DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located (Two-letter U.S. postal code (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Postal_codes)). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy` • `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!</code`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*

Feature	Description
project_essay_4	Fourth application essay*
project_submitted_datetime	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
teacher_id	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
teacher_prefix	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
teacher_number_of_previously_posted_projects	Number of project applications previously submitted by the same teacher. **Example:** `2`

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- __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 math
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

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

In [3]:
```
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 [4]:
```
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[4]:

	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 [5]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

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

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

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

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

1.3 preprocessing of project_subject_subcategories

In [6]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

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

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

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

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

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

1.3 Text preprocessing

Removing null values from project essay 3 & 4

In [7]:
```
# check if we have any nan values are there in the column
print(project_data['project_essay_3'].isnull().values.any())
print("number of nan values",project_data['project_essay_3'].isnull().values.sum())
```

```
True
number of nan values 105490
```

In [8]:
```
#Replacing the Nan values with most frequent value in the column
project_data['project_essay_3']=project_data['project_essay_3'].fillna(' ')
```

In [9]:
```
# check if we have any nan values are there in the column
print(project_data['project_essay_3'].isnull().values.any())
print("number of nan values",project_data['project_essay_3'].isnull().values.sum())
```

```
False
number of nan values 0
```

In [10]:
```
# check if we have any nan values are there in the column
print(project_data['project_essay_4'].isnull().values.any())
print("number of nan values",project_data['project_essay_4'].isnull().values.sum())
```

```
True
number of nan values 105490
```

In [11]:
```
#Replacing the Nan values with most frequent value in the column
project_data['project_essay_4']=project_data['project_essay_4'].fillna(' ')
```

In [12]:
```
# check if we have any nan values are there in the column
print(project_data['project_essay_4'].isnull().values.any())
print("number of nan values",project_data['project_essay_4'].isnull().values.sum())
```

```
False
number of nan values 0
```

In [13]:
```
# 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 [14]:
```
project_data.head(2)
```

Out[14]:

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

In [15]:
```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [16]:
```
# 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 second or third languages. We are
a melting pot of refugees, immigrants, and native-born Americans bringing the gift of language to our sc
hool. \r\n\r\n We have over 24 languages represented in our English Learner program with students at eve
ry level of mastery.  We also have over 40 countries represented with the families within our school.  E
ach student brings a wealth of knowledge and experiences to us that open our eyes to new cultures, belie
fs, and respect.\"The limits of your language are the limits of your world.\"-Ludwig Wittgenstein  Our E
nglish learner's have a strong support system at home that begs for more resources.  Many times our pare
nts are learning to read and speak English along side of their children.  Sometimes this creates barrier
s for parents to be able to help their child learn phonetics, letter recognition, and other reading skil
ls.\r\n\r\nBy providing these dvd's and players, students are able to continue their mastery of the Engl
ish language even if no one at home is able to assist.  All families with students within the Level 1 pr
oficiency status, will be a offered to be a part of this program.  These educational videos will be spec
ially 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\nParents that do not have access to a dvd player will
have the opportunity to check out a dvd player to use for the year.  The plan is to use these videos and
educational dvd's for the years to come for other EL students.\r\n
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at least m
ost of the time. At our school, 97.3% of the students receive free or reduced price lunch. Of the 560 st
udents, 97.3% are minority students. \r\nThe school has a vibrant community that loves to get together a
nd celebrate. Around Halloween there is a whole school parade to show off the beautiful costumes that st
udents 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 hard work put in during the scho
ol year, with a dunk tank being the most popular activity.My students will use these five brightly color
ed Hokki stools in place of regular, stationary, 4-legged chairs. As I will only have a total of ten in
the classroom and not enough for each student to have an individual one, they will be used in a variety
of ways. During independent reading time they will be used as special chairs students will each use on o
ccasion. 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 the students who need the highest amount of movement in their l
ife in order to stay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my students
always say more Hokki Stools. They can't get their fill of the 5 stools we already have. When the studen
ts 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 ta
ken. There are always students who head over to the kidney table to get one of the stools who are disapp
ointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours a day. The H
okki stools will be a compromise that allow my students to do desk work and move at the same time. These
stools will help students to meet their 60 minutes a day of movement by allowing them to activate their
core muscles for balance while they sit. For many of my students, these chairs will take away the barrie
r that exists in schools for a child who can't sit still.
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of desk
s, and a teacher in front of the room? A typical day in our room is nothing like that. I work hard to cr
eate a warm inviting themed room for my students look forward to coming to each day.\r\n\r\nMy class is
made up of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey attend a Title I sch
ool, which means there is a high enough percentage of free and reduced-price lunch to qualify. Our schoo
l is an \"open classroom\" concept, which is very unique as there are no walls separating the classroom
s. These 9 and 10 year-old students are very eager learners; they are like sponges, absorbing all the in
formation and experiences and keep on wanting more.With these resources such as the comfy red throw pill
ows and the whimsical nautical hanging decor and the blue fish nets, I will be able to help create the m
ood in our classroom setting to be one of a themed nautical environment. Creating a classroom environmen
t 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 evenin
g. 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 scho
ol! The nautical thank you cards will be used throughout the year by the students as they create thank y
ou 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 y
ear a very successful one. Thank you!
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, 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 meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e 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 w
orksheets. They want to learn to count by jumping and playing. Physical engagement is the key to our suc
cess. The number toss and color and shape mats can make that happen. My students will forget they are do
ing work and just have the fun a 6 year old deserves.
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teac
her inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% African-Americ
an, making up the largest segment of the student body. A typical school in Dallas is made up of 23.2% Af
rican-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 min
ds of young children and we focus not only on academics but one smart, effective, efficient, and discipl
ined students with good character.In our classroom we can utilize the Bluetooth for swift transitions du
ring class. I use a speaker which doesn't amplify the sound enough to receive the message. Due to the vo
lume of my speaker my students can't hear videos or books clearly and it isn't making the lessons as mea
ningful. But with the bluetooth speaker my students will be able to hear and I can stop, pause and repla
y 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 pic
tures for students to learn about different letters and it is more accessible.
==================================================
```

In [17]:
```python
# https://stackoverflow.com/a/47091490/4084039
import re

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

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

In [18]:
```python
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, 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 meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e 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 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 su
ccess. The number toss and color and shape mats can make that happen. My students will forget they are d
oing work and just have the fun a 6 year old deserves.
==================================================
```

In [19]:
```
# \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 del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations.     The materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price lunch.  Despite their di
sabilities and limitations, my students love coming to school and come eager to learn and explore.Have y
ou 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 c
hairs are the answer and I love 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 not want to sit and do works
heets. 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 students will forget they are doing
work and just have the fun a 6 year old deserves.
```

In [20]:
```
#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 dela
ys gross fine motor delays to autism They are eager beavers and always strive to work their hardest work
ing past their limitations The materials we have are the ones I seek out for my students I teach in a Ti
tle I school where most of the students receive free or reduced price lunch Despite their disabilities a
nd 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 m
y 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 They also want to learn through games my kids do not want to sit and do worksheets They want to l
earn to count by jumping and playing Physical engagement is the key to our success The number toss and c
olor and shape mats can make that happen My students will forget they are doing work and just have the f
un a 6 year old deserves
```

In [21]:
```
# 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', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'befor
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't"
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'n
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [22]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [01:10<00:00, 1558.56it/s]
```

In [23]:
```
# after preprocesing
preprocessed_essays[20000]
```

Out[23]:
```
'my kindergarten students varied disabilities ranging speech language delays cognitive delays gross fine
motor delays autism they eager beavers always strive work hardest working past limitations the materials
ones i seek students i teach title i school students receive free reduced price lunch despite disabiliti
es limitations students love coming school come eager learn explore have ever felt like ants pants neede
d groove move meeting this kids feel time the want able move learn say wobble chairs answer i love devel
op core enhances gross motor turn fine motor skills they also want learn games kids not want sit workshe
ets they want learn count jumping playing physical engagement key success the number toss color shape ma
ts make happen my students forget work fun 6 year old deserves'
```

1.4 Preprocessing of `project_title`

In [24]:
```
# similarly you can preprocess the titles also
project_data.head(2)
```

Out[24]:

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

In [25]:
```
# printing some random project titles.
print(project_data['project_title'].values[54])
print("="*50)
print(project_data['project_title'].values[89])
print("="*50)
print(project_data['project_title'].values[999])
print("="*50)
print(project_data['project_title'].values[11156])
print("="*50)
print(project_data['project_title'].values[89436])
print("="*50)
```

```
Swim For Life At YMCA!
==================================================
Education Through Technology
==================================================
Focus Pocus
==================================================
Making Math Interactive!
==================================================
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [26]:
```
#Removing phrases from the title features
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
    phrase = re.sub(r"Gotta", "Got to", 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 [27]:
```
#Checkingt titles after removing phrases
sent = decontracted(project_data['project_title'].values[89436])
print(sent)
print("="*50)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [28]:
```
# Remove \\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)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
```

In [29]:
```
#Removing numbers & symbols form the titles
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
Classroom Supplies Help a New Teacher Organize the Classroom
```

In [30]:
```
# 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', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", '
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [31]:
```
#Combining all the above preprocessed statements
from tqdm import tqdm
preprocessed_titles = []
# 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_titles.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [00:03<00:00, 32448.51it/s]
```

In [32]:
```
#checking cleaned text after preprocesing
print(preprocessed_titles[54])
print("="*50)
print(preprocessed_titles[89])
print("="*50)
print(preprocessed_titles[999])
print("="*50)
print(preprocessed_titles[11156])
print("="*50)
print(preprocessed_titles[89436])
```

```
swim for life at ymca
==================================================
education through technology
==================================================
focus pocus
==================================================
making math interactive
==================================================
classroom supplies help new teacher organize classroom
```

1.5 Preparing data for models

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

Out[33]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay'],
      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 [34]:
```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True)
categories_one_hot = vectorizer.fit_transform(project_data['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",categories_one_hot.shape)
```

```
['Literacy_Language', 'AppliedLearning', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'Warmth', 'Math_
Science', 'Health_Sports', 'SpecialNeeds']
Shape of matrix after one hot encodig  (109248, 9)
```

In [35]:
```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=True)
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Civics_Government', 'Mathematics', 'TeamSports', 'Warmth', 'CharacterEducation', 'EnvironmentalScienc
e', 'Economics', 'SpecialNeeds', 'ParentInvolvement', 'AppliedSciences', 'NutritionEducation', 'College_
CareerPrep', 'ForeignLanguages', 'PerformingArts', 'Music', 'History_Geography', 'EarlyDevelopment', 'Li
teracy', 'Health_Wellness', 'VisualArts', 'SocialSciences', 'ESL', 'CommunityService', 'Literature_Writi
ng', 'Other', 'Care_Hunger', 'Extracurricular', 'Gym_Fitness', 'Health_LifeScience', 'FinancialLiterac
y']
Shape of matrix after one hot encodig  (109248, 30)
```

In [36]:
```
# you can do the similar thing with state, teacher_prefix and project_grade_category also
#Converting states text into smaller case
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].value_counts()
```

Out[36]:
```
ca    15388
tx     7396
ny     7318
fl     6185
nc     5091
il     4350
ga     3963
sc     3936
mi     3161
pa     3109
in     2620
mo     2576
oh     2467
la     2394
ma     2389
wa     2334
ok     2276
nj     2237
az     2147
va     2045
wi     1827
al     1762
ut     1731
tn     1688
ct     1663
md     1514
nv     1367
ms     1323
ky     1304
or     1242
mn     1208
co     1111
ar     1049
id      693
ia      666
ks      634
nm      557
dc      516
hi      507
me      505
wv      503
nh      348
ak      345
de      343
ne      309
sd      300
ri      285
mt      245
nd      143
wy       98
vt       80
Name: school_state, dtype: int64
```

In [37]:
```
#Replacing spaces & hyphens in the text of project grade category with underscore
#converting Capital letters in the string to smaller letters
#Performing avalue count of project grade category
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-onp
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[37]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [38]:
```
# check if we have any nan values are there in the column
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.sum())
```

```
True
number of nan values 3
```

In [39]:
```
#Replacing the Nan values with most frequent value in the column
project_data['teacher_prefix']=project_data['teacher_prefix'].fillna('Mrs.')
```

In [40]:
```
# check if we have any nan values are there in the column
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.sum())
```

```
False
number of nan values 0
```

In [41]:
```
#Converting teacher prefix text into smaller case
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
project_data['teacher_prefix'].value_counts()
```

Out[41]:
```
mrs.       57272
ms.        38955
mr.        10648
teacher     2360
dr.           13
Name: teacher_prefix, dtype: int64
```

In [42]:
```
project_data.isnull().any(axis=0)
```

Out[42]:
```
Unnamed: 0                                      False
id                                              False
teacher_id                                      False
teacher_prefix                                  False
school_state                                    False
project_submitted_datetime                      False
project_grade_category                          False
project_title                                   False
project_essay_1                                 False
project_essay_2                                 False
project_essay_3                                 False
project_essay_4                                 False
project_resource_summary                        False
teacher_number_of_previously_posted_projects    False
project_is_approved                             False
clean_categories                                False
clean_subcategories                             False
essay                                           False
dtype: bool
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [43]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
text_bow = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_bow.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16617)
```

In [44]:
```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

1.5.2.2 TFIDF vectorizer

In [45]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (109248, 16617)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [46]:
```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

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

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

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

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

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

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

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


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-l

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


'''
```

Out[46]:
```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef (https://stackoverflow.com/a/38230349/4084039\ndef) loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n        word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        model[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel = loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading Glove Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n# ============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\' \'))\n\nfor i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the coupus", len(words))\nwords = set(words)\nprint("the unique words in the coupus", len(words))\n\ninter_words = set(model.keys()).intersection(words)\nprint("The number of words that are present in both glove vectors and our coupus", len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove = set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\nprint("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport (http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport) pickle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [47]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-l
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [48]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors.append(vector)

print(len(avg_w2v_vectors))
print(len(avg_w2v_vectors[0]))
```

```
100%|██████████| 109248/109248 [00:37<00:00, 2950.95it/s]

109248
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [49]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [50]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors.append(vector)

print(len(tfidf_w2v_vectors))
print(len(tfidf_w2v_vectors[0]))
```

```
100%|██████████| 109248/109248 [03:43<00:00, 488.92it/s]

109248
300
```

In [51]:
```
# Similarly you can vectorize for title also
```

1.5.3 Vectorizing Numerical features

In [52]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [53]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Standar
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.73   5.5
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data['price'].values.reshape(-1,1)) # finding the mean and standard deviation of
f_mean = price_scalar.mean_[0]
Standard_deviation = (np.sqrt(price_scalar.var_[0]))
print(f_mean)
print(Standard_deviation)

# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].values.reshape(-1, 1))
```

```
298.1193425966608
367.49634838483496
```

In [54]:
```
price_standardized
```

Out[54]:
```
array([[-0.3905327 ],
       [ 0.00239637],
       [ 0.59519138],
       ...,
       [-0.15825829],
       [-0.61243967],
       [-0.51216657]])
```

1.5.4 Merging all the above features

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

In [55]:
```
print(categories_one_hot.shape)
print(sub_categories_one_hot.shape)
print(text_bow.shape)
print(price_standardized.shape)
```

```
(109248, 9)
(109248, 30)
(109248, 16617)
(109248, 1)
```

In [56]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
X.shape
```

Out[56]:
```
(109248, 16657)
```

In [57]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

__ Computing Sentiment Scores__

In [58]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

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

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest students with the
for learning my students learn in many different ways using all of our senses and multiple intelligences i
of techniques to help all my students succeed students in my class come from a variety of different backgr
for wonderful sharing of experiences and cultures including native americans our school is a caring commun
learners which can be seen through collaborative student project based learning in and out of the classroo
in my class love to work with hands on materials and have many different opportunities to practice a skill
mastered having the social skills to work cooperatively with friends is a crucial aspect of the kindergart
montana is the perfect place to learn about agriculture and nutrition my students love to role play in our
in the early childhood classroom i have had several kids ask me can we try cooking with real food i will t
and create common core cooking lessons where we learn important math and writing concepts while cooking de
food for snack time my students will have a grounded appreciation for the work that went into making the f
of where the ingredients came from as well as how it is healthy for their bodies this project would expand
nutrition and agricultural cooking recipes by having us peel our own apples to make homemade applesauce ma
and mix up healthy plants from our classroom garden in the spring we will also create our own cookbooks to
shared with families students will gain math and literature skills as well as a life long enjoyment for he
nannan'
ss = sid.polarity_scores(for_sentiment)

for k in ss:
    print('{0}: {1}, '.format(k, ss[k]), end='')

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

```
neu: 0.745, pos: 0.245, compound: 0.9975, neg: 0.01,
```

Assignment 7: SVM

1. **[Task-1] Apply Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on these feature sets**
    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)
2. **The hyper paramter tuning (best alpha in range [10^-4 to 10^4], and the best penalty among 'l1', 'l2')**
    - Find the best hyper parameter which will give the maximum AUC (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/)](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. (https://seaborn.pydata.org/generated/seaborn.heatmap.html)](https://seaborn.pydata.org/generated/seaborn.heatmap.html)

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

   - Consider these set of features Set 5 :
     - **school_state** : categorical data
     - **clean_categories** : categorical data
     - **clean_subcategories** : categorical data
     - **project_grade_category** :categorical data
     - **teacher_prefix** : categorical data
     - **quantity** : numerical data
     - **teacher_number_of_previously_posted_projects** : numerical data
     - **price** : numerical data
     - **sentiment score's of each of the essay** : numerical data
     - **number of words in the title** : numerical data
     - **number of words in the combine essays** : numerical data
     - **Apply [TruncatedSVD (http://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html)](http://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html) on [TfidfVectorizer (https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfVectorizer.html)](https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfVectorizer.html) of essay text, choose the number of components (`n_components`) using [elbow method (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/pca-code-example-using-non-visualization/)](https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/pca-code-example-using-non-visualization/) : numerical data

   - **Conclusion**
     - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library [link (http://zetcode.com/python/prettytable/)](http://zetcode.com/python/prettytable/)

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-leakage, 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)](https://soundcloud.com/applied-ai-course/leakage-bow-and-tfidf)

2. Support Vector Machines

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

In [59]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
data = project_data
data.head(5)
```

Out[59]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

In [60]:
```
data.shape
```

Out[60]:
```
(109248, 20)
```

In [61]:
```
y = data['project_is_approved'].values
data.drop(['project_is_approved'], axis=1, inplace=True)
data.head(1)
```

Out[61]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_c
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grades

In [62]:
```
X = data
```

In [63]:
```
# check if we have any nan values are there in the column
print(X['teacher_prefix'].isnull().values.any())
print("number of nan values",X['teacher_prefix'].isnull().values.sum())
```

```
False
number of nan values 0
```

In [64]:
```
#Converting teacher prefix text into smaller case
X['teacher_prefix'] = X['teacher_prefix'].str.lower()
X['teacher_prefix'].value_counts()
```

Out[64]:
```
mrs.       57272
ms.        38955
mr.        10648
teacher     2360
dr.           13
Name: teacher_prefix, dtype: int64
```

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

In [65]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
#Splitting data into test & train set
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_split.html
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)
```

In [66]:
```
#Splitting training data into training & cross validation sets
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train,
                                                stratify= y_train,
                                                test_size = 0.33)
```

In [67]:
```
# printing some random reviews
print(X_train['essay'].values[0])
print("="*50)
print(X_train['essay'].values[100])
print("="*50)
print(X_train['essay'].values[300])
print("="*50)
print(X_train['essay'].values[5000])
print("="*50)
print(X_train['essay'].values[20000])
print("="*50)
```

```
The students at our school come from many diverse backgrounds. Many students are the first generation to
graduate high school, let alone dream of going on to college. These students have choose to put themselv
es in the best position possible by participating in a college-prep education. However, this education d
oes not come easy.  Most of the students come from low socio-eco backgrounds and would otherwise have be
en glanced over. \r\nHowever, these students have bigger goals for themselves. These students endure a g
rueling curriculum of Pre-AP and AP courses from the moment they step into the school. Because of this b
y the time they graduate 100% of our seniors have been accepted into a college or university.Students wi
ll be using these materials everyday in the classroom. Colored paper will be used to construct DNA molec
ules, create models of cells;  Chart paper will help us collect data as a team and graph paper helps us
to discuss graphing and analysis of data together; and construction paper will help students to create s
afety posters to post around the room. Also staplers and glue will help students keep all their material
s organized and in one location. Also the pencil sharpener, pencils and pens will allow students to be p
repared to participate in the class environment and succeed in the classroom.
==================================================
Even though we live in a world full of technology, my students don't have daily access to the technology
they need in order to keep up with everyone else. During our listening station, we use an old tape playe
r. Most of our stories do not come with tapes anymore. We use old books for research.My students are fif
th graders in a multicultural, urban community have an extremely limited budget with minimal support fro
m our local government to fund basic supplies. These students love their neighborhood school, because it
creates a sense of community. This is especially important because many of the students come from broken
homes. \r\nWith an iPad mini, my students will be able to explore the different learning applications av
ailable to them when they are struggling with a specific reading or math strand. They will be able to he
ar new and up to date stories instead of old stories from tapes. They will be able to use the iPads to r
esearch and see videos on the things that we are learning about in order to gain the background knowledg
e that they so need. They will learn how to use a computer!We have three classroom computers, and they a
re very old.\r\nWe have a tape player in our listening center that is obsolete. Help my students take a
step into the future. Thank you so much! \r\n
==================================================
Hello, I am Mrs. Zeeb, I teach third grade at an Elementary school. Our classroom is a self-contained cl
assroom made up of regular education and special education students. We are a smaller school district in
rural South Dakota. Donor's Choose is an amazing way to help us receive items that our district cannot f
und. \r\n I am in need of a Chrome Book Charging Cart and a few other classroom supplies. Donors like yo
u are ways in which I can make this dream happen. My goal is to meet the needs of all students in the cl
assroom. I have multiple learning strategies that I use to reach the children. Our school was able to pu
rchase Chrome Books for my classroom. This technology in the hands of young children is a great way for
our classroom to grow and explore outside of the classroom walls. We are now in need of a charging cart
for our Chrome Books.  Please, take a look into our project.Technology plays a huge part in our daily li
ves. The teaching and instructional strategies of today are also changing. We use paper and pencils, but
add technology to our daily lessons to further there understanding. \r\n\r\nCharging our new Chrome Book
s is a necessary part of using technology in our daily work. Our classroom has one to one Chrome Books f
or the first time this school year. The learning tools will be easily available for all the students. We
use a variety of learning sites and research to complete instruction in our classroom. We need to be abl
e to store the technology safely. With a charging cart we will be able to safely store them and be able
to move through out our building. We have classes in different rooms and it would be great if we can rol
l the cart down the hall, instead of relying on the students to transport them. The charging cart would
also help us keep the technology safe. The cart has a great latch the can be locked.
==================================================
My students are a group of underprivileged kids who deserve nothing but the best.  Due to their socioeco
nomic status, they are not always provided with the materials they need to be successful.  That is why t
his project is so important so that I am able to provide my students with the materials they need in ord
er to be a success.  The goal by the time they leave our school is to ensure that no matter where they g
o, they were held to high standards and were learning in a structured environment conducive to learning.
Each student will receive six different colored folders in the beginning of the school year.  Each folde
r will represent either a different subject, a take home folder, or an incomplete work folder.  These fo
lders will help to improve each of my students' organizational skills.  They will put their completed wo
rk in each of their subject area folders.  I plan to use the rolling carts to help organize each group's
materials.  My students will be able to keep any specific group work and/or independent work in the cart
s.  This will make it easier for groups to get their assignments and to stay more on task and organized.
==================================================
We are a new public charter school.  Our focus is in healthy living and well-rounded students.  Our scho
ol believes in PE every day and healthy eating.  Students learn music and language at every grade.  Brai
n-based strategies are used in every class.  Due to our public charter, our students are very diverse in
```

```
both race, socio-economic status, and learning abilities.  \r\n\r\nMany parents select Bradford because
we are student focused.  Our decisions are based on what is best for our students.  We foster relationsh
ips, build communities, and serve our surrounding area.  Bradford's core values build better students.Re
member when your teacher used to roll in that huge TV cart with a VHS player? Do you remember how excite
d you were? You may not have even realized you were learning. BrainPOP will excite my students and engag
e them in learning. BrainPOP helps make learning fun.\r\n\r\nI teach 5th grade math and science to appro
ximately 95 kids. My students are very diverse. Our students study Spanish and Latin and I love applying
language to math and science.  My kids work hard and they are extraordinary.\r\n\r\nBrainPOP has been us
ed in my classroom before; however, we have only had the free trial version. My kids get excited as soon
as they see the website up. They know they'll get to learn in a different and exciting way. BrainPOP wo
n't replace the essential standards they need or my curriculum. It will supplement the curriculum; it's
easy to utilize BrainPOP with my standards because it is aligned to state standards. I prefer to use Bra
inPOP and other videos as a review. We usually learn something about the topic and then watch the video.
This way the students connect their understanding to the concept being taught. On occasion, BrainPOP is
vital in introducing a foreign concept. It helps fill in the gaps where my kids have no prior knowledge.
Moreover, BrainPOP is more than a video; it provides activity pages, quizzes, games, experiments, and mo
re for the teacher to implement.\r\n\r\nMy students are limited in many experiences that we take for gra
nted. BrainPOP gives them an opportunity to see and understand concepts outside their immediate world. I
t is exciting to them and they don't always realize they're learning because of that excitement.\r\n
==================================================
```

In [68]:
```python
# https://stackoverflow.com/a/47091490/4084039
import re

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

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

In [69]:
```python
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, 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 meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e 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 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 su
ccess. The number toss and color and shape mats can make that happen. My students will forget they are d
oing work and just have the fun a 6 year old deserves.
==================================================
```

In [70]:
```
# \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 del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations.     The materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price lunch.  Despite their di
sabilities and limitations, my students love coming to school and come eager to learn and explore.Have y
ou 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 c
hairs are the answer and I love 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 not want to sit and do works
heets. 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 students will forget they are doing
work and just have the fun a 6 year old deserves.
```

In [71]:
```
#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 dela
ys gross fine motor delays to autism They are eager beavers and always strive to work their hardest work
ing past their limitations The materials we have are the ones I seek out for my students I teach in a Ti
tle I school where most of the students receive free or reduced price lunch Despite their disabilities a
nd 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 m
y 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 They also want to learn through games my kids do not want to sit and do worksheets They want to l
earn to count by jumping and playing Physical engagement is the key to our success The number toss and c
olor and shape mats can make that happen My students will forget they are doing work and just have the f
un a 6 year old deserves
```

In [72]:
```
# 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', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'agai
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't"
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'n
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

Preprocessing for Train Data

In [73]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xtr = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_xtr.append(sent.lower().strip())
```

```
100%|██████████| 49041/49041 [00:31<00:00, 1548.63it/s]
```

In [74]:
```
# after preprocesing
preprocessed_essays_xtr[300]
```

Out[74]:
```
'hello mrs zeeb teach third grade elementary school classroom self contained classroom made regular educ
ation special education students smaller school district rural south dakota donor choose amazing way hel
p us receive items district cannot fund need chrome book charging cart classroom supplies donors like wa
ys make dream happen goal meet needs students classroom multiple learning strategies use reach children
school able purchase chrome books classroom technology hands young children great way classroom grow exp
lore outside classroom walls need charging cart chrome books please take look project technology plays h
uge part daily lives teaching instructional strategies today also changing use paper pencils add technol
ogy daily lessons understanding charging new chrome books necessary part using technology daily work cla
ssroom one one chrome books first time school year learning tools easily available students use variety
learning sites research complete instruction classroom need able store technology safely charging cart a
ble safely store able move building classes different rooms would great roll cart hall instead relying s
tudents transport charging cart would also help us keep technology safe cart great latch locked'
```

In [75]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xcv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_xcv.append(sent.lower().strip())
```

```
100%|██████████| 24155/24155 [00:15<00:00, 1535.32it/s]
```

In [76]:
```
# after preprocesing
preprocessed_essays_xcv[300]
```

Out[76]:
```
'want students feel safe happy school classroom family area around school low income want students feel
successful dream big despite circumstances rowdy bunch many crave attention love many behind require alo
t extra help want provide positive educational experience teacher remember someone cared technology movi
ng fast hard school systems keep students today need comfortable types technology internet tablets stude
nts work one time students third grade taught gather information famous americans habitats government et
c social studies book reading math books found online students practice skills taught classroom gives te
acher freedom divide students small study groups works students struggling kids need interact technology
every day'
```

In [77]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xte = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_xte.append(sent.lower().strip())
```

```
100%|██████████| 36052/36052 [00:23<00:00, 1544.90it/s]
```

In [78]:
```
# after preprocesing
preprocessed_essays_xte[300]
```

Out[78]:
```
'classes include students affluent families business world inner city poverty vary different reading lex
ile levels twenty students read low elementary level forty read highschool college level ninety read rig
ht around sixth grade level many students claim hate reading believe simply not found right books higher
level students need stories interesting challenging lower grade level students need stories entertaining
read help improve literacy skills project help insure students access books meet personal needs book hel
ps child form habit reading make reading one deep continuing needs good maya angelou goal teacher help c
hild find one perfect book helps fall love reading many students school claim hate reading often lack li
teracy skills believe student become book lover takes meeting right book project project beginning diffe
rentiated reading library students varied ability levels classroom differentiated reading excellent way
help increase reading levels students grade level literacy skills encourage growth students grade level
challenge students read grade level need way increase skills meaningful way way cultivate love reading b
ooks reading skills interest levels students books chosen meet needs varied ability students reading lev
els range 1st 8th grade written students 6th grade books written wide range topics including science fic
tion sports fantasy friendship something student encourage love reading'
```

In [79]:
```
# similarly you can preprocess the titles also
#printing random titles
print(data['project_title'].values[49])
print("="*50)
print(data['project_title'].values[89])
print("="*50)
print(data['project_title'].values[999])
print("="*50)
print(data['project_title'].values[11156])
print("="*50)
print(data['project_title'].values[20000])
print("="*50)
```

```
Rainy Day Run Around!
==================================================
Education Through Technology
==================================================
Focus Pocus
==================================================
Making Math Interactive!
==================================================
We Need To Move It While We Input It!
==================================================
```

In [80]:
```
#Removing phrases from the title features
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
    phrase = re.sub(r"Gotta",  "Got to",  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 [81]:
```
#Checkingt titles after removing phrases
sent = decontracted(project_data['project_title'].values[89436])
print(sent)
print("="*50)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [82]:
```
# Remove \\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)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
```

In [83]:
```
#Removing stop words from the preprocessed titles
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', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these',
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'agai
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't"
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'n
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [84]:
```
preprocessed_titles_xtr = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xtr.append(sent.lower().strip())
```

```
100%|██████████| 49041/49041 [00:01<00:00, 32189.25it/s]
```

In [85]:
```
#checking cleaned text after preprocesing
print(preprocessed_titles_xtr[89])
print("="*50)
```

```
second graders need carpet too
==================================================
```

In [86]:
```
preprocessed_titles_xcv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xcv.append(sent.lower().strip())
```

```
100%|██████████| 24155/24155 [00:00<00:00, 31984.44it/s]
```

In [87]:
```
print(preprocessed_titles_xcv[89])
print("="*50)
```

```
divide color
==================================================
```

In [88]:
```
preprocessed_titles_xte = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xte.append(sent.lower().strip())
```

```
100%|██████████| 36052/36052 [00:01<00:00, 32055.85it/s]
```

In [89]:
```
print(preprocessed_titles_xte[89])
print("="*50)
```

```
alternative seating busy learners
==================================================
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [90]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
#We use fit only for train data
vectorizer_state = CountVectorizer(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("="*75)
```

```
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', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'n
y', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
===========================================================================
```

2.2.2 One hot encoding the categorical features : teacher_prefix

In [91]:
```
# we use count vectorizer to convert the values into one
#We use fit only for train data
vectorizer_tp = CountVectorizer(binary=True)
vectorizer_tp.fit(X_train['teacher_prefix'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer_tp.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer_tp.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer_tp.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_tp.get_feature_names())
print("="*50)
```

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

2.2.3 One hot encoding the categorical features : grades

In [92]:
```
#Replacing spaces & hyphens in the text of project grade category with underscore
#converting Capital letters in the string to smaller letters
#Performing avalue count of project grade category
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-on-
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[92]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [93]:
```
#We use fit only for train data
vectorizer_grade = CountVectorizer()
vectorizer_grade.fit(X_train['project_grade_category'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer_grade.transform(X_train['project_grade_category'].values)
X_cv_grade_ohe = vectorizer_grade.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer_grade.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_grade.get_feature_names())
print("="*70)
```

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

2.2.4 One hot encoding the categorical features : project subject category

In [94]:
```
#We use fit only for train data
vectorizer_category = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), binary=True)
vectorizer_category.fit(X_train['clean_categories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_cat_ohe = vectorizer_category.transform(X_train['clean_categories'].values)
X_cv_cat_ohe = vectorizer_category.transform(X_cv['clean_categories'].values)
X_test_cat_ohe = vectorizer_category.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_category.get_feature_names())
print("="*70)
```

```
After vectorizations
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
['Literacy_Language', 'AppliedLearning', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'Warmth', 'Math_
Science', 'Health_Sports', 'SpecialNeeds']
======================================================================
```

In [95]:
```
#We use fit only for train data
vectorizer_subcat = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), binary=True)
vectorizer_subcat.fit(X_train['clean_subcategories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat_ohe = vectorizer_subcat.transform(X_train['clean_subcategories'].values)
X_cv_subcat_ohe = vectorizer_subcat.transform(X_cv['clean_subcategories'].values)
X_test_subcat_ohe = vectorizer_subcat.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_subcat.get_feature_names())
print("="*70)
```

```
After vectorizations
(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
['Civics_Government', 'Mathematics', 'TeamSports', 'Warmth', 'CharacterEducation', 'EnvironmentalScienc
e', 'Economics', 'SpecialNeeds', 'ParentInvolvement', 'AppliedSciences', 'NutritionEducation', 'College_
CareerPrep', 'ForeignLanguages', 'PerformingArts', 'Music', 'History_Geography', 'EarlyDevelopment', 'Li
teracy', 'Health_Wellness', 'VisualArts', 'SocialSciences', 'ESL', 'CommunityService', 'Literature_Writi
ng', 'Other', 'Care_Hunger', 'Extracurricular', 'Gym_Fitness', 'Health_LifeScience', 'FinancialLiterac
y']
======================================================================
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [96]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

i) BoW Encoding

1.5.2.1 Bag of words on Essay Feature

In [97]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
#Applying BoW on essays feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)



from sklearn.feature_extraction.text import CountVectorizer
vectorizer_essay_bow = CountVectorizer(min_df=10)
vectorizer_essay_bow.fit(preprocessed_essays_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xtr)
X_cv_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xcv)
X_test_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xte)

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)
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 12026) (49041,)
(24155, 12026) (24155,)
(36052, 12026) (36052,)
====================================================================================================
```

1.5.2.2 Bag of words on Project Title feature

In [98]:
```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
#Applying BoW on project titles feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)



from sklearn.feature_extraction.text import CountVectorizer
vectorizer_titles_bow = CountVectorizer(min_df=10)
vectorizer_titles_bow.fit(preprocessed_titles_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xtr)
X_cv_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xcv)
X_test_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xte)

print("After vectorizations")
print(X_train_titles_bow.shape, y_train.shape)
print(X_cv_titles_bow.shape, y_cv.shape)
print(X_test_titles_bow.shape, y_test.shape)
print("="*100)
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 2098) (49041,)
(24155, 2098) (24155,)
(36052, 2098) (36052,)
====================================================================================================
```

ii) TFIDF Vectorization

TFIDF vectorizer on essay feature

In [99]:
```
#Applying TF-IDF on essays feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)

from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_essay_tfidf = TfidfVectorizer(min_df=10)
vectorizer_essay_tfidf.fit(preprocessed_essays_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xtr)
X_cv_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xcv)
X_test_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xte)

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)
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 12026) (49041,)
(24155, 12026) (24155,)
(36052, 12026) (36052,)
====================================================================================================
```

TFIDF on Project Title feature

In [100]:
```
#Applying Tfidf on project titles feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)


from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_title = TfidfVectorizer(min_df=10)
vectorizer_tfidf_title.fit(preprocessed_titles_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xtr)
X_cv_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xcv)
X_test_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xte)

print("After vectorizations")
print(X_train_titles_tfidf.shape, y_train.shape)
print(X_cv_titles_tfidf.shape, y_cv.shape)
print(X_test_titles_tfidf.shape, y_test.shape)
print("="*100)
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 2098) (49041,)
(24155, 2098) (24155,)
(36052, 2098) (36052,)
====================================================================================================
```

iii) Using Pre-Trained Models : AvgW2v

In [101]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-l

with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words = set(model.keys())
```

Applying to Train set for Essay feature

In [102]:
```
preprocessed_essays_xtr[0]
```

Out[102]:
```
'students school come many diverse backgrounds many students first generation graduate high school let a
lone dream going college students choose put best position possible participating college prep education
however education not come easy students come low socio eco backgrounds would otherwise glanced however
students bigger goals students endure grueling curriculum pre ap ap courses moment step school time grad
uate 100 seniors accepted college university students using materials everyday classroom colored paper u
sed construct dna molecules create models cells chart paper help us collect data team graph paper helps
us discuss graphing analysis data together construction paper help students create safety posters post a
round room also staplers glue help students keep materials organized one location also pencil sharpener
pencils pens allow students prepared participate class environment succeed classroom'
```

In [103]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_extr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xtr): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_extr.append(vector)

print(len(avg_w2v_vectors_extr))
print(len(avg_w2v_vectors_extr[0]))
```

```
100%|██████████| 49041/49041 [00:16<00:00, 3033.05it/s]

49041
300
```

Applying to Cross validation set for Essay feature

In [104]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_excv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xcv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_excv.append(vector)

print(len(avg_w2v_vectors_excv))
print(len(avg_w2v_vectors_excv[0]))
```

```
100%|██████████| 24155/24155 [00:07<00:00, 3136.29it/s]

24155
300
```

Applying to test set for Essay feature

In [105]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_exte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xte): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_exte.append(vector)

print(len(avg_w2v_vectors_exte))
print(len(avg_w2v_vectors_exte[0]))
```

```
100%|██████████| 36052/36052 [00:11<00:00, 3240.56it/s]

36052
300
```

Applying to Train set for Project title feature

In [106]:
```
# Vectorizing project_title using avgw2v method
avg_w2v_vectors_txtr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xtr): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_txtr.append(vector)

print(len(avg_w2v_vectors_txtr))
print(len(avg_w2v_vectors_txtr[0]))
```

```
100%|██████████| 49041/49041 [00:00<00:00, 55593.55it/s]

49041
300
```

Applying to Cross validation set for Project title feature

In [107]:
```
# Vectorizing project_title using avgw2v method
avg_w2v_vectors_txcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xcv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_txcv.append(vector)

print(len(avg_w2v_vectors_txcv))
print(len(avg_w2v_vectors_txcv[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 54131.81it/s]

24155
300
```

Applying to Test set for Project title feature

In [108]:
```
# Vectorizing project_title using avgw2v method
avg_w2v_vectors_txte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xte): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_txte.append(vector)

print(len(avg_w2v_vectors_txte))
print(len(avg_w2v_vectors_txte[0]))
```

```
100%|██████████| 36052/36052 [00:00<00:00, 54693.21it/s]

36052
300
```

iv) Using Pretrained Models: TFIDF weighted W2V

Applying on Training set of essays feature

In [109]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_xtr)
# 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 [110]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_extr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xtr): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_extr.append(vector)

print(len(tfidf_w2v_vectors_extr))
print(len(tfidf_w2v_vectors_extr[0]))
```

```
100%|██████████| 49041/49041 [01:24<00:00, 579.35it/s]

49041
300
```

Applying on Cross validation set of essays feature

In [111]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_excv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xcv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_excv.append(vector)

print(len(tfidf_w2v_vectors_excv))
print(len(tfidf_w2v_vectors_excv[0]))
```

```
100%|██████████| 24155/24155 [00:41<00:00, 576.30it/s]

24155
300
```

Applying on test set of essays feature

In [112]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_exte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xte): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_exte.append(vector)

print(len(tfidf_w2v_vectors_exte))
print(len(tfidf_w2v_vectors_exte[0]))
```

```
100%|██████████| 36052/36052 [01:03<00:00, 571.44it/s]

36052
300
```

Applying on Training set of project title feature

In [113]:
```
# Similarly you can vectorize for title also
# vectorizing project_title using TFIDF weighted W2V pretrained model
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles_xtr)
# 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 [114]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_txtr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xtr): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_txtr.append(vector)

print(len(tfidf_w2v_vectors_txtr))
print(len(tfidf_w2v_vectors_txtr[0]))
```

```
100%|██████████| 49041/49041 [00:02<00:00, 23021.39it/s]

49041
300
```

Applying on Cross validation set of project title feature

In [115]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_txcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xcv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_txcv.append(vector)

print(len(tfidf_w2v_vectors_txcv))
print(len(tfidf_w2v_vectors_txcv[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 24386.89it/s]

24155
300
```

Applying on test set of project title feature

In [116]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_txte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xte): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_txte.append(vector)

print(len(tfidf_w2v_vectors_txte))
print(len(tfidf_w2v_vectors_txte[0]))
```

```
100%|██████████| 36052/36052 [00:01<00:00, 26267.38it/s]

36052
300
```

1.5.3 Vectorizing Numerical features

For Price feature

In [117]:
```
from sklearn.preprocessing import Normalizer
price_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.
price_normalizer.fit(X_train['price'].values.reshape(1,-1))

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

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

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

In [118]:
```
X_train_price_norm = X_train_price_norm.T
X_cv_price_norm = X_cv_price_norm.T
X_test_price_norm = X_test_price_norm.T

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)
```

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

For Quantity

In [119]:
```
#Normalizing quantity
from sklearn.preprocessing import Normalizer
quan_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.
quan_normalizer.fit(X_train['quantity'].values.reshape(1,-1))

X_train_quantity_norm = quan_normalizer.transform(X_train['quantity'].values.reshape(1,-1))
X_cv_quantity_norm = quan_normalizer.transform(X_cv['quantity'].values.reshape(1,-1))
X_test_quantity_norm = quan_normalizer.transform(X_test['quantity'].values.reshape(1,-1))

print("After vectorizations")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print("="*100)
```

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

In [120]:
```
X_train_quantity_norm = X_train_quantity_norm.T
X_cv_quantity_norm = X_cv_quantity_norm.T
X_test_quantity_norm = X_test_quantity_norm.T

print("Final Matrix")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

For teacher previously posted projects

In [121]:
```
# Normalizing teacher previously posted projects
from sklearn.preprocessing import Normalizer
tpp_normalizer = Normalizer()
# normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].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.
tpp_normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

X_train_tpp_norm = tpp_normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values
X_cv_tpp_norm = tpp_normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.resha
X_test_tpp_norm = tpp_normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.r

print("After vectorizations")
print(X_train_tpp_norm.shape, y_train.shape)
print(X_cv_tpp_norm.shape, y_cv.shape)
print(X_test_tpp_norm.shape, y_test.shape)
print("="*100)
```

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

In [122]:
```
X_train_tpp_norm = X_train_tpp_norm.T
X_cv_tpp_norm = X_cv_tpp_norm.T
X_test_tpp_norm = X_test_tpp_norm.T

print(X_train_tpp_norm.shape, y_train.shape)
print(X_cv_tpp_norm.shape, y_cv.shape)
print(X_test_tpp_norm.shape, y_test.shape)
print("="*100)
```

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

Merging Numerical & Categorical features

- we need to merge all the numerical vectors & catogorical features

In [123]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_numcat = hstack((X_train_state_ohe, X_train_teacher_ohe, X_train_grade_ohe, X_train_price_norm, X_tra
X_cv_numcat = hstack((X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe, X_cv_price_norm, X_cv_cat_ohe, X_c
X_te_numcat = hstack((X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe, X_test_price_norm, X_test_ca

print("Final Data matrix")
print(X_tr_numcat.shape, y_train.shape)
print(X_cv_numcat.shape, y_cv.shape)
print(X_te_numcat.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 102) (49041,)
(24155, 102) (24155,)
(36052, 102) (36052,)
====================================================================================================
```

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

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

In [124]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

2.4.1 Applying SVM on BOW, SET 1

Consider Set 1 :- categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)

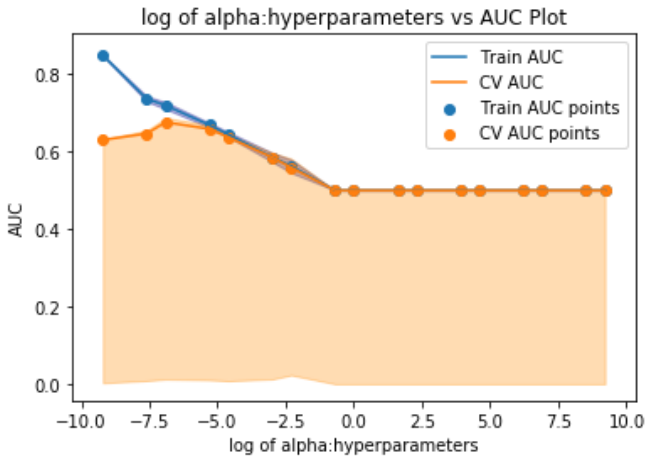
In [125]:
```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set1 = hstack((X_train_essay_bow, X_train_titles_bow, X_tr_numcat )).tocsr()
X_cv_set1 = hstack((X_cv_essay_bow, X_cv_titles_bow, X_cv_numcat)).tocsr()
X_te_set1 = hstack((X_test_essay_bow, X_test_titles_bow, X_te_numcat )).tocsr()

print("Final Data matrix")
print(X_tr_set1.shape, y_train.shape)
print(X_cv_set1.shape, y_cv.shape)
print(X_te_set1.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 14226) (49041,)
(24155, 14226) (24155,)
(36052, 14226) (36052,)
====================================================================================================
```

Finding the hyperparameter using L1 Regularization

In [126]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1', class_weight='balanced'), tuned_parameters,
model.fit(X_tr_set1, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='(

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 43744.27it/s]
```



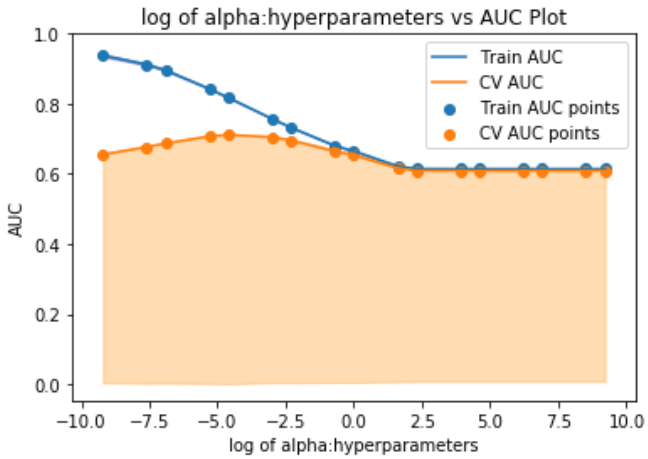
In [127]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.001
0.6759043429540507
```

Finding the hyperparameter using L2 Regularization

In [128]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', class_weight='balanced'), tuned_parameters, cv=5, scoring
model.fit(X_tr_set1, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='(

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 74429.19it/s]
```



Train the model using best hyper parameter

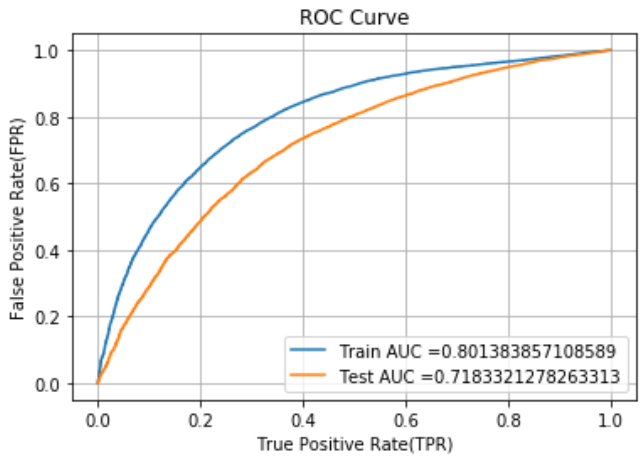
In [129]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.01
0.7108118891404714
```

L2 regularizer is giving us a better score so we will be using L2 regularizer for this set

In [130]:
```
def batch_predict(clf, data):

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
# consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
# in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
# we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [131]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC

model = SGDClassifier(loss='hinge', alpha= best_a, class_weight='balanced')

model.fit(X_tr_set1, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
y_train_pred = model.decision_function(X_tr_set1)
y_test_pred = model.decision_function(X_te_set1)

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("ROC Curve")
plt.grid(True)
plt.show()
```



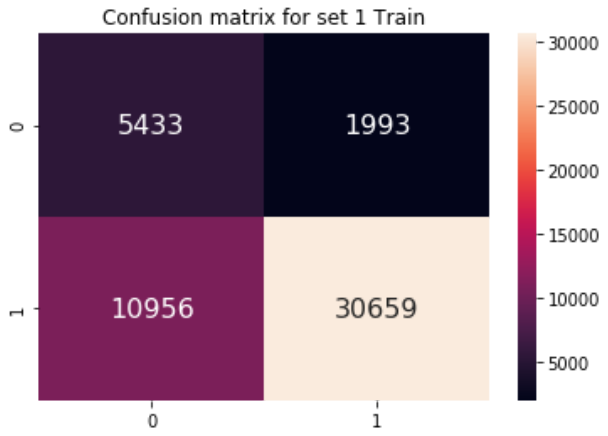
In [132]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [133]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.5390050654462489 for threshold -0.305
[[ 5433  1993]
 [10956 30659]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.5390050654462489 for threshold -0.305
[[ 3353  2106]
 [ 8457 22136]]
```

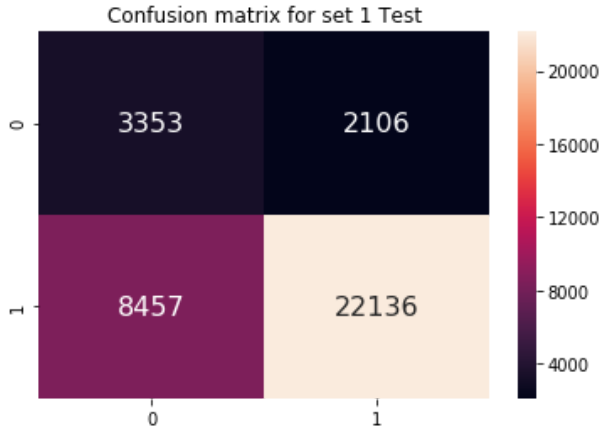
In [204]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[5433,1993],
        [10956,30659]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 1 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[204]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2eb36dc88>
```



In [205]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3353,2106],
        [8457,22136]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 1 Test')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[205]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2ebec3d30>
```



2.4.2 Applying SVM on TFIDF, SET 2

Consider Set 2 :- categorical, numerical features + project_title(TFIDF) + preprocessed_essay (TFIDF)

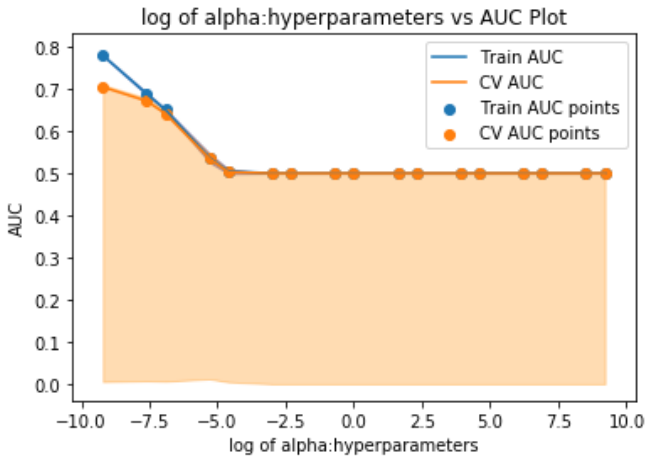
In [230]:
```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set2 = hstack((X_train_essay_tfidf, X_train_titles_tfidf, X_tr_numcat )).tocsr()
X_cv_set2 = hstack((X_cv_essay_tfidf, X_cv_titles_tfidf, X_cv_numcat)).tocsr()
X_te_set2 = hstack((X_test_essay_tfidf, X_test_titles_tfidf, X_te_numcat )).tocsr()

print("Final Data matrix")
print(X_tr_set2.shape, y_train.shape)
print(X_cv_set2.shape, y_cv.shape)
print(X_te_set2.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 14226) (49041,)
(24155, 14226) (24155,)
(36052, 14226) (36052,)
====================================================================================================
```

Finding the hyperparameter using L1 Regularization

In [231]:
```
data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1', class_weight='balanced'), tuned_parameters,
model.fit(X_tr_set2, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='d

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 51297.24it/s]
```



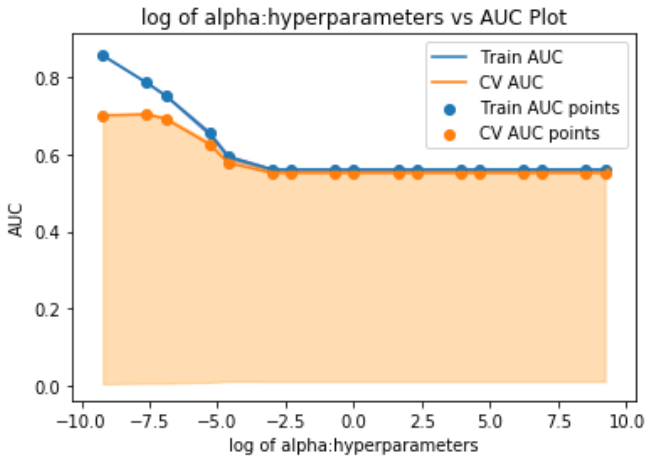
In [232]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.0001
0.7047179425537662
```

Finding the hyperparameter using L2 Regularization

In [233]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', class_weight='balanced'), tuned_parameters, cv=5, scoring
model.fit(X_tr_set2, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='(

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 73056.52it/s]
```



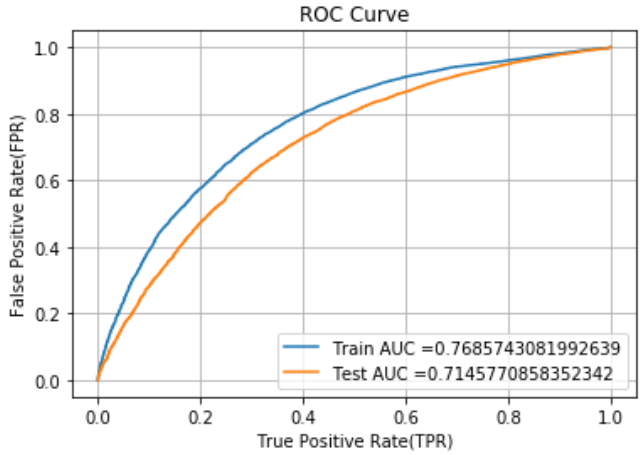
In [234]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.0005
0.703567263434533
```

For set 2 we are getting slightly better scores with L1 regularizer

In [235]:
```
best_a = 0.0001
```

In [236]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC

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

model.fit(X_tr_set2, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
y_train_pred = model.decision_function(X_tr_set2)
y_test_pred = model.decision_function(X_te_set2)

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("ROC Curve")
plt.grid(True)
plt.show()
```



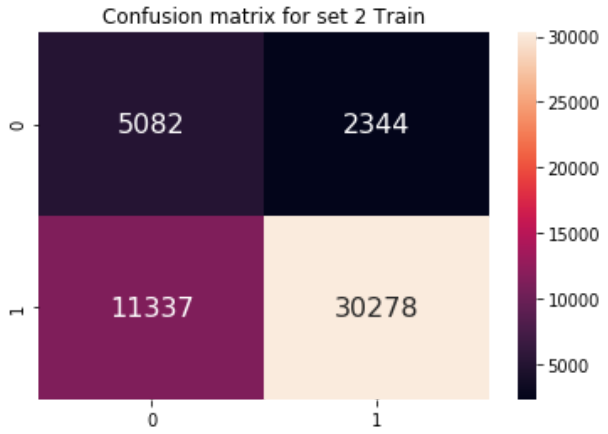
In [237]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [238]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.49791705409833426 for threshold -0.162
[[ 5082  2344]
 [11337 30278]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.49791705409833426 for threshold -0.162
[[ 3327  2132]
 [ 8621 21972]]
```

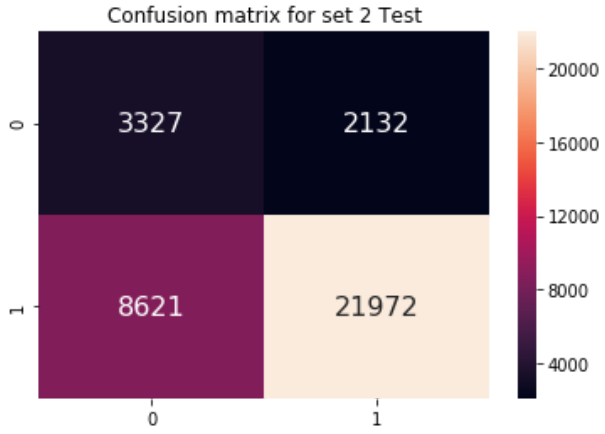
In [239]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[5082,2344],
        [11337,30278]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 2 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[239]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2eb07c320>
```



In [240]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3327,2132],
        [8621,21972]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 2 Test')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[240]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2dc825fd0>
```



2.4.3 Applying SVM on AVG W2v, SET 3

Consider Set 3 :- categorical, numerical features + project_title(AVG W2V) + preprocessed_essay (AVG W2v)

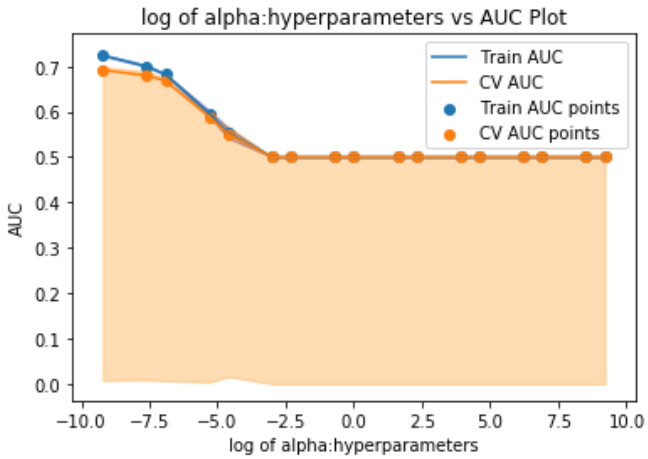
In [146]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set3 = hstack((avg_w2v_vectors_extr, avg_w2v_vectors_txtr, X_tr_numcat)).tocsr()
X_cv_set3 = hstack((avg_w2v_vectors_excv, avg_w2v_vectors_txcv, X_cv_numcat)).tocsr()
X_te_set3 = hstack((avg_w2v_vectors_exte, avg_w2v_vectors_txte, X_te_numcat )).tocsr()

print("Final Data matrix")
print(X_tr_set3.shape, y_train.shape)
print(X_cv_set3.shape, y_cv.shape)
print(X_te_set3.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 702) (49041,)
(24155, 702) (24155,)
(36052, 702) (36052,)
====================================================================================================
```

Finding the hyperparameter using L1 Regularization

In [147]:
```
data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1', class_weight='balanced'), tuned_parameters,
model.fit(X_tr_set3, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='d

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 95837.59it/s]
```



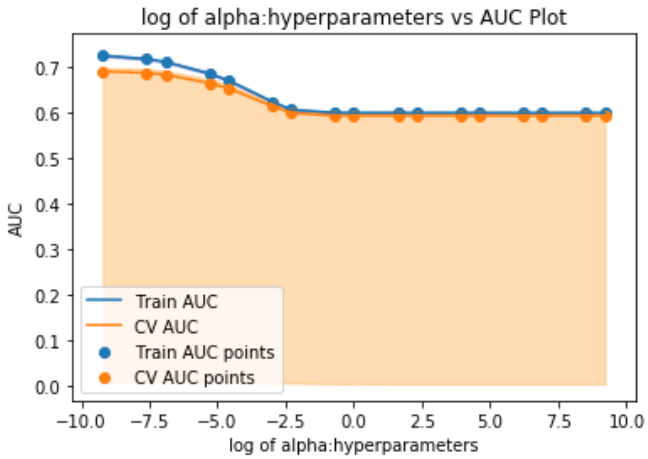
In [148]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.0001
0.6915506765942588
```

Finding the hyperparameter using L2 Regularization

In [149]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', class_weight='balanced'), tuned_parameters, cv=5, scoring
model.fit(X_tr_set3, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='(

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 39070.23it/s]
```



In [150]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

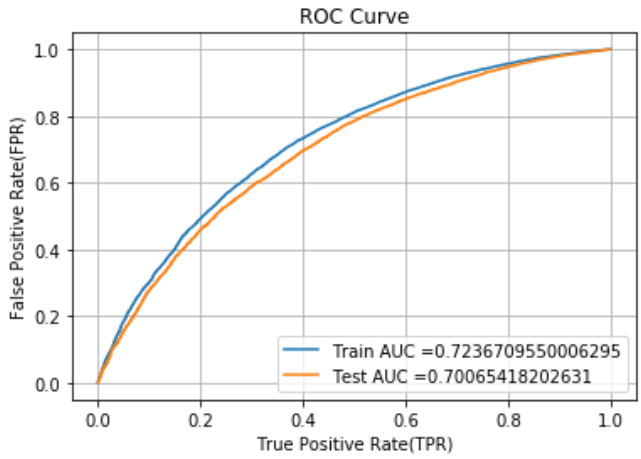
```
Best a :0.0001
0.6911669286674792
```

We got a slightly better score with L1 regularizer so we are using L1 regularizer for this set.

In [208]:
```
best_a = 0.0001
```

In [209]:
```
def batch_predict(clf, data):

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
# consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
# in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
# we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [210]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC

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

model.fit(X_tr_set3, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
y_train_pred = model.decision_function(X_tr_set3)
y_test_pred = model.decision_function(X_te_set3)

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("ROC Curve")
plt.grid(True)
plt.show()
```



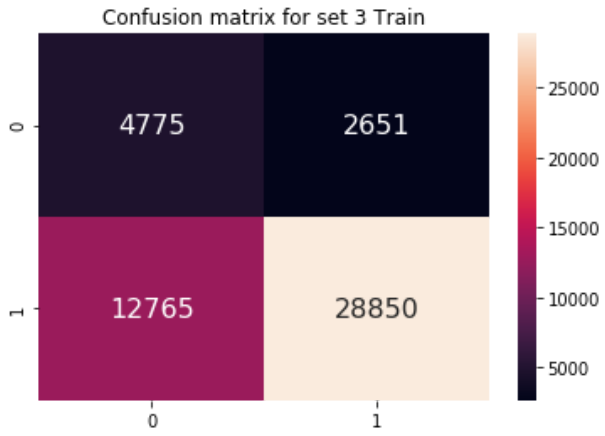
In [211]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [212]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4457736049474848 for threshold -0.779
[[ 4775  2651]
 [12765 28850]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.4457736049474848 for threshold -0.779
[[ 3311  2148]
 [ 9514 21079]]
```

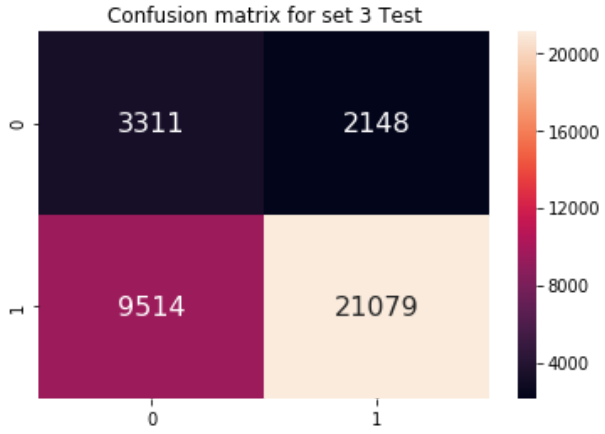
In [213]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[4775,2651],
        [12765,28850]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 3 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[213]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2ec1967f0>
```



In [214]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3311,2148],
        [9514,21079]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 3 Test')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[214]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2eb253b70>
```



2.4.4 Applying SVM on TFIDF W2V, SET 4

Consider Set 4 :- categorical, numerical features + project_title(TFIDF w2v) + preprocessed_essay (TFIDF w2v)

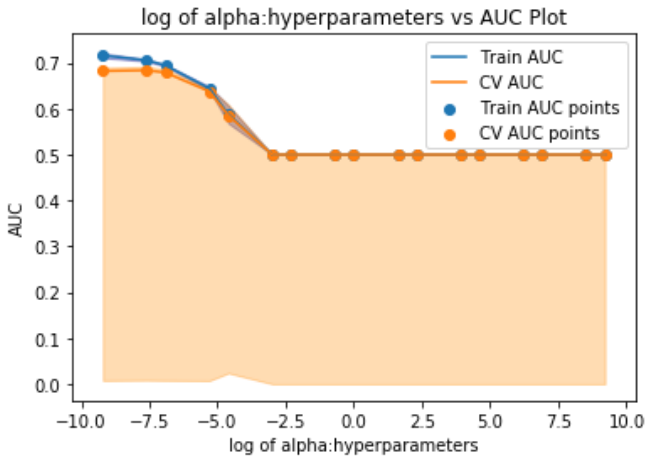
In [158]:
```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set4 = hstack((tfidf_w2v_vectors_extr, tfidf_w2v_vectors_txtr, X_tr_numcat)).tocsr()
X_cv_set4 = hstack((tfidf_w2v_vectors_excv, tfidf_w2v_vectors_txcv, X_cv_numcat)).tocsr()
X_te_set4 = hstack((tfidf_w2v_vectors_exte, tfidf_w2v_vectors_txte, X_te_numcat)).tocsr()

print("Final Data matrix")
print(X_tr_set4.shape, y_train.shape)
print(X_cv_set4.shape, y_cv.shape)
print(X_te_set4.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 702) (49041,)
(24155, 702) (24155,)
(36052, 702) (36052,)
====================================================================================================
```

Finding the hyperparameter using L1 Regularization

In [159]:
```
data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1', class_weight='balanced'), tuned_parameters,
model.fit(X_tr_set4, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='d

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 57970.06it/s]
```



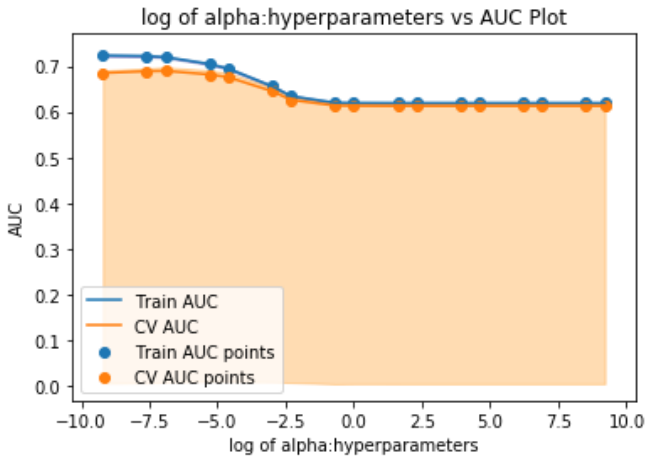
In [160]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.0005
0.6837987645239647
```

Finding the hyperparameter using L2 Regularization

In [161]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', class_weight='balanced'), tuned_parameters, cv=5, scoring
model.fit(X_tr_set4, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='(

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 64295.01it/s]
```



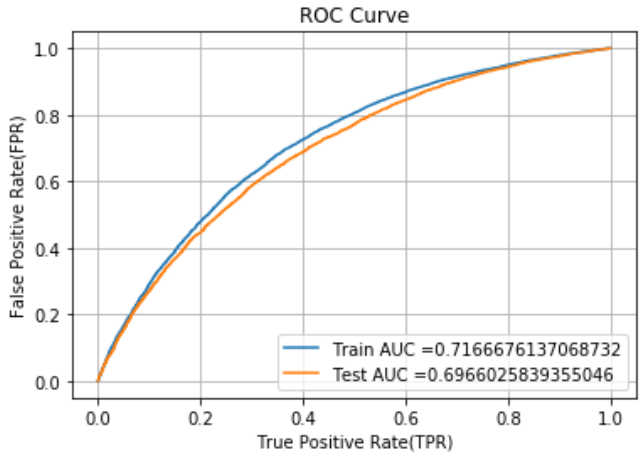
In [162]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.001
0.6894103386325235
```

L2 regularizer is giving us a better score so we will be using L2 regularizer for this set

In [163]:
```
def batch_predict(clf, data):

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
# consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
# in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
# we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [164]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC

model = SGDClassifier(loss='hinge', alpha= best_a, class_weight='balanced')

model.fit(X_tr_set4, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
y_train_pred = model.decision_function(X_tr_set4)
y_test_pred = model.decision_function(X_te_set4)

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("ROC Curve")
plt.grid(True)
plt.show()
```



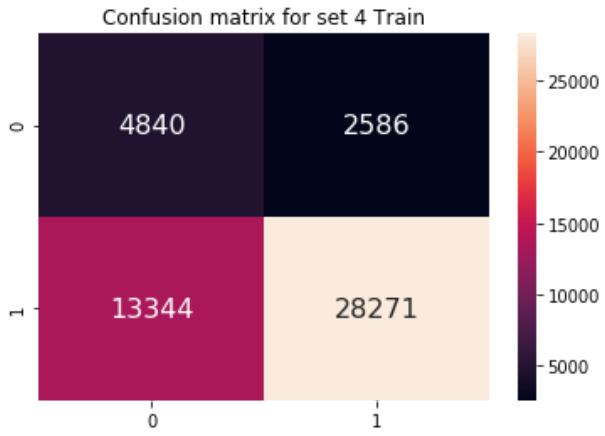
In [165]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [166]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4427735692555025 for threshold -0.096
[[ 4840  2586]
 [13344 28271]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.4427735692555025 for threshold -0.096
[[ 3392  2067]
 [10075 20518]]
```

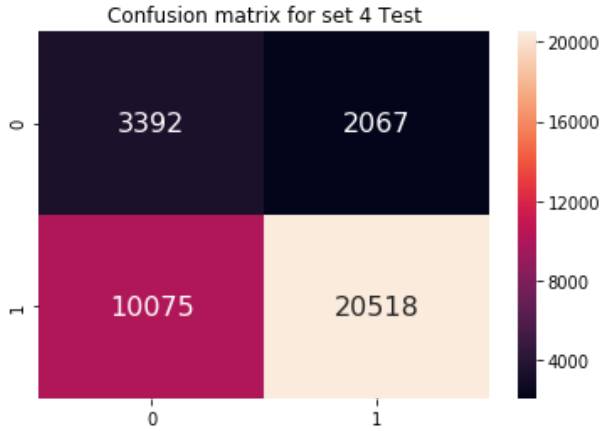
In [215]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[4840,2586],
        [13344,28271]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 4 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[215]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2eb8e8978>
```



In [216]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3392,2067],
        [10075,20518]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 4 Test')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[216]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2ec191898>
```



2.5 Support Vector Machines with added Features `Set 5`

In [169]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

Counting the number of words in Essays

In [170]:
```
project_data["preprocessed_essays"] = preprocessed_essays
```

In [171]:
```
essay_words_total = []
for _ in project_data["preprocessed_essays"]:
    x = len(_.split())
    essay_words_total.append(x)
```

In [172]:
```
project_data["essay_words_total"] = essay_words_total
```

In [173]:
```
project_data.head()
```

Out[173]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

5 rows × 21 columns

In [174]:
```
project_data.drop(['essay'], axis=1, inplace=True)
```

In [175]:
```
project_data.head()
```

Out[175]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

Counting the number of words in Project Title

In [176]:
```
project_data["preprocessed_titles"] = preprocessed_titles
```

In [177]:
```
project_data.head()
```

Out[177]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

5 rows × 21 columns

In [178]:
```
title_words_total = []
for _ in project_data["preprocessed_titles"]:
    y = len(_.split())
    title_words_total.append(y)
```

In [179]:
```
project_data["title_words_total"] = title_words_total
```

In [180]:
```
project_data.head()
```

Out[180]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

5 rows × 22 columns

Calculate sentiment score for essays

In [181]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
sid = SentimentIntensityAnalyzer()
neg = []
pos = []
neu = []
compound = []

for _ in tqdm(project_data["preprocessed_essays"]) :
    w = sid.polarity_scores(_)['neg']
    x = sid.polarity_scores(_)['pos']
    y = sid.polarity_scores(_)['neu']
    z = sid.polarity_scores(_)['compound']
    neg.append(w)
    pos.append(x)
    neu.append(y)
    compound.append(z)
```

```
100%|██████████| 109248/109248 [15:01<00:00, 127.14it/s]
```

In [182]:
```
project_data["pos"] = pos
```

In [183]:
```
project_data["neg"] = neg
```

In [184]:
```
project_data["neu"] = neu
```

In [185]:
```
project_data["compound"] = compound
```

In [186]:
```
project_data.head()
```

Out[186]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

5 rows × 26 columns

In [187]:
```
data5 = project_data
```

In [188]:
```
x5 = data5
```

Splitting data into Train and cross validation(or test)

In [189]:
```
#Splitting data into test & train set
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_split.html
from sklearn.model_selection import train_test_split
X5_train, X5_test = train_test_split(X,test_size = 0.33)
```

In [190]:
```
#Splitting training data into training & cross validation sets
X5_train, X5_cv = train_test_split(X5_train,test_size = 0.33)
```

In [191]:
```
print(X5_train.shape)
print(X5_cv.shape)
print(X5_test.shape)
```

```
(49041, 26)
(24155, 26)
(36052, 26)
```

Normalising Essay word count

In [192]:
```
from sklearn.preprocessing import Normalizer
essay_words_norm = Normalizer()
# normalizer.fit(X5_train['essay_word_total'].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.
essay_words_norm.fit(X5_train['essay_words_total'].values.reshape(1,-1))

X5_train_ewords_norm = essay_words_norm.transform(X5_train['essay_words_total'].values.reshape(1,-1))
X5_cv_ewords_norm = essay_words_norm.transform(X5_cv['essay_words_total'].values.reshape(1,-1))
X5_test_ewords_norm = essay_words_norm.transform(X5_test['essay_words_total'].values.reshape(1,-1))

print("After vectorizations")
print(X5_train_ewords_norm.shape, y_train.shape)
print(X5_cv_ewords_norm.shape, y_cv.shape)
print(X5_test_ewords_norm.shape, y_test.shape)
print("="*100)
```

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

In [193]:
```
X5_train_ewords_norm = X5_train_ewords_norm.T
X5_cv_ewords_norm = X5_cv_ewords_norm.T
X5_test_ewords_norm = X5_test_ewords_norm.T

print("Final Matrix")
print(X5_train_ewords_norm.shape, y_train.shape)
print(X5_cv_ewords_norm.shape, y_cv.shape)
print(X5_test_ewords_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

Normalising Project Title word count

In [194]:
```
from sklearn.preprocessing import Normalizer
title_words_norm = Normalizer()
# normalizer.fit(X5_train['essay_word_total'].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.
title_words_norm.fit(X5_train['title_words_total'].values.reshape(1,-1))

X5_train_twords_norm = title_words_norm.transform(X5_train['title_words_total'].values.reshape(1,-1))
X5_cv_twords_norm = title_words_norm.transform(X5_cv['title_words_total'].values.reshape(1,-1))
X5_test_twords_norm = title_words_norm.transform(X5_test['title_words_total'].values.reshape(1,-1))

print("After vectorizations")
print(X5_train_twords_norm.shape, y_train.shape)
print(X5_cv_twords_norm.shape, y_cv.shape)
print(X5_test_twords_norm.shape, y_test.shape)
print("="*100)
```

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

In [195]:
```
X5_train_twords_norm = X5_train_twords_norm.T
X5_cv_twords_norm = X5_cv_twords_norm.T
X5_test_twords_norm = X5_test_twords_norm.T

print("Final Matrix")
print(X5_train_twords_norm.shape, y_train.shape)
print(X5_cv_twords_norm.shape, y_cv.shape)
print(X5_test_twords_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

Normalising Essay Sentiment scores

Normalising positive score

In [196]:
```
from sklearn.preprocessing import Normalizer
senti_pos_norm = Normalizer()
# normalizer.fit(X5_train['essay_word_total'].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.
senti_pos_norm.fit(X5_train['pos'].values.reshape(1,-1))

X5_train_pos_norm = senti_pos_norm.transform(X5_train['pos'].values.reshape(1,-1))
X5_cv_pos_norm = senti_pos_norm.transform(X5_cv['pos'].values.reshape(1,-1))
X5_test_pos_norm = senti_pos_norm.transform(X5_test['pos'].values.reshape(1,-1))

print("After vectorizations")
print(X5_train_pos_norm.shape, y_train.shape)
print(X5_cv_pos_norm.shape, y_cv.shape)
print(X5_test_pos_norm.shape, y_test.shape)
print("="*100)
```

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

In [197]:
```
X5_train_pos_norm = X5_train_pos_norm.T
X5_cv_pos_norm = X5_cv_pos_norm.T
X5_test_pos_norm = X5_test_pos_norm.T

print("Final Matrix")
print(X5_train_pos_norm.shape, y_train.shape)
print(X5_cv_pos_norm.shape, y_cv.shape)
print(X5_test_pos_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

Normalising Negative score

In [198]:
```
from sklearn.preprocessing import Normalizer
senti_neg_norm = Normalizer()
# normalizer.fit(X5_train['essay_word_total'].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.
senti_neg_norm.fit(X5_train['neg'].values.reshape(1,-1))

X5_train_neg_norm = senti_neg_norm.transform(X5_train['neg'].values.reshape(1,-1))
X5_cv_neg_norm = senti_neg_norm.transform(X5_cv['neg'].values.reshape(1,-1))
X5_test_neg_norm = senti_neg_norm.transform(X5_test['neg'].values.reshape(1,-1))

print("After vectorizations")
print(X5_train_neg_norm.shape, y_train.shape)
print(X5_cv_neg_norm.shape, y_cv.shape)
print(X5_test_neg_norm.shape, y_test.shape)
print("="*100)
```

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

In [199]:
```
X5_train_neg_norm = X5_train_neg_norm.T
X5_cv_neg_norm = X5_cv_neg_norm.T
X5_test_neg_norm = X5_test_neg_norm.T

print("Final Matrix")
print(X5_train_neg_norm.shape, y_train.shape)
print(X5_cv_neg_norm.shape, y_cv.shape)
print(X5_test_neg_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

Normalising Neutral scores

In [200]:
```
from sklearn.preprocessing import Normalizer
senti_neu_norm = Normalizer()
# normalizer.fit(X5_train['essay_word_total'].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.
senti_neu_norm.fit(X5_train['neu'].values.reshape(1,-1))

X5_train_neu_norm = senti_neu_norm.transform(X5_train['neu'].values.reshape(1,-1))
X5_cv_neu_norm = senti_neu_norm.transform(X5_cv['neu'].values.reshape(1,-1))
X5_test_neu_norm = senti_neu_norm.transform(X5_test['neu'].values.reshape(1,-1))

print("After vectorizations")
print(X5_train_neu_norm.shape, y_train.shape)
print(X5_cv_neu_norm.shape, y_cv.shape)
print(X5_test_neu_norm.shape, y_test.shape)
print("="*100)
```

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

In [201]:
```
X5_train_neu_norm = X5_train_neu_norm.T
X5_cv_neu_norm = X5_cv_neu_norm.T
X5_test_neu_norm = X5_test_neu_norm.T

print("Final Matrix")
print(X5_train_neu_norm.shape, y_train.shape)
print(X5_cv_neu_norm.shape, y_cv.shape)
print(X5_test_neu_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

Normalising Compound scores

In [202]:
```
from sklearn.preprocessing import Normalizer
senti_comp_norm = Normalizer()
# normalizer.fit(X5_train['essay_word_total'].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.
senti_comp_norm.fit(X5_train['compound'].values.reshape(1,-1))

X5_train_comp_norm = senti_comp_norm.transform(X5_train['compound'].values.reshape(1,-1))
X5_cv_comp_norm = senti_comp_norm.transform(X5_cv['compound'].values.reshape(1,-1))
X5_test_comp_norm = senti_comp_norm.transform(X5_test['compound'].values.reshape(1,-1))

print("After vectorizations")
print(X5_train_comp_norm.shape, y_train.shape)
print(X5_cv_comp_norm.shape, y_cv.shape)
print(X5_test_comp_norm.shape, y_test.shape)
print("="*100)
```

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

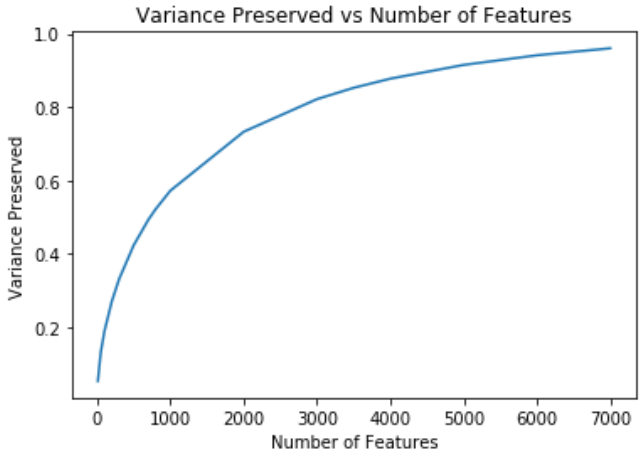
In [203]:
```
X5_train_comp_norm = X5_train_comp_norm.T
X5_cv_comp_norm = X5_cv_comp_norm.T
X5_test_comp_norm = X5_test_comp_norm.T

print("Final Matrix")
print(X5_train_comp_norm.shape, y_train.shape)
print(X5_cv_comp_norm.shape, y_cv.shape)
print(X5_test_comp_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

Dimensionality reduction using Truncated SVD

In [205]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html
#Initially we considered 5000 features but due to memory issue we are limiting the number of features to 1
from sklearn.decomposition import TruncatedSVD
Number_of_features = [10,50,100,200,300,500,700,800,1000,2000,3000,3500,4000,5000,6000,7000]
variance_preserved = []

for i in tqdm(Number_of_features):
    svd = TruncatedSVD(n_components=i, n_iter=5)
    svd.fit(X_train_essay_tfidf)
    variance_preserved.append(svd.explained_variance_ratio_.sum())

plt.plot(Number_of_features,variance_preserved)
plt.xlabel("Number of Features")
plt.ylabel("Variance Preserved")
plt.title("Variance Preserved vs Number of Features")
plt.show()
```

```
100%|██████████| 16/16 [1:17:20<00:00, 755.91s/it]
```



Considering n-components as 7000 as it is preserving more than 90% of the variance

In [217]:
```
from sklearn.decomposition import TruncatedSVD
svd = TruncatedSVD(n_components= 7000, n_iter=7, random_state=42)
svd.fit(X_train_essay_tfidf)
train_svd = svd.transform(X_train_essay_tfidf)
test_svd = svd.transform(X_test_essay_tfidf)
```

In [218]:
```
print(train_svd.shape)
print(test_svd.shape)
```

```
(49041, 7000)
(36052, 7000)
```

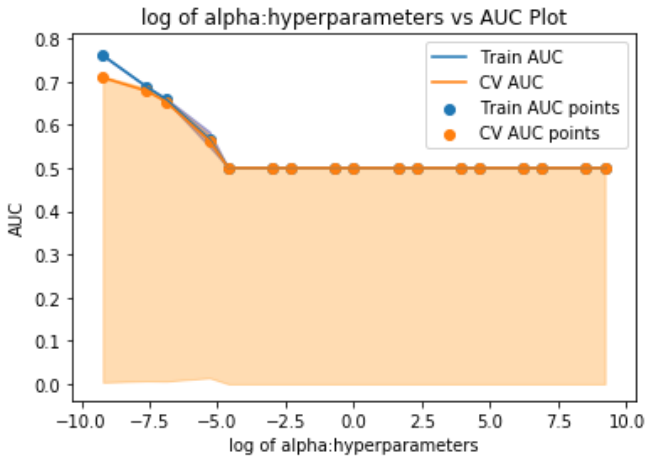
In [219]:
```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set5 = hstack((train_svd, X5_train_pos_norm, X5_train_neg_norm, X5_train_neu_norm, X5_train_comp_norm
X_te_set5 = hstack((test_svd, X5_test_pos_norm, X5_test_neg_norm, X5_test_neu_norm, X5_test_comp_norm, X5_

print("Final Data matrix")
print(X_tr_set5.shape, y_train.shape)
print(X_te_set5.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 7108) (49041,)
(36052, 7108) (36052,)
====================================================================================================
```

Finding the hyperparameter using L1 Regularization

In [220]:
```
data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1', class_weight='balanced'), tuned_parameters,
model.fit(X_tr_set5, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='d

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 53370.63it/s]
```



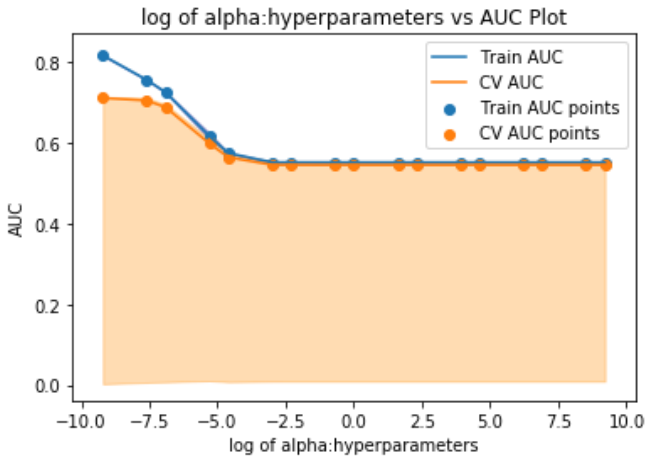
In [221]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.0001
0.7089607399128669
```

Finding the hyperparameter using L2 Regularization

In [222]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

tuned_parameters = {'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500,

#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='hinge', class_weight='balanced'), tuned_parameters, cv=5, scoring
model.fit(X_tr_set5, y_train)

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

log_alpha = []
for z in tqdm(tuned_parameters['alpha']):
    y = math.log(z)
    log_alpha.append(y)

log_alpha = np.array(log_alpha)

plt.figure()
plt.plot(log_alpha, train_auc, label = "Train AUC")
plt.gca().fill_between(log_alpha, train_auc - train_auc_std,train_auc + train_auc_std, alpha=0.3, color='(

plt.plot(log_alpha, cv_auc, label = "CV AUC")
plt.gca().fill_between(log_alpha, cv_auc_std, cv_auc + cv_auc_std,alpha=0.3, color='darkorange')
plt.scatter(log_alpha, train_auc, label='Train AUC points')
plt.scatter(log_alpha, cv_auc, label='CV AUC points')

plt.legend(loc='best')
plt.xlabel("log of alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("log of alpha:hyperparameters vs AUC Plot")
plt.show()
```

```
100%|██████████| 17/17 [00:00<00:00, 15965.78it/s]
```



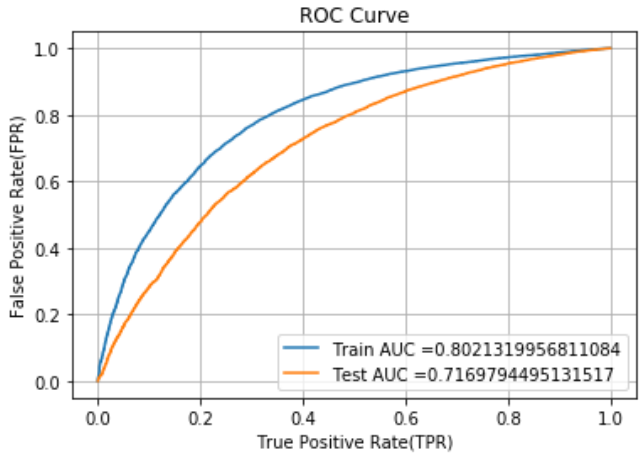
In [223]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.0001
0.7114612703344321
```

L2 regularizer is giving us a better score so we will be using L2 regularizer for this set

In [224]:
```
def batch_predict(clf, data):

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
# consider you X_tr shape is 49041, then your cr_loop will be 49041 - 49041%1000 = 49000
# in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
# we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [225]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier
from sklearn.svm import SVC

model = SGDClassifier(loss='hinge', alpha= best_a, class_weight='balanced')

model.fit(X_tr_set5, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs
y_train_pred = model.decision_function(X_tr_set5)
y_test_pred = model.decision_function(X_te_set5)

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("ROC Curve")
plt.grid(True)
plt.show()
```



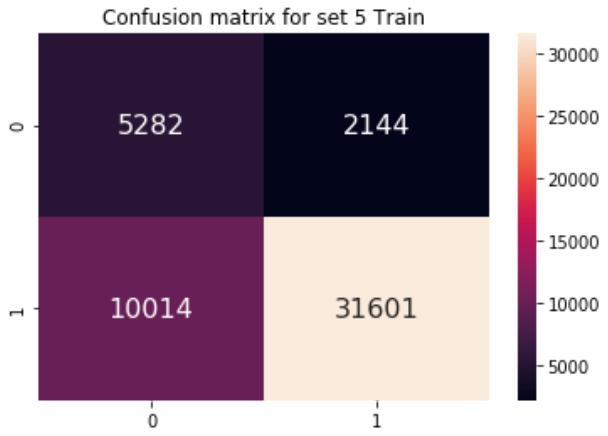
In [226]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [227]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.5401251238581356 for threshold -0.173
[[ 5282  2144]
 [10014 31601]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.5401251238581356 for threshold -0.173
[[ 3202  2257]
 [ 7924 22669]]
```

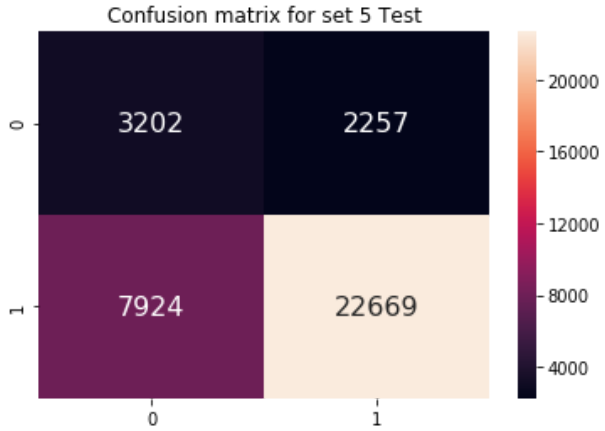
In [228]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[5282,2144],
        [10014,31601]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 5 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[228]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2eb3c5ba8>
```



In [229]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3202,2257],
        [7924,22669]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 5 Test')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[229]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa2db2c6c50>
```



3. Conclusion

In [241]:
```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Alpha:Hyper Parameter", "Regularizer", "AUC"]
x.add_row(["BOW", "SVM", 0.01, "L2", 0.71])
x.add_row(["TFIDF", "SVM", 0.0001, "L1", 0.71])
x.add_row(["AVG W2V", "SVM", 0.0001, "L1", 0.70])
x.add_row(["TFIDF W2V", "SVM", 0.001, "L2", 0.69])
x.add_row(["Truncated SVD", "SVM", 0.0001, "L2", 0.71])
print(x)
```

```
+---------------+-------+----------------------+-------------+------+
|   Vectorizer  | Model | Alpha:Hyper Parameter | Regularizer | AUC  |
+---------------+-------+----------------------+-------------+------+
|      BOW      |  SVM  |         0.01         |      L2     | 0.71 |
|     TFIDF     |  SVM  |        0.0001        |      L1     | 0.71 |
|    AVG W2V    |  SVM  |        0.0001        |      L1     | 0.7  |
|   TFIDF W2V   |  SVM  |        0.001         |      L2     | 0.69 |
| Truncated SVD |  SVM  |        0.0001        |      L2     | 0.71 |
+---------------+-------+----------------------+-------------+------+
```

In [ ]: