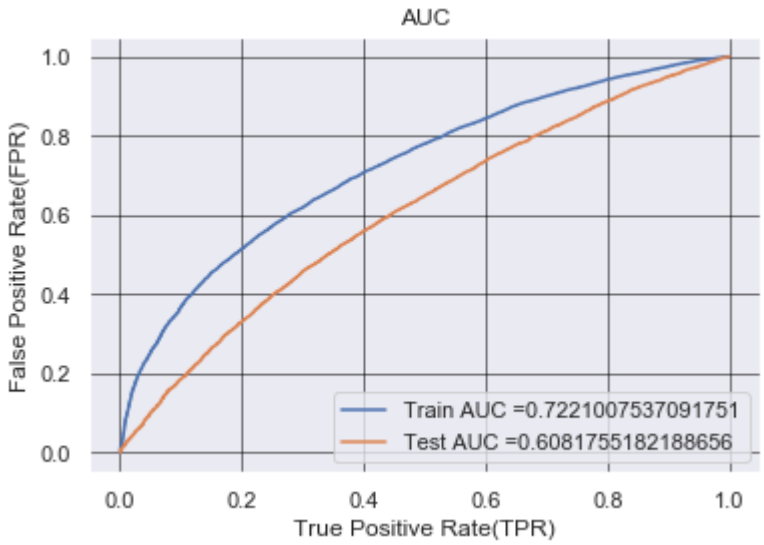
In [155]:

```
plt.figure(figsize=(10,10))
plt.plot(log_alphas, train_auc, label='Train AUC')
plt.plot(log_alphas, cv_auc, label='CV AUC')
plt.scatter(log_alphas, train_auc, label='Train AUC points')
plt.scatter(log_alphas, cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC")
plt.grid()
plt.show()
```



In [156]:

```
#selecting the best alpha
from sklearn.metrics import roc_curve, auc
nb_tfidf = MultinomialNB(alpha = 0.1,class_prior=[0.5,0.5])
nb_tfidf.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
he positiveclass
# not the predicted outputs
y_train_pred = nb_tfidf.predict_proba( X_tr[:])[:,1]
y_test_pred = nb_tfidf.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("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("AUC")
plt.grid(color='black', linestyle='-', linewidth=0.5)
plt.show()
```



In [157]:

```
# 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, threshould, fpr, tpr):

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

    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high

    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.rou
nd(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [158]:

```
print("Train confusion matrix")
conf_matr_df_train_2=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,tr_thre
sholds,train_fpr,train_tpr)),range(2),range(2))
sns.set(font_scale=1)#for label size
sns.heatmap(conf_matr_df_train_2,annot=True,annot_kws={"size":30},fmt='g')
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4358943198912194 for threshold 0.476
```

Out[158]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1eb22433278>
```

In [132]:

```
bow_features_names1 = []
for cnt6 in vectorizer_bow_essay.get_feature_names() :
    bow_features_names1.append(cnt6)
for cnt5 in vectorizer_bow_prtitle.get_feature_names() :
    bow_features_names1.append(cnt5)

for cnt2 in vectorizer_state.get_feature_names() :
    bow_features_names1.append(cnt2)
#i have given vectorizer of project grade category name of "states"
for cnt3 in vectorizer_grades.get_feature_names() :
    bow_features_names1.append(cnt3)
for cnt in vectorizer_ccategory.get_feature_names() :
    bow_features_names1.append(cnt)
for cnt1 in vectorizer_csc.get_feature_names() :
    bow_features_names1.append(cnt1)


for cnt4 in vectorizer_tprefix.get_feature_names() :
    bow_features_names1.append(cnt4)



bow_features_names1.append("price")
bow_features_names1.append("prev_proposed_projects")

len(bow_features_names1)
```

Out[132]:

4654

2.4.2.1 Top 10 important features of positive class from SET 2

In [133]:

```
# Please write all the code with proper documentation
pos_class_prob_sorted = nb_tfidf.feature_log_prob_[1, :].argsort()[::-1][:7206]
for i in pos_class_prob_sorted[:30]:
    print(bow_features_names1[i])
```

```
price
prev_proposed_projects
Grades_9_12
AppliedSciences
Literacy_Language
Care_Hunger
Grades_PreK_2
Care_Hunger
Other
PerformingArts
students
ParentInvolvement
want
learn
Health_Sports
CA
SpecialNeeds
the
they
motor
delays
Civics_Government
Mr
Math_Science
History_Civics
Grades_6_8
CommunityService
CharacterEducation
Music
want learn
```

2.4.2.2 Top 10 important features of negative class from SET 2

In [134]:

```
# Please write all the code with proper documentation
neg_class_prob_sorted = nb_tfidf.feature_log_prob_[0, :].argsort()[::-1][:7206]
for i in neg_class_prob_sorted[0:30]:
    print(bow_features_names1[i])
```

```
price
prev_proposed_projects
Grades_9_12
AppliedSciences
Care_Hunger
Literacy_Language
Grades_PreK_2
Care_Hunger
PerformingArts
Other
students
ParentInvolvement
want
learn
Health_Sports
Civics_Government
Mr
SpecialNeeds
CA
the
delays
they
motor
Math_Science
CommunityService
History_Civics
Grades_6_8
CharacterEducation
TX
my
```

3. Conclusions

In [159]:

```
# Please compare all your models using Prettytable library
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prett
ytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Alpha:Hyper Parameter", " Test AUC"]
x.add_row(["BOW", "Naive Bayes", 1, 0.609])
x.add_row(["TFIDF", "Naive Bayes", 0.1, 0.608])
print(x)
```

```
+------------+-------------+-----------------------+-----------+
| Vectorizer |    Model    | Alpha:Hyper Parameter |  Test AUC |
+------------+-------------+-----------------------+-----------+
|    BOW     | Naive Bayes |           1           |   0.609   |
|   TFIDF    | Naive Bayes |          0.1          |   0.608   |
+------------+-------------+-----------------------+-----------+
```

In [160]:

```
print(X_cv_project_norm)
```

```
[[0.00042281]
 [0.00232543]
 [0.00232543]
 ...
 [0.00042281]
 [0.00084561]
 [0.0002114 ]]
```

In [ ]:

```

```