DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

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 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 & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [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 & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

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

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

```
    my_counter.update(word.split())

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

1.3 Text preprocessing

In [7]:

```
# 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 [8]:

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

Out[8]:

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

In [9]:

```
# 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. W
e are a melting pot of refugees, immigrants, and native-born Americans bringing the gift of langua
ge to our school. \r\n\r\n We have over 24 languages represented in our English Learner program wi
th students at every level of mastery.  We also have over 40 countries represented with the
families within our school.  Each student brings a wealth of knowledge and experiences to us that
open our eyes to new cultures, beliefs, and respect.\"The limits of your language are the limits o
f your world.\"-Ludwig Wittgenstein  Our English learner's have a strong support system at home th
at begs for more resources.  Many times our parents are learning to read and speak English along s
ide of their children.  Sometimes this creates barriers for parents to be able to help their child
learn phonetics, letter recognition, and other reading skills.\r\n\r\nBy providing these dvd's and
players, students are able to continue their mastery of the English language even if no one at hom
e is able to assist.  All families with students within the Level 1 proficiency status, will be a
offered to be a part of this program.  These educational videos will be specially chosen by the En
glish Learner Teacher and will be sent home regularly to watch.  The videos are to help the child
develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will have the
opportunity to check out a dvd player to use for the year.  The plan is to use these videos and ed
ucational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at l
east most of the time. At our school, 97.3% of the students receive free or reduced price lunch. O
```

f the 560 students, 97.3% are minority students. \r\nThe school has a vibrant community that loves to get together and celebrate. Around Halloween there is a whole school parade to show off the bea utiful costumes that students wear. On Cinco de Mayo we put on a big festival with crafts made by the students, dances, and games. At the end of the year the school hosts a carnival to celebrate t he hard work put in during the school year, with a dunk tank being the most popular activity.My st udents will use these five brightly colored Hokki stools in place of regular, stationary, 4-legged chairs. As I will only have a total of ten in the classroom and not enough for each student to hav e an individual one, they will be used in a variety of ways. During independent reading time they will be used as special chairs students will each use on occasion. I will utilize them in place of chairs at my small group tables during math and reading times. The rest of the day they will be us ed by the students who need the highest amount of movement in their life in order to stay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my students always say more Hokki Stools. They can't get their fill of the 5 stools we already have. When the students are sitting i n group with me on the Hokki Stools, they are always moving, but at the same time doing their work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta ken. There are always students who head over to the kidney table to get one of the stools who are disappointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours a day. The Hokki stools will be a compromise that allow my students to do desk work and move at th e same time. These stools will help students to meet their 60 minutes a day of movement by allowing them to activate their core muscles for balance while they sit. For many of my students, these chairs will take away the barrier that exists in schools for a child who can't sit still.nannan

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How do you remember your days of school? Was it in a sterile environment with plain walls, rows of desks, and a teacher in front of the room? A typical day in our room is nothing like that. I work hard to create a warm inviting themed room for my students look forward to coming to each day.\r\n \r\nMy class is made up of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey attend a Title I school, which means there is a high enough percentage of free a nd reduced-price lunch to qualify. Our school is an \"open classroom\" concept, which is very uniq ue as there are no walls separating the classrooms. These 9 and 10 year-old students are very eage r learners; they are like sponges, absorbing all the information and experiences and keep on wanti ng more.With these resources such as the comfy red throw pillows and the whimsical nautical hangin g decor and the blue fish nets, I will be able to help create the mood in our classroom setting to be one of a themed nautical environment. Creating a classroom environment is very important in the success in each and every child's education. The nautical photo props will be used with each child as they step foot into our classroom for the first time on Meet the Teacher evening. I'll take pic tures of each child with them, have them developed, and then hung in our classroom ready for their first day of 4th grade. This kind gesture will set the tone before even the first day of school! The nautical thank you cards will be used throughout the year by the students as they create thank you cards to their team groups.\r\n\r\nYour generous donations will help me to help make our classroom a fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of my own pocket on resources to get our classroom ready. Please consider helping with this project t o make our new school year a very successful one. Thank you!nannan

==========

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

==========

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

==========

In [10]:

```
# 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 [11]:

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

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

In [12]:

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

In [13]:

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

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitiv
e delays gross fine motor delays to autism They are eager beavers and always strive to work their
hardest working past their limitations The materials we have are the ones I seek out for my studen
ts I teach in a Title I school where most of the students receive free or reduced price lunch
```

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

In [14]:

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

In [15]:

```
# 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
[01:56<00:00, 935.36it/s]
```

In [30]:

```
# after preprocesing
preprocessed_essays[2000]
```

Out[30]:

'describing students not easy task many would say inspirational creative hard working they unique unique interests learning abilities much what common desire learn day despite difficulties encounter our classroom amazing understand everyone learns pace as teacher i pride making sure stu dents always engaged motivated inspired create learning this project help students choose seating

```
appropriate developmentally many students tire sitting chairs lessons different seats available he
lps keep engaged learning flexible seating important classroom many students struggle attention fo
cus engagement we currently stability balls seating well regular chairs stools help students
trouble balance find difficult sit stability ball long period time we excited try stools part enga
ging classroom community nannan'
```

1.4 Preprocessing of `project_title`

In [31]:

```
# similarly you can preprocess the titles also
# Using above lines of code for preprocessing Title text

from tqdm import tqdm
preprocessed_title = []

for sentance in tqdm(project_data['project_title'].values):
    sentTitle = decontracted(sentance)
    sentTitle = sentTitle.replace('\\r', ' ')
    sentTitle = sentTitle.replace('\\"', ' ')
    sentTitle = sentTitle.replace('\\n', ' ')
    sentTitle = re.sub('[^A-Za-z0-9]+', ' ', sentTitle)
    # https://gist.github.com/sebleier/554280
    sentTitle = ' '.join(e for e in sentTitle.split() if e not in stopwords)
    preprocessed_title.append(sentTitle.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[00:05<00:00, 18235.95it/s]
```

In [32]:

```
# after preprocessing Project title

preprocessed_title[20000]
```

Out[32]:

```
'we need to move it while we input it'
```

1.5 Preparing data for models

In [19]:

```
project_data.columns
```

Out[19]:

```
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/

In [20]:

```
# 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)
```

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

In [21]:

```
# 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)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
Shape of matrix after one hot encodig  (109248, 30)
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [22]:

```
# 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, 16623)
```

In [23]:

```
# Similarly you can vectorize for title also
# Using above lines of code

vectorizerTitle = CountVectorizer(min_df=10)
text_bow_title = vectorizerTitle.fit_transform(preprocessed_title)
print("Shape of matrix after one hot encodig ",text_bow_title.shape)
```

```
Shape of matrix after one hot encodig  (109248, 3329)
```

1.5.2.2 TFIDF vectorizer

In [194]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
essays_text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encoding ",essays_text_tfidf.shape)
```

```
Shape of matrix after one hot encoding  (109248, 16623)
```

In [195]:

```
# Similarly you can vectorize for title also
# Using above lines of code

from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
title_text_tfidf = vectorizer.fit_transform(preprocessed_title)
print("Shape of matrix after one hot encoding ",title_text_tfidf.shape)
```

```
Shape of matrix after one hot encoding  (109248, 3329)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [104]:

```
'''
# 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-load-variables-in-python/

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


'''
```

Out[104]:

```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n        word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        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 pickle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [105]:

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

In [106]:

```
# 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 [01:05<00:00, 1679.47it/s]
```

```
109248
300
```

In [107]:

```
# Similarly you can vectorize for title also
# Using above lines of code
# average Word2Vec for Project Title

avg_w2v_vectors_title = []; # the avg-w2v for each sentence/review is stored in this list
```

```
avg_w2v_vectors_title = []; # the avg w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_title): # 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_title.append(vector)

print(len(avg_w2v_vectors_title))
print(len(avg_w2v_vectors_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[00:03<00:00, 33539.30it/s]
```

```
109248
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [108]:

```
# 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 [109]:

```
# 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)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors.append(vector)

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

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[08:18<00:00, 219.33it/s]
```

```
109248
300
```

In [110]:

```
# Similarly you can vectorize for title also

tfidf_model_title = TfidfVectorizer()
tfidf_model_title.fit(preprocessed_title)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary_title = dict(zip(tfidf_model_title.get_feature_names(), list(tfidf_model_title.idf_)))
tfidf_words_title = set(tfidf_model_title.get_feature_names())
```

In [111]:

```
# Using above lines of code
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_title): # 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_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary_title[word]*(sentence.count(word)/len(sentence.split())) # getting
the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_title.append(vector)

print(len(tfidf_w2v_vectors_title))
print(len(tfidf_w2v_vectors_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[00:06<00:00, 16986.94it/s]
```

```
109248
300
```

1.5.3 Vectorizing Numerical features

In [38]:

```
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 [39]:

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

# 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 this data
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")

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

```
Mean : 298.1193425966608, Standard deviation : 367.49634838483496
```

In [40]:

```
price_standardized
```

Out[40]:

```
array([[-0.3905327 ],
```

```
       [ 0.00239637],
       [ 0.59519138],
       ...,
       [-0.15825829],
       [-0.61243967],
       [-0.51216657]])
```

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 value
   - Find the best hyper paramter using k-fold cross validation or simple cross validation data
   - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning
3. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure.
   - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
   - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points. Please visualize your confusion matrices using seaborn heatmaps.
4. **[Task-2] Apply the Support Vector Machines on these features by finding the best hyper paramter as suggested in step 2 and step 3**
   - Consider these set of features Set 5 :
     - **school_state** : categorical data
     - **clean_categories** : categorical data
     - **clean_subcategories** : categorical data
     - **project_grade_category** :categorical data
     - **teacher_prefix** : categorical data
     - **quantity** : numerical data
     - **teacher_number_of_previously_posted_projects** : numerical data
     - **price** : numerical data
     - **sentiment score's of each of the essay** : numerical data
     - **number of words in the title** : numerical data
     - **number of words in the combine essays** : numerical data
     - **Apply TruncatedSVD on TfidfVectorizer of essay text, choose the number of components (`n_components`) using elbow method** : numerical data
   - **Conclusion**
     - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

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.

2. Support Vector Machines

2. Support Vector Machines

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

In [52]:

```
# 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 spliting
# Using project_data, which is a merge of project_data , price_date tables

from sklearn.model_selection import train_test_split
Donor_train, Donor_test, Approved_train, Approved_test = train_test_split(project_data, project_dat
a['project_is_approved'], test_size=0.33, stratify=project_data['project_is_approved'])
print(Donor_train.shape,Approved_train.shape)
print(Donor_test.shape,Approved_test.shape)
project_data.columns
```

```
(73196, 20) (73196,)
(36052, 20) (36052,)
```

Out[52]:

```
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', 'price',
       'quantity'],
      dtype='object')
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [42]:

```
# 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

# One hot encoding the catogorical features : School State, Clean Categories, Clean Sub-Categories
, Project Grade and Teacher Prefix
# One hot Encoding for School State
vectorizer = CountVectorizer()
vectorizer.fit(Donor_train['school_state'].values) # fit has to happen only on train data
Donor_train_state_ohe = vectorizer.transform(Donor_train['school_state'].values)
Donor_test_state_ohe = vectorizer.transform(Donor_test['school_state'].values)

# Print One Hot Encoding - School State output
print("After vectorizations School state")
print(Donor_train_state_ohe.shape, Approved_train.shape)
print(Donor_test_state_ohe.shape, Approved_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations School state
```

```
(73196, 51) (73196,)
(36052, 51) (36052,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'k
s', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm',
'nv', 'ny', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv
', 'wy']
==========================================================================================================
```

In [43]:

```
# Preprocessing Project grade
from collections import Counter
my_counter = Counter()
for word in project_data['project_grade_category'].values:
    my_counter.update(word.split("'",1))

project_grade_category_dict = dict(my_counter)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), key=lambda
kv: kv[1]))
vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys()), lowercase
=False, binary=True)

# One Hot Encoding - Project grade category

vectorizer.fit(Donor_train['project_grade_category'].values) # fit has to happen only on train
data
Donor_train_grade_ohe = vectorizer.transform(Donor_train['project_grade_category'].values)
Donor_test_grade_ohe = vectorizer.transform(Donor_test['project_grade_category'].values)

# Print One Hot Encoding - Project grade output
print("After vectorizations Project grade category")
print(Donor_train_grade_ohe.shape, Approved_train.shape)
print(Donor_test_grade_ohe.shape, Approved_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations Project grade category
(73196, 4) (73196,)
(36052, 4) (36052,)
['Grades 9-12', 'Grades 6-8', 'Grades 3-5', 'Grades PreK-2']
==========================================================================================================
```

In [44]:

```
# One hot Encoding for project subject categories
vectorizer = CountVectorizer()
vectorizer.fit(Donor_train['clean_categories'].values) # fit has to happen only on train data
Donor_train_clean_cat_ohe = vectorizer.transform(Donor_train['clean_categories'].values)
Donor_test_clean_cat_ohe = vectorizer.transform(Donor_test['clean_categories'].values)

# Print One Hot Encoding - Project subject output
print("After vectorizations project subject categories")
print(Donor_train_clean_cat_ohe.shape, Approved_train.shape)
print(Donor_test_clean_cat_ohe.shape, Approved_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations project subject categories
(73196, 9) (73196,)
(36052, 9) (36052,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language',
'math_science', 'music_arts', 'specialneeds', 'warmth']
==========================================================================================================
```

In [45]:

```
# One hot Encoding for project subject subcategories
vectorizer = CountVectorizer()
vectorizer.fit(Donor_train['clean_subcategories'].values) # fit has to happen only on train data
Donor_train_clean_subcat_ohe = vectorizer.transform(Donor_train['clean_subcategories'].values)
```

```
Donor_test_clean_subcat_ohe = vectorizer.transform(Donor_test['clean_subcategories'].values)

# Print One Hot Encoding - project subject subcategories output
print("After vectorizations project subject subcategories")
print(Donor_train_clean_subcat_ohe.shape, Approved_train.shape)
print(Donor_test_clean_subcat_ohe.shape, Approved_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations project subject subcategories
(73196, 30) (73196,)
(36052, 30) (36052,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government',
'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'environmentalscience',
'esl', 'extracurricular', 'financialliteracy', 'foreignlanguages', 'gym_fitness',
'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'm
athematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socia
lsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
====================================================================================================
```

In [54]:

```
# To avoid np.NaN invalid document error;
# Source : https://stackoverflow.com/questions/39303912/tfidfvectorizer-in-scikit-learn-
valueerror-np-nan-is-an-invalid-document/39308809
# One hot Encoding for Teacher Prefix

Donor_train['teacher_prefix'] = Donor_train['teacher_prefix'].fillna(0)
Donor_test['teacher_prefix'] = Donor_test['teacher_prefix'].fillna(0)

vectorizer = CountVectorizer()
vectorizer.fit(Donor_train['teacher_prefix'].values.astype('U')) # fit has to happen only on train
data
Donor_train_teacher_ohe = vectorizer.transform(Donor_train['teacher_prefix'].values.astype('U'))
Donor_test_teacher_ohe = vectorizer.transform(Donor_test['teacher_prefix'].values.astype('U'))

# Print One Hot Encoding - Teacher Prefix output
print("After vectorizations Teacher Prefix")
print(Donor_train_teacher_ohe.shape, Approved_train.shape)
print(Donor_test_teacher_ohe.shape, Approved_test.shape)
print(vectorizer.get_feature_names())
print("="*100)
```

```
After vectorizations Teacher Prefix
(73196, 5) (73196,)
(36052, 5) (36052,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================================
```

Numerical Features

In [55]:

```
# Normalizing the Numerical data : Price
# Using code from Sample solution

from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(Donor_train['price'].values.reshape(-1,1))
Donor_train_price_norm = normalizer.transform(Donor_train['price'].values.reshape(-1,1))
Donor_test_price_norm = normalizer.transform(Donor_test['price'].values.reshape(-1,1))

print("After vectorizations Numerical Data: Price")
print(Donor_train_price_norm.shape, Approved_train.shape)
print(Donor_test_price_norm.shape, Approved_test.shape)
print("="*100)
```

```
After vectorizations Numerical Data: Price
(73196, 1) (73196,)
```

```
(36052, 1) (36052,)
==================================================================================================
```

In [56]:

```
# Normalizing the Numerical data : teacher_number_of_previously_posted_projects

from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(Donor_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
Donor_train_postedCount_norm =
normalizer.transform(Donor_train['teacher_number_of_previously_posted_projects'].values.reshape(-1
,1))
Donor_test_postedCount_norm =
normalizer.transform(Donor_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,
1))

print("After vectorizations Numerical Data: Previously Posted Projects")
print(Donor_train_postedCount_norm.shape, Approved_train.shape)
print(Donor_test_postedCount_norm.shape, Approved_test.shape)
print("="*100)
```

```
After vectorizations Numerical Data: Previously Posted Projects
(73196, 1) (73196,)
(36052, 1) (36052,)
==================================================================================================
```

In [57]:

```
# Normalizing the Numerical data : Quantity
# Using code from Sample solution

from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(Donor_train['quantity'].values.reshape(-1,1))
Donor_train_quantity_norm = normalizer.transform(Donor_train['quantity'].values.reshape(-1,1))
Donor_test_quantity_norm = normalizer.transform(Donor_test['quantity'].values.reshape(-1,1))

print("After vectorizations Numerical Data: Quantity")
print(Donor_train_quantity_norm.shape, Approved_train.shape)
print(Donor_test_quantity_norm.shape, Approved_test.shape)
print("="*100)
```

```
After vectorizations Numerical Data: Quantity
(73196, 1) (73196,)
(36052, 1) (36052,)
==================================================================================================
```

2.3 Make Data Model Ready: encoding eassay, and project_title

BoW : Project Essays

In [58]:

```
# 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

# Using sample solution code
```

```
# Using max features as 5000 ,min df = 10 and bigrams

from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(Donor_train['essay'].values) # fit has to happen only on train data
Donor_train_essay_bow = vectorizer.transform(Donor_train['essay'].values)
Donor_test_essay_bow = vectorizer.transform(Donor_test['essay'].values)

print("After vectorizing Project Essays BoW")
print(Donor_train_essay_bow.shape, Approved_train.shape)
print(Donor_test_essay_bow.shape, Approved_test.shape)
print("="*100)
```

```
After vectorizing Project Essays BoW
(73196, 5000) (73196,)
(36052, 5000) (36052,)
====================================================================================================
```

BoW : Project Title

In [59]:

```
# Using sample solution code
# Using max features as 3000, to make column size same

from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,2), max_features=3000)
vectorizer.fit(Donor_train['project_title'].values) # fit has to happen only on train data
Donor_train_title_bow = vectorizer.transform(Donor_train['project_title'].values)
Donor_test_title_bow = vectorizer.transform(Donor_test['project_title'].values)

print("After vectorizing Project Essays BoW")
print(Donor_train_title_bow.shape, Approved_train.shape)
print(Donor_test_title_bow.shape, Approved_test.shape)
print("="*100)
```

```
After vectorizing Project Essays BoW
(73196, 3000) (73196,)
(36052, 3000) (36052,)
====================================================================================================
```

TFIDF : Project Essays

In [63]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,2), max_features=5000)
vectorizer.fit(Donor_train['essay'].values) # fit has to happen only on train data
Donor_train_essay_tfidf = vectorizer.transform(Donor_train['essay'].values)
Donor_test_essay_tfidf = vectorizer.transform(Donor_test['essay'].values)

print("After vectorizing Project Essays TFIDF")
print(Donor_train_essay_tfidf.shape, Approved_train.shape)
print(Donor_test_essay_tfidf.shape, Approved_test.shape)
print("="*100)
```

```
After vectorizing Project Essays TFIDF
(73196, 5000) (73196,)
(36052, 5000) (36052,)
====================================================================================================
```

TFIDF : Project Title

In [62]:

```
%%time
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,2), max_features=3000)
vectorizer.fit(Donor_train['project_title'].values) # fit has to happen only on train data
Donor_train_title_tfidf = vectorizer.transform(Donor_train['project_title'].values)
Donor_test_title_tfidf = vectorizer.transform(Donor_test['project_title'].values)

print("After vectorizing Project Title using TFIDF: ")
print(Donor_train_title_tfidf.shape, Approved_train.shape)
print(Donor_test_title_tfidf.shape, Approved_test.shape)
print("="*100)
```

```
After vectorizing Project Title using TFIDF:
(73196, 3000) (73196,)
(36052, 3000) (36052,)
====================================================================================================

Wall time: 4.67 s
```

AVG W2V : Project Essay

In [112]:

```
# AVG W2V for Train Data
avg_w2v_vectors_train_essays = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(Donor_train['essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train_essays.append(vector)

print(len(avg_w2v_vectors_train_essays))
print(len(avg_w2v_vectors_train_essays[0]))

# AVG W2V for Test Data
avg_w2v_vectors_test_essays = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(Donor_test['essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test_essays.append(vector)

print(len(avg_w2v_vectors_test_essays))
print(len(avg_w2v_vectors_test_essays[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 73196/73196
[01:01<00:00, 1196.93it/s]

73196
300

100%|████████████████████████████████████████████████████████████████| 36052/36052
[00:29<00:00, 1231.96it/s]

36052
300
```

AVG W2V : Project Title

In [113]:

```
# AVG W2V for Train Data
avg_w2v_vectors_train_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(Donor_train['project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_train_title.append(vector)

print(len(avg_w2v_vectors_train_title))
print(len(avg_w2v_vectors_train_title[0]))

# AVG W2V for Test Data
avg_w2v_vectors_test_title = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(Donor_test['project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_test_title.append(vector)

print(len(avg_w2v_vectors_test_title))
print(len(avg_w2v_vectors_test_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 73196/73196
[00:01<00:00, 72509.23it/s]
```

```
73196
300
```

```
100%|██████████████████████████████████████████████████████████████████████████| 36052/36052
[00:00<00:00, 78390.97it/s]
```

```
36052
300
```

TFIDF : Project Essay

In [131]:

```
Donor_train_tfidf_w2v_vectors = [];
for sentence in tqdm(Donor_train['essay']): # 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
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Donor_train_tfidf_w2v_vectors.append(vector)

print(len(Donor_train_tfidf_w2v_vectors))
print(len(Donor_train_tfidf_w2v_vectors[0]))

Donor_test_tfidf_w2v_vectors = [];
for sentence in tqdm(Donor_test['essay']): # 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
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Donor_test_tfidf_w2v_vectors.append(vector)

print(len(Donor_test_tfidf_w2v_vectors))
print(len(Donor_test_tfidf_w2v_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 73196/73196 [10:
37<00:00, 108.00it/s]
```

```
73196
300
```

```
100%|██████████████████████████████████████████████████████████████████████████| 36052/36052 [05:
41<00:00, 105.70it/s]
```

```
36052
300
```

TFIDF W2V : Project Title

In [132]:

```
Donor_train_tfidf_w2v_title = [];
for sentence in tqdm(Donor_train['project_title']): # 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
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Donor_train_tfidf_w2v_title.append(vector)

print(len(Donor_train_tfidf_w2v_title))
print(len(Donor_train_tfidf_w2v_title[0]))

Donor_test_tfidf_w2v_title = [];
for sentence in tqdm(Donor_test['project_title']): # 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
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    Donor_test_tfidf_w2v_title.append(vector)

print(len(Donor_test_tfidf_w2v_title))
print(len(Donor_test_tfidf_w2v_title[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 73196/73196
[00:01<00:00, 49619.10it/s]
```

```
73196
300
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052
[00:00<00:00, 51219.99it/s]
```

```
36052
300
```

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

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

2.4.1 Applying Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on BOW, SET 1

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

In [64]:

```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# Using sample soultion code

from scipy.sparse import hstack
Donor_tr = hstack((Donor_train_essay_bow,Donor_train_title_bow, Donor_train_state_ohe,
Donor_train_teacher_ohe, Donor_train_grade_ohe,
Donor_train_clean_cat_ohe,Donor_train_clean_subcat_ohe,Donor_train_price_norm,Donor_train_postedCou
nt_norm,Donor_train_quantity_norm)).tocsr()
Donor_te = hstack((Donor_test_essay_bow,Donor_test_title_bow, Donor_test_state_ohe,
Donor_test_teacher_ohe, Donor_test_grade_ohe, Donor_test_clean_cat_ohe,Donor_test_clean_subcat_ohe
,Donor_test_price_norm,Donor_test_postedCount_norm,Donor_test_quantity_norm)).tocsr()

print("Final Donor Data Matrix for Set 1")
print(Donor_tr.shape,Approved_train.shape)
print(Donor_te.shape,Approved_test.shape)

print("="*100)
```

```
Final Donor Data Matrix for Set 1
(73196, 8102) (73196,)
(36052, 8102) (36052,)
====================================================================================================
```

In [71]:

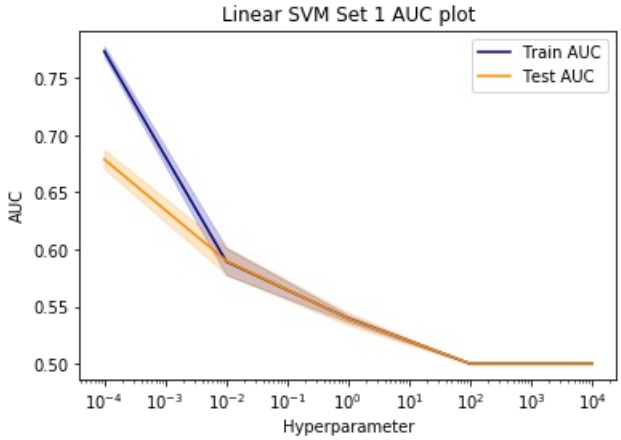
```
%%time
# Performing Grid Search using SGD Classifier with loss ="hinge" and penalty="L1"
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier

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

#Using GridSearchCV
model = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1',max_iter=1000,epsilon=0.1),
parameters, scoring = 'roc_auc', cv=5, return_train_score = True)
model.fit(Donor_tr, Approved_train)

print(model.best_estimator_)
print(model.score(Donor_te, Approved_test))
```

```
SGDClassifier(alpha=0.0001, average=False, class_weight=None,
```

```
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=1000,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l1',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
0.6899150633559261
Wall time: 1h 29min 40s
```

In [72]:

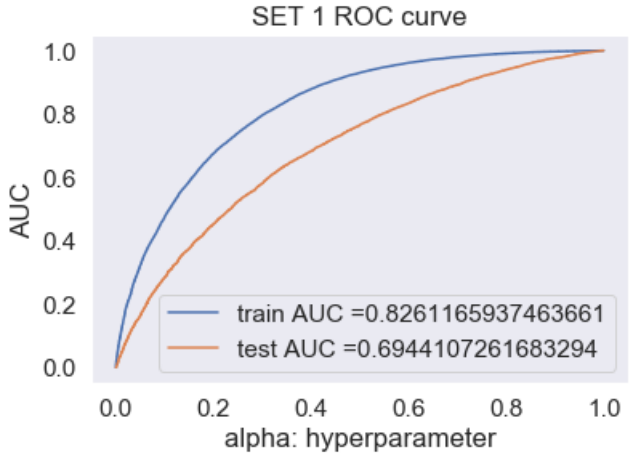
```
# Plotting AUC for Train and Test data of Set 1

hyperparams = [10**-4, 10**-2, 10**0, 10**2, 10**4]

train_auc= model.cv_results_['mean_train_score']
train_auc_std= model.cv_results_['std_train_score']
test_auc = model.cv_results_['mean_test_score']
test_auc_std= model.cv_results_['std_test_score']

plt.figure()
plt.title('Linear SVM Set 1 AUC plot')
plt.xlabel('Hyperparameter')
plt.ylabel('AUC')

plt.semilogx(hyperparams, train_auc, label='Train AUC',color='darkblue')
plt.gca().fill_between(hyperparams,train_auc - train_auc_std,train_auc + train_auc_std,alpha=0.2,co
lor='darkblue')

plt.semilogx(hyperparams, test_auc,label='Test AUC', color='darkorange')
plt.gca().fill_between(hyperparams, test_auc - test_auc_std, test_auc + test_auc_std,alpha=0.2,colo
r='darkorange')

plt.legend(loc='best')
plt.show()
```



In [158]:

```
%%time
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
# Source: https://stackoverflow.com/questions/55893734/how-can-i-use-sgdclassifier-hinge-loss-with
-gridsearchcv-using-log-loss-metric
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier

# Set the SGD classifier as the base estimator
# Using CalibratedClassifierCV to generate probability estimates

set1Model = SGDClassifier(alpha=0.0001,loss='hinge', penalty='l2',max_iter=500,epsilon=0.1);
calibrated_clf1 = CalibratedClassifierCV(base_estimator = set1Model, method='sigmoid', cv=3)
calibrated_clf1.fit(Donor_tr, Approved_train)

Approved_train_pred = calibrated_clf1.predict_proba(Donor_tr)
Approved_test_pred = calibrated_clf1.predict_proba(Donor_te)
```

```
train_fpr, train_tpr, tr_thresholds = roc_curve(Approved_train, Approved_train_pred[:, 1])
test_fpr, test_tpr, te_thresholds = roc_curve(Approved_test, Approved_test_pred[:, 1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("SET 1 ROC curve")
plt.grid()
plt.show()
```




```
Wall time: 1min 22s
```

In [82]:

```
# Writing own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def predictcm(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
```

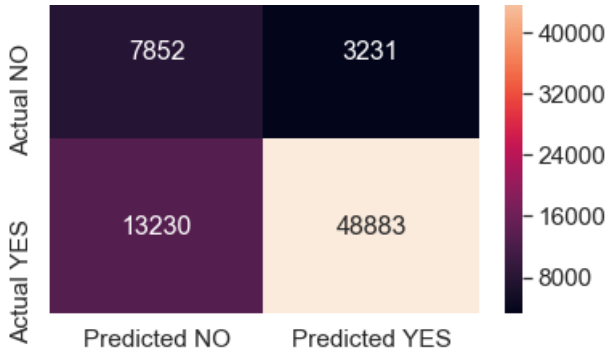
In [160]:

```
# Confustion Matrix for Set 1 Train vs Test data

print("Train confusion matrix for Set 1")
donor_SET1_tr = pd.DataFrame(confusion_matrix(Approved_train, predictcm(Approved_train_pred[:, 1],
tr_thresholds, train_fpr, train_tpr)))
donor_SET1_tr.columns = ['Predicted NO','Predicted YES']
donor_SET1_tr = donor_SET1_tr.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)#for label size
sns.heatmap(donor_SET1_tr, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Train confusion matrix for Set 1
the maximum value of tpr*(1-fpr) 0.5575685935774116 for threshold 0.822
```

Out[160]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25ea2007978>
```



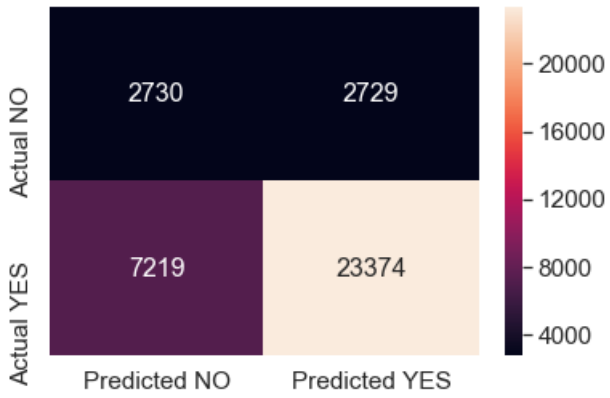
In [161]:

```
print("="*100)
print("Test confusion matrix for Set 1")
donor_SET1_te = pd.DataFrame(confusion_matrix(Approved_test, predictcm(Approved_test_pred[:, 1],
te_thresholds, test_fpr, test_fpr)))
donor_SET1_te.columns = ['Predicted NO','Predicted YES']
donor_SET1_te = donor_SET1_te.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)#for label size
sns.heatmap(donor_SET1_te, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================================

Test confusion matrix for Set 1
the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 0.817
```

Out[161]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25e863fc2b0>
```



2.4.2 Applying Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on TFIDF, SET 2

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

In [87]:

```
# Using sample soultion code
from scipy.sparse import hstack
Donor_tr_tfidf = hstack((Donor_train_essay_tfidf,Donor_train_title_tfidf, Donor_train_state_ohe,
Donor_train_teacher_ohe, Donor_train_grade_ohe,
Donor_train_clean_cat_ohe,Donor_train_clean_subcat_ohe,Donor_train_price_norm,Donor_train_postedCou
nt_norm,Donor_train_quantity_norm)).tocsr()
Donor_te_tfidf = hstack((Donor_test_essay_tfidf,Donor_test_title_tfidf, Donor_test_state_ohe,
Donor_test_teacher_ohe, Donor_test_grade_ohe, Donor_test_clean_cat_ohe,Donor_test_clean_subcat_ohe
,Donor_test_price_norm,Donor_test_postedCount_norm,Donor_test_quantity_norm)).tocsr()

print("Donor Data Matrix for Set 2")
print(Donor_tr_tfidf.shape,Approved_train.shape)
print(Donor_te_tfidf.shape,Approved_test.shape)
print("="*100)
```

```
Donor Data Matrix for Set 2
(73196, 8102) (73196,)
(36052, 8102) (36052,)
==========================================================================================================
```

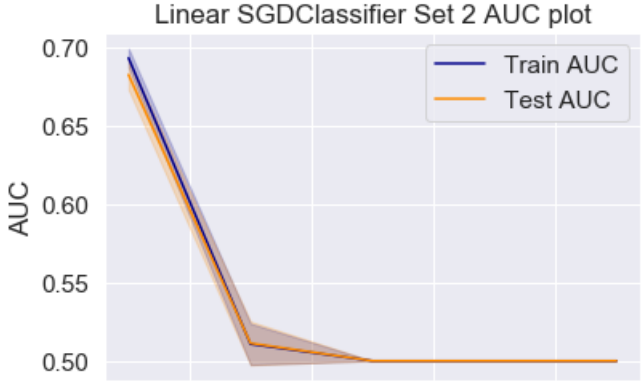
In [89]:

```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import LogisticRegression

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

#Using GridSearchCV
model2 = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1',max_iter=1000,epsilon=0.1),
parameters, scoring = 'roc_auc', cv=5, return_train_score = True)
model2.fit(Donor_tr_tfidf, Approved_train)

print(model2.best_estimator_)
print(model2.score(Donor_te_tfidf, Approved_test))
```

```
SGDClassifier(alpha=0.0001, average=False, class_weight=None,
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=1000,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l1',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
0.6568146225946552
Wall time: 35min 18s
```

In [90]:

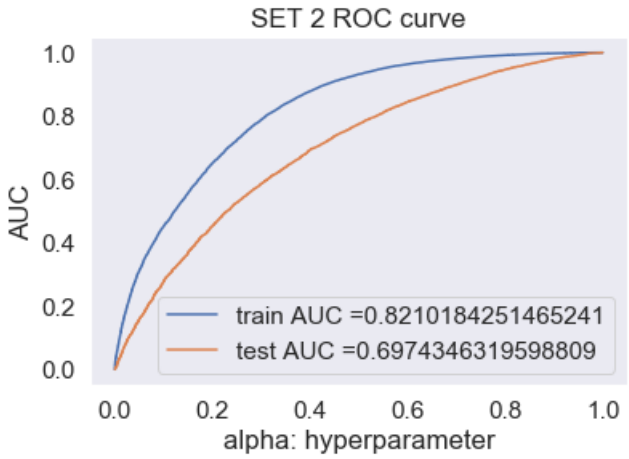
```
%%time

# Plotting AUC for Train and Test data of Set 2

hyperparams = [10**-4, 10**-2, 10**0, 10**2, 10**4]
set2_train_auc= model2.cv_results_['mean_train_score']
set2_train_auc_std= model2.cv_results_['std_train_score']
set2_test_auc = model2.cv_results_['mean_test_score']
set2_test_auc_std= model2.cv_results_['std_test_score']

plt.figure()
plt.title('Linear SGDClassifier Set 2 AUC plot')
plt.xlabel('Hyperparameter')
plt.ylabel('AUC')
plt.semilogx(hyperparams, set2_train_auc, label='Train AUC',color='darkblue')
plt.gca().fill_between(hyperparams,set2_train_auc - set2_train_auc_std,set2_train_auc + set2_train_
auc_std,alpha=0.2,color='darkblue')
plt.semilogx(hyperparams, set2_test_auc,label='Test AUC', color='darkorange')
plt.gca().fill_between(hyperparams, set2_test_auc - set2_test_auc_std, set2_test_auc + set2_test_au
c_std,alpha=0.2,color='darkorange')
plt.legend(loc='best')
plt.show()
```



Wall time: 1.32 s

In [162]:

```
%%time
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
# Source : https://stackoverflow.com/questions/55893734/how-can-i-use-sgdclassifier-hinge-loss-wit
h-gridsearchcv-using-log-loss-metric

from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier

# Set the SGD classifier as the base estimator
# Using CalibratedClassifierCV to generate probability estimates

set2Model = SGDClassifier(loss='hinge', alpha = 0.0001, penalty='l2',max_iter=500, epsilon=0.1);
calibrated_clf2 = CalibratedClassifierCV(base_estimator = set2Model, method='sigmoid', cv=3)
calibrated_clf2.fit(Donor_tr_tfidf, Approved_train)

Approved_train_pred_set2 = calibrated_clf2.predict_proba(Donor_tr_tfidf)
Approved_test_pred_set2 = calibrated_clf2.predict_proba(Donor_te_tfidf)

train_fpr, train_tpr, tr_thresholds = roc_curve(Approved_train, Approved_train_pred_set2[:, 1])
test_fpr, test_tpr, te_thresholds = roc_curve(Approved_test, Approved_test_pred_set2[:, 1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("SET 2 ROC curve")
plt.grid()
plt.show()
```



Wall time: 1min 26s

In [163]:

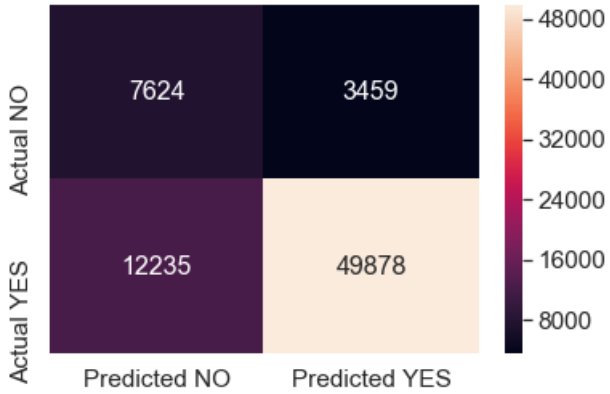
```
print("Train confusion matrix for Set 2")
donor_SET2_tr = pd.DataFrame(confusion_matrix(Approved_train,
predictcm(Approved_train_pred_set2[:, 1], tr_thresholds, train_fpr, train_tpr)))
donor_SET2_tr.columns = ['Predicted NO','Predicted YES']
donor_SET2_tr = donor_SET2_tr.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)#for label size
sns.heatmap(donor_SET2_tr, annot=True,annot_kws={"size": 16}, fmt='g')
```

Train confusion matrix for Set 2

```
the maximum value of tpr*(1-fpr) 0.5523979771021512 for threshold 0.822
```

Out[163]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25f22629668>
```



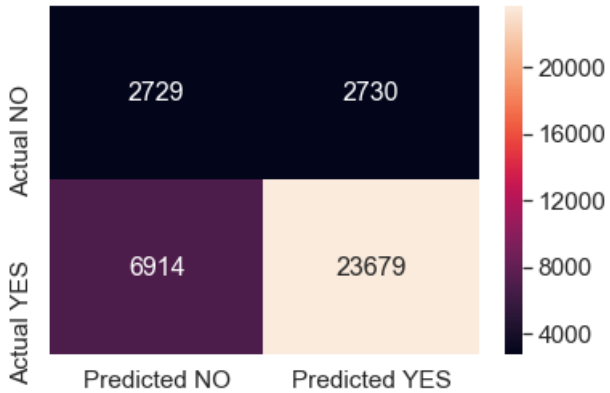
In [164]:

```
print("="*100)
print("Test confusion matrix for Set 2")
donor_SET2_te = pd.DataFrame(confusion_matrix(Approved_test, predictcm(Approved_test_pred_set2[:,1
], te_thresholds, test_fpr, test_fpr)))
donor_SET2_te.columns = ['Predicted NO','Predicted YES']
donor_SET2_te = donor_SET2_te.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)#for label size
sns.heatmap(donor_SET2_te, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================================

Test confusion matrix for Set 2
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.816
```

Out[164]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25e8647b208>
```



2.4.2 Applying Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on Avg W2V, SET 3

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

In [114]:

```
from scipy.sparse import hstack
Donor_tr_AvgW2V = hstack((avg_w2v_vectors_train_essays,avg_w2v_vectors_train_title,
Donor_train_state_ohe, Donor_train_teacher_ohe, Donor_train_grade_ohe, Donor_train_clean_cat_ohe,D
onor_train_clean_subcat_ohe,Donor_train_price_norm,Donor_train_postedCount_norm,Donor_train_quantit
y_norm)).tocsr()
```

```
Donor_te_AvgW2V = hstack((avg_w2v_vectors_test_essays,avg_w2v_vectors_test_title,
Donor_test_state_ohe, Donor_test_teacher_ohe, Donor_test_grade_ohe,
Donor_test_clean_cat_ohe,Donor_test_clean_subcat_ohe,Donor_test_price_norm,Donor_test_postedCount_r
orm,Donor_test_quantity_norm)).tocsr()

print("Final Donor Data Matrix for Set 2")
print(Donor_tr_AvgW2V.shape,Approved_train.shape)
print(Donor_te_AvgW2V.shape,Approved_test.shape)
print("="*100)
```

```
Final Donor Data Matrix for Set 2
(73196, 702) (73196,)
(36052, 702) (36052,)
====================================================================================================
```

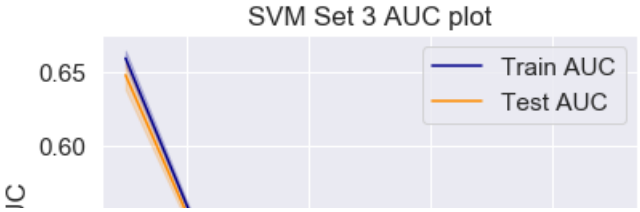
In [115]:

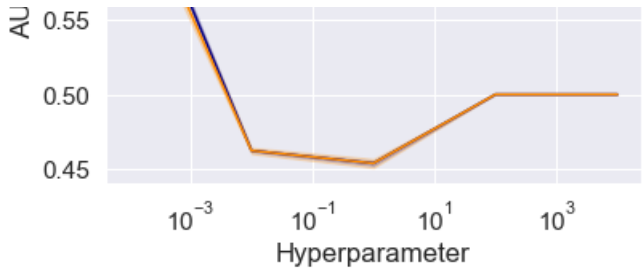
```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import LogisticRegression

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

#Using GridSearchCV
modelSet3 = GridSearchCV(SGDClassifier(loss='hinge', penalty='l1',max_iter=1000,epsilon=0.1),
parameters, scoring = 'roc_auc', cv=3, return_train_score = True)
modelSet3.fit(Donor_tr_AvgW2V, Approved_train)

print(modelSet3.best_estimator_)
print(modelSet3.score(Donor_te_AvgW2V, Approved_test))
```

```
SGDClassifier(alpha=0.0001, average=False, class_weight=None,
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=1000,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l1',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
0.6542181864305038
Wall time: 1h 6min 54s
```

In [116]:

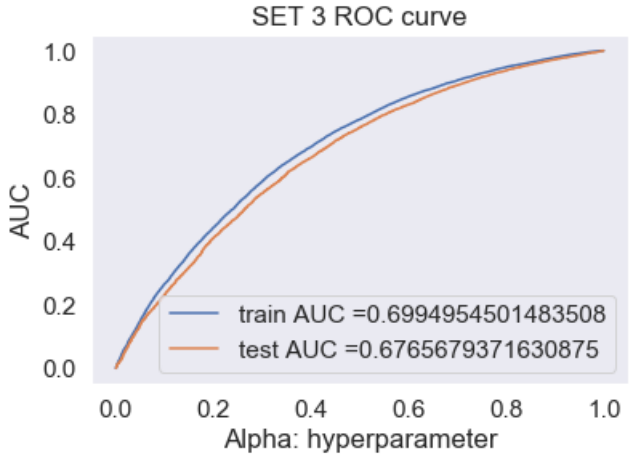
```
# Plotting AUC for Train and Test data of Set 3

hyperparams = [10**-4, 10**-2, 10**0, 10**2, 10**4]
set3_train_auc= modelSet3.cv_results_['mean_train_score']
set3_train_auc_std= modelSet3.cv_results_['std_train_score']
set3_test_auc = modelSet3.cv_results_['mean_test_score']
set3_test_auc_std= modelSet3.cv_results_['std_test_score']

plt.figure()
plt.title('SVM Set 3 AUC plot')
plt.xlabel('Hyperparameter')
plt.ylabel('AUC')
plt.semilogx(hyperparams, set3_train_auc, label='Train AUC',color='darkblue')
plt.gca().fill_between(hyperparams,set3_train_auc - set3_train_auc_std,set3_train_auc + set3_train_
auc_std,alpha=0.2,color='darkblue')
plt.semilogx(hyperparams, set3_test_auc,label='Test AUC', color='darkorange')
plt.gca().fill_between(hyperparams, set3_test_auc - set3_test_auc_std, set3_test_auc + set3_test_au
c_std,alpha=0.2,color='darkorange')
plt.legend(loc='best')
plt.show()
```





In [165]:

```
%%time
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
# Source : https://stackoverflow.com/questions/55893734/how-can-i-use-sgdclassifier-hinge-loss-wit
h-gridsearchcv-using-log-loss-metric

from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier

# Set the SGD classifier as the base estimator
# Using CalibratedClassifierCV to generate probability estimates

set3Model = SGDClassifier(loss='hinge', alpha = 0.0001, penalty='l2',max_iter=500, epsilon=0.1);
calibrated_clf2 = CalibratedClassifierCV(base_estimator = set3Model, method='sigmoid', cv=3)
calibrated_clf2.fit(Donor_tr_AvgW2V, Approved_train)

Approved_train_pred_set3 = calibrated_clf2.predict_proba(Donor_tr_AvgW2V)
Approved_test_pred_set3 = calibrated_clf2.predict_proba(Donor_te_AvgW2V)

train_fpr, train_tpr, tr_thresholds = roc_curve(Approved_train, Approved_train_pred_set3[:,1])
test_fpr, test_tpr, te_thresholds = roc_curve(Approved_test, Approved_test_pred_set3[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("SET 3 ROC curve")
plt.grid()
plt.show()
```




```
Wall time: 2min 32s
```

In [166]:

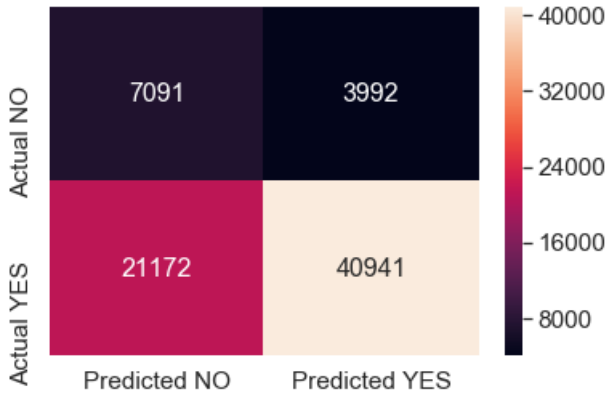
```
# Confustion Matrix for Set 3 Train vs Test data

print("Train confusion matrix for Set 3")
donor_SET3_tr = pd.DataFrame(confusion_matrix(Approved_train,
predictcm(Approved_train_pred_set3[:,1], tr_thresholds, train_fpr, train_tpr)))
donor_SET3_tr.columns = ['Predicted NO','Predicted YES']
```

```
donor_SET3_tr = donor_SET3_tr.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)
sns.heatmap(donor_SET3_tr, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Train confusion matrix for Set 3
the maximum value of tpr*(1-fpr) 0.42172183993478 for threshold 0.841
```

Out[166]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25ea2153c88>
```



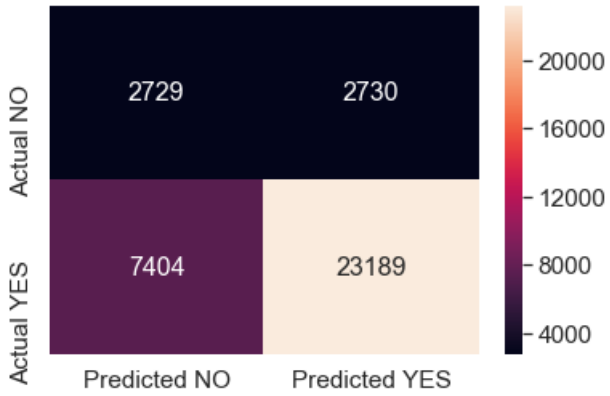
In [167]:

```
print("="*100)
print("Test confusion matrix for Set 3")
donor_SET3_te = pd.DataFrame(confusion_matrix(Approved_test, predictcm(Approved_test_pred_set3[:,1
], te_thresholds, test_fpr, test_fpr)))
donor_SET3_te.columns = ['Predicted NO','Predicted YES']
donor_SET3_te = donor_SET3_te.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)
sns.heatmap(donor_SET3_te, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================================

Test confusion matrix for Set 3
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.826
```

Out[167]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25f1c7cd710>
```



2.4.2 Applying Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on TFIDF W2V, SET 4

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

In [133]:

```
from scipy.sparse import hstack
Donor_tr_TFIDFW2V = hstack((Donor_train_tfidf_w2v_vectors,Donor_train_tfidf_w2v_title,
Donor_train_state_ohe, Donor_train_teacher_ohe, Donor_train_grade_ohe, Donor_train_clean_cat_ohe,D
onor_train_clean_subcat_ohe,Donor_train_price_norm,Donor_train_postedCount_norm,Donor_train_quantit
y_norm)).tocsr()
Donor_te_TFIDFW2V = hstack((Donor_test_tfidf_w2v_vectors,Donor_test_tfidf_w2v_title,
Donor_test_state_ohe, Donor_test_teacher_ohe, Donor_test_grade_ohe,
Donor_test_clean_cat_ohe,Donor_test_clean_subcat_ohe,Donor_test_price_norm,Donor_test_postedCount_r
orm,Donor_test_quantity_norm)).tocsr()

print("Final Donor Data Matrix for Set 2")
print(Donor_tr_TFIDFW2V.shape,Approved_train.shape)
print(Donor_te_TFIDFW2V.shape,Approved_test.shape)
print("="*100)
```

```
Final Donor Data Matrix for Set 2
(73196, 702) (73196,)
(36052, 702) (36052,)
====================================================================================================
```

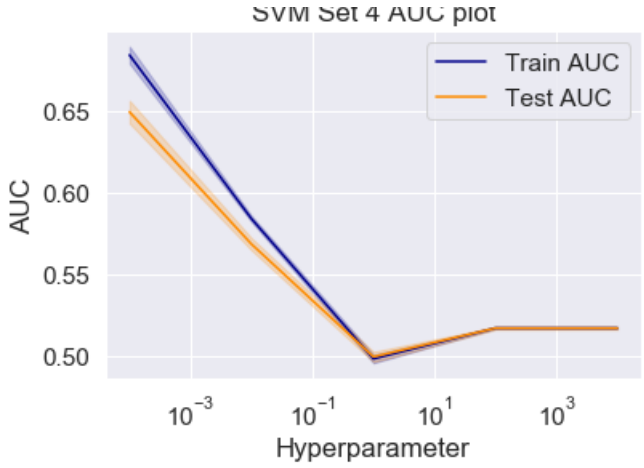
In [139]:

```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import LogisticRegression

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

#Using GridSearchCV
modelSet4 = GridSearchCV(SGDClassifier(loss='hinge',
penalty='l2',max_iter=1000,epsilon=0.1,class_weight='balanced'), parameters, scoring = 'roc_auc',
cv=3, return_train_score = True)
modelSet4.fit(Donor_tr_TFIDFW2V, Approved_train)

print(modelSet4.best_estimator_)
print(modelSet4.score(Donor_te_TFIDFW2V, Approved_test))
```

```
SGDClassifier(alpha=0.0001, average=False, class_weight='balanced',
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=1000,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l2',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
0.6613313353993562
Wall time: 3h 50min 43s
```

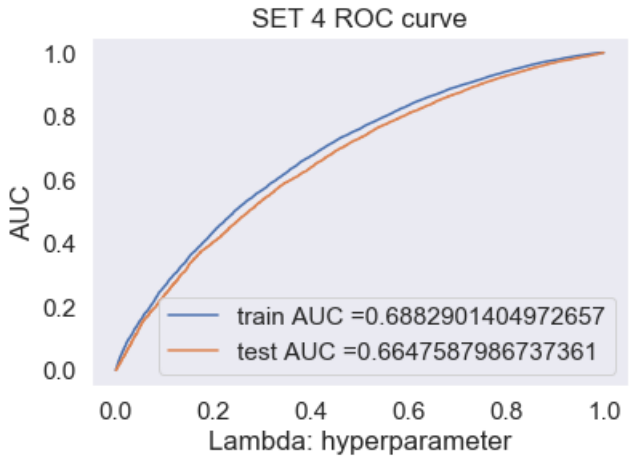
In [146]:

```
# Plotting AUC for Train and Test data of Set 4

hyperparams = [10**-4, 10**-2, 10**0, 10**2, 10**4]
set4_train_auc= modelSet4.cv_results_['mean_train_score']
set4_train_auc_std= modelSet4.cv_results_['std_train_score']
set4_test_auc = modelSet4.cv_results_['mean_test_score']
set4_test_auc_std= modelSet4.cv_results_['std_test_score']

plt.figure()
plt.title('SVM Set 4 AUC plot')
plt.xlabel('Hyperparameter')
plt.ylabel('AUC')
plt.semilogx(hyperparams, set4_train_auc, label='Train AUC',color='darkblue')
plt.gca().fill_between(hyperparams,set4_train_auc - set4_train_auc_std,set4_train_auc + set4_train_
auc_std,alpha=0.2,color='darkblue')
plt.semilogx(hyperparams, set4_test_auc,label='Test AUC', color='darkorange')
plt.gca().fill_between(hyperparams, set4_test_auc - set4_test_auc_std, set4_test_auc + set4_test_au
c_std,alpha=0.2,color='darkorange')
plt.legend(loc='best')
plt.show()
```



In [149]:

```
%%time
# Source: https://stackoverflow.com/questions/55893734/how-can-i-use-sgdclassifier-hinge-loss-with
-gridsearchcv-using-log-loss-metric
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier



set4Model = SGDClassifier(alpha=0.0001,loss='hinge', penalty='12',max_iter=500,epsilon=0.1);
calibrated_clf = CalibratedClassifierCV(base_estimator = set4Model, method='sigmoid', cv=3)
calibrated_clf.fit(Donor_tr_TFIDFW2V, Approved_train)

Approved_train_pred_set4 = calibrated_clf.predict_proba(Donor_tr_TFIDFW2V)
Approved_test_pred_set4 = calibrated_clf.predict_proba(Donor_te_TFIDFW2V)

train_fpr, train_tpr, tr_thresholds = roc_curve(Approved_train, Approved_train_pred_set4[:, 1])
test_fpr, test_tpr, te_thresholds = roc_curve(Approved_test, Approved_test_pred_set4[:, 1])

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("Lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("SET 4 ROC curve")
plt.grid()
plt.show()
```




```
Wall time: 2min 29s
```

In [151]:

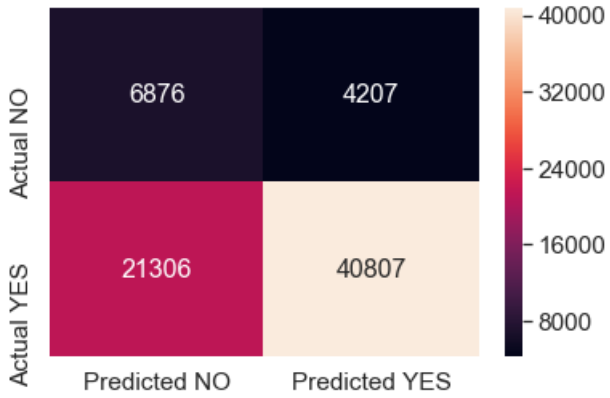
```
# Confustion Matrix for Set 5 Train vs Test data
```

```
# Confusion Matrix for Set 3 Train vs Test data

print("Train confusion matrix for Set 4")
donor_SET4_tr = pd.DataFrame(confusion_matrix(Approved_train,
predictcm(Approved_train_pred_set4[:, 1], tr_thresholds, train_fpr, train_tpr)))
donor_SET4_tr.columns = ['Predicted NO','Predicted YES']
donor_SET4_tr = donor_SET4_tr.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)
sns.heatmap(donor_SET4_tr, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Train confusion matrix for Set 4
the maximum value of tpr*(1-fpr) 0.4075967354943467 for threshold 0.841
```

Out[151]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25e893ee5c0>
```



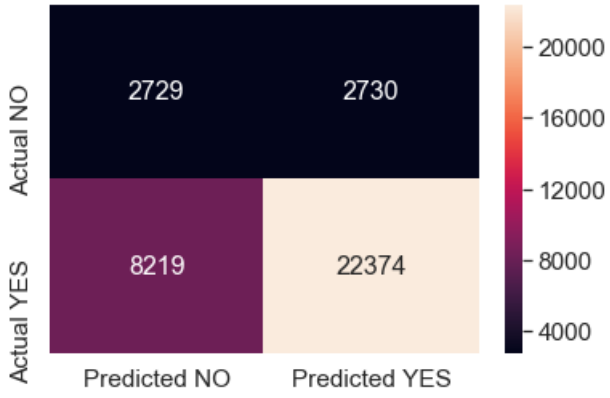
In [153]:

```
print("="*100)
print("Test confusion matrix for Set 4")
donor_SET4_te = pd.DataFrame(confusion_matrix(Approved_test, predictcm(Approved_test_pred_set4[:,
1], te_thresholds, test_fpr, test_fpr)))
donor_SET4_te.columns = ['Predicted NO','Predicted YES']
donor_SET4_te = donor_SET4_te.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)
sns.heatmap(donor_SET4_te, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================================

Test confusion matrix for Set 4
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.834
```

Out[153]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25e863da208>
```



2.5 Support Vector Machines with added Features `Set 5`

Apply TruncatedSVD on TfidfVectorizer of essay text, choose the number of components (`n_components`) using elbow method

In [206]:

```
%%time
# Source: https://scikit-
learn.org/stable/modules/generated/sklearn.cluster.MiniBatchKMeans.html#sklearn.cluster.MiniBatchKM

# Source: https://stackoverflow.com/questions/19197715/scikit-learn-k-means-elbow-criterion

from sklearn.cluster import MiniBatchKMeans
import matplotlib.pyplot as plt

print("Shape of Essay TFIDF matrix ",essays_text_tfidf.shape)
data = essays_text_tfidf
sse = {}
for k in range(50,350,50):
    miniBatchkmeans = MiniBatchKMeans(n_clusters = k,batch_size = 20000).fit(data)
    sse[k] = miniBatchkmeans.inertia_
    print(k)
    print(sse[k])
plt.figure()
plt.plot(list(sse.keys()), list(sse.values()))
plt.xlabel("Number of clusters")
plt.ylabel("SSE")
plt.show()
```

```
Shape of Essay TFIDF matrix  (109248, 16623)
50
94338.45040117028
100
92763.43884684847
150
91618.90858462009
200
91018.40152153981
250
90431.25701831798
300
90094.13061863677
```


```
Wall time: 32min 3s
```

In [222]:

```
from sklearn.decomposition import TruncatedSVD

svdtrain_essay_tfidf = TruncatedSVD (n_components=250)
svd_essay_train = svdtrain_essay_tfidf.fit(Donor_train_essay_tfidf.T)

print(svd_essay_train.components_)

svdtest_essay_tfidf = TruncatedSVD (n_components=250)
svd_essay_test = svdtest_essay_tfidf.fit(Donor_test_essay_tfidf.T)
```

```
print(svd_essay_test.components_)
```

```
[[ 0.00341515  0.00331115  0.00352285 ...  0.00351764  0.00390715
   0.00395686]
 [-0.00034887  0.00331923 -0.00688793 ... -0.00036942 -0.00248863
   0.00014328]
 [ 0.00024525 -0.00701779  0.00039249 ... -0.00080166  0.00348015
   0.00198212]
 ...
 [ 0.00517148 -0.00263573  0.00407351 ... -0.00110654  0.00098127
   0.00102416]
 [ 0.00153787  0.00134047  0.00199465 ...  0.00320746 -0.00294876
  -0.00091623]
 [ 0.0008264   0.00040265 -0.0020928  ... -0.00716216  0.00080634
   0.00497605]]
[[ 0.00547033  0.0061761   0.00536646 ...  0.00517112  0.0063348
   0.00508669]
 [-0.00406722  0.00357356 -0.00343514 ...  0.00957527 -0.00972323
  -0.00047301]
 [ 0.00391402 -0.00123034  0.00129478 ... -0.00040071  0.0027632
  -0.0038847 ]
 ...
 [-0.00826162 -0.00028921 -0.00273627 ... -0.00344581 -0.00852226
   0.0051339 ]
 [-0.00031209  0.00749791 -0.00385237 ... -0.00330768 -0.00614094
   0.01793414]
 [-0.00125316 -0.00122083 -0.00294296 ...  0.00368142 -0.0051009
   0.00718856]]
```

In [225]:

```
print(svd_essay_train.components_.T.shape)
print(svd_essay_test.components_.T.shape)
```

```
(73196, 250)
(36052, 250)
```

[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

In [226]:

```
from scipy.sparse import hstack
Donor_tr_set5 = hstack((svd_essay_train.components_.T,Donor_train_state_ohe,
Donor_train_teacher_ohe, Donor_train_grade_ohe,
Donor_train_clean_cat_ohe,Donor_train_clean_subcat_ohe,Donor_train_price_norm,Donor_train_postedCou
nt_norm,Donor_train_quantity_norm)).tocsr()
Donor_te_set5 = hstack((svd_essay_test.components_.T,Donor_test_state_ohe, Donor_test_teacher_ohe,
Donor_test_grade_ohe, Donor_test_clean_cat_ohe,Donor_test_clean_subcat_ohe,Donor_test_price_norm,D
onor_test_postedCount_norm,Donor_test_quantity_norm)).tocsr()

print("Final Donor Data Matrix for Set 5")
print(Donor_tr_set5.shape,Approved_train.shape)
print(Donor_te_set5.shape,Approved_test.shape)
print("="*100)
```

```
Final Donor Data Matrix for Set 5
(73196, 352) (73196,)
(36052, 352) (36052,)
====================================================================================================
```

In [227]:

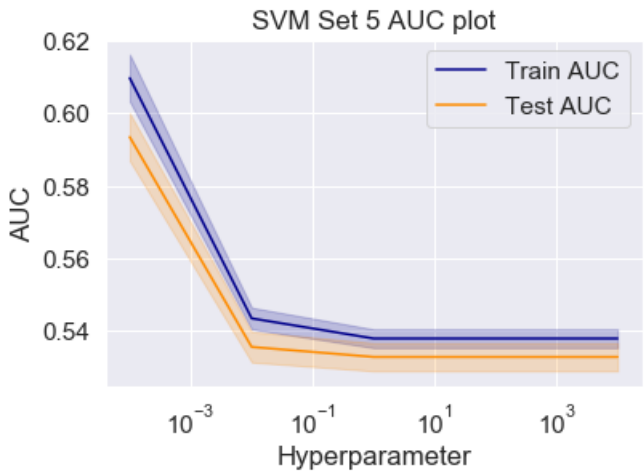
```
%%time
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import LogisticRegression
```

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

#Using GridSearchCV
modelSet5 = GridSearchCV(SGDClassifier(loss='hinge',
penalty='l2',max_iter=500,epsilon=0.1,class_weight='balanced'), parameters, scoring = 'roc_auc',
cv=3, return_train_score = True)
modelSet5.fit(Donor_tr_set5, Approved_train)

print(modelSet5.best_estimator_)
print(modelSet5.score(Donor_te_set5, Approved_test))
```

```
SGDClassifier(alpha=0.0001, average=False, class_weight='balanced',
       early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
       l1_ratio=0.15, learning_rate='optimal', loss='hinge', max_iter=500,
       n_iter=None, n_iter_no_change=5, n_jobs=None, penalty='l2',
       power_t=0.5, random_state=None, shuffle=True, tol=None,
       validation_fraction=0.1, verbose=0, warm_start=False)
0.5467251178836993
Wall time: 11min 13s
```

In [228]:

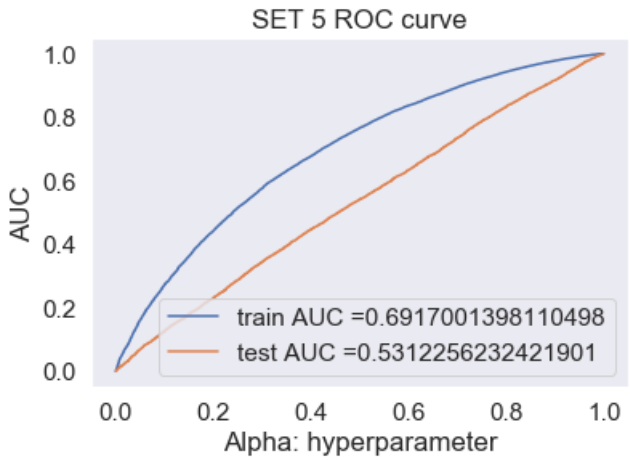
```
# Plotting AUC for Train and Test data of Set 4

hyperparams = [10**-4, 10**-2, 10**0, 10**2, 10**4]
set5_train_auc= modelSet5.cv_results_['mean_train_score']
set5_train_auc_std= modelSet5.cv_results_['std_train_score']
set5_test_auc = modelSet5.cv_results_['mean_test_score']
set5_test_auc_std= modelSet5.cv_results_['std_test_score']

plt.figure()
plt.title('SVM Set 5 AUC plot')
plt.xlabel('Hyperparameter')
plt.ylabel('AUC')
plt.semilogx(hyperparams, set5_train_auc, label='Train AUC',color='darkblue')
plt.gca().fill_between(hyperparams,set5_train_auc - set5_train_auc_std,set5_train_auc + set5_train_
auc_std,alpha=0.2,color='darkblue')
plt.semilogx(hyperparams, set5_test_auc,label='Test AUC', color='darkorange')
plt.gca().fill_between(hyperparams, set5_test_auc - set5_test_auc_std, set5_test_auc + set5_test_au
c_std,alpha=0.2,color='darkorange')
plt.legend(loc='best')
plt.show()
```



In [235]:

```
%%time
# Source: https://stackoverflow.com/questions/55893734/how-can-i-use-sgdclassifier-hinge-loss-with
-gridsearchcv-using-log-loss-metric
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import SGDClassifier
```

```
set5Model = SGDClassifier(alpha=0.0001,loss='hinge', penalty='12',max_iter=500,epsilon=0.1);
calibrated_clf5 = CalibratedClassifierCV(base_estimator = set5Model, method='sigmoid', cv=3)
calibrated_clf5.fit(Donor_tr_set5, Approved_train)

Approved_train_pred_set5 = calibrated_clf5.predict_proba(Donor_tr_set5)
Approved_test_pred_set5 = calibrated_clf5.predict_proba(Donor_te_set5)

train_fpr, train_tpr, tr_thresholds = roc_curve(Approved_train, Approved_train_pred_set5[:, 1])
test_fpr, test_tpr, te_thresholds = roc_curve(Approved_test, Approved_test_pred_set5[:, 1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("Alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("SET 5 ROC curve")
plt.grid()
plt.show()
```




```
Wall time: 1min 29s
```

In [234]:

```
# Confustion Matrix for Set 5 Train vs Test data

print("Train confusion matrix for Set 5")
donor_SET5_tr = pd.DataFrame(confusion_matrix(Approved_train,
predictcm(Approved_train_pred_set5[:, 1], tr_thresholds, train_fpr, train_tpr)))
donor_SET5_tr.columns = ['Predicted NO','Predicted YES']
donor_SET5_tr = donor_SET5_tr.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)
sns.heatmap(donor_SET5_tr, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Train confusion matrix for Set 5
the maximum value of tpr*(1-fpr) 0.41054578078836534 for threshold 0.844
```

Out[234]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25f1f882ba8>
```

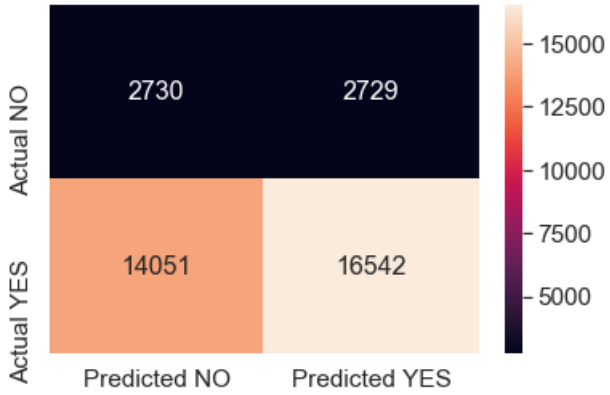
In [236]:

```
print("="*100)
print("Test confusion matrix for Set 5")
donor_SET5_te = pd.DataFrame(confusion_matrix(Approved_test, predictcm(Approved_test_pred_set5[:,
1], te_thresholds, test_fpr, test_fpr)))
donor_SET5_te.columns = ['Predicted NO','Predicted YES']
donor_SET5_te = donor_SET5_te.rename({0: 'Actual NO', 1: 'Actual YES'})
sns.set(font_scale=1.4)
sns.heatmap(donor_SET5_te, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================================

Test confusion matrix for Set 5
the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 0.854
```

Out[236]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25ea448dd30>
```



3. Conclusion

In [237]:

```
# Please compare all your models using Prettytable library

from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Penalty","Hyper Parameter", "Train AUC","Test AUC"]

x.add_row(["Set 1", "SGDClassifier with hinge loss: Linear SVM", "L1", 0.0001, 82.6, 69.4])
x.add_row(["Set 2", "SGDClassifier with hinge loss: Linear SVM", "L1", 0.0001, 82.1, 69.7])
x.add_row(["Set 3", "SGDClassifier with hinge loss: Linear SVM", "L1", 0.0001, 69.9, 67.6])
x.add_row(["Set 4", "SGDClassifier with hinge loss: Linear SVM", "L2", 0.0001, 68.8, 66.4])
x.add_row(["Set 5", "SGDClassifier with hinge loss: Linear SVM", "L2", 0.0001, 69.1, 53.1])

print(x)
```

```
+------------+---------------------------------------------+---------+-----------------+-----------+-
------+
| Vectorizer |                    Model                    | Penalty | Hyper Parameter | Train AUC |
est AUC |
+------------+---------------------------------------------+---------+-----------------+-----------+-
------+
|   Set 1    | SGDClassifier with hinge loss: Linear SVM |    L1   |      0.0001     |    82.6   |
69.4   |
|   Set 2    | SGDClassifier with hinge loss: Linear SVM |    L1   |      0.0001     |    82.1   |
69.7   |
|   Set 3    | SGDClassifier with hinge loss: Linear SVM |    L1   |      0.0001     |    69.9   |
67.6   |
|   Set 4    | SGDClassifier with hinge loss: Linear SVM |    L2   |      0.0001     |    68.8   |
```

```
66.4   |
|   Set 5    | SGDClassifier with hinge loss: Linear SVM |    L2   |      0.0001     |    69.1   |
53.1   |
+------------+-------------------------------------------+---------+-----------------+-----------+-
------+
```