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 [2]:

```
%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
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 [3]:

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

In [4]:

```
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 [5]:

```
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[5]:

	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 [6]:

```
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 [7]:

```
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 preprocessing of `project_grade_category`

In [8]:

```
grades = list(project_data['project_grade_category'].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
grade_list = []
for i in grades:
    if 'Grades' in i.split(): # this will split each of the catogory based on space "Math & Science
"=> "Math","&", "Science"
            i=i.replace('Grades','') # if we have the words "The" we are going to replace it with '
'(i.e removing 'The')
            i = i.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Sc
ience"=>"Math&Science"
    grade_list.append(i.strip())

project_data['project_grade_category'] = grade_list

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

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

1.3 Text preprocessing

In [9]:

```
# 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 [10]:

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

Out[10]:

	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	Pr
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	

In [11]:

```
# 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
==================================================
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 [12]:

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

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

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

In [13]:

```python
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 [14]:

```
# \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 [15]:

```
#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
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 [16]:

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

In [17]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[02:07<00:00, 860.06it/s]
```

In [18]:

```
project_data['essay'] = preprocessed_essays
```

1.4 Preprocessing of `project_title`

In [19]:

```
# similarly you can preprocess the titles also

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

```
100%|████████████████████████████████████████████████████████████████████████| 109248/109248
[00:06<00:00, 17264.25it/s]
```

In [20]:

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

Removing unnecessary columns

In [21]:

```
#Removing unnecessary columns
# drop columns fron pandas dataframe https://stackoverflow.com/questions/13411544/delete-column-fr
om-pandas-dataframe

project_data.drop(['project_essay_1','project_essay_2', 'project_essay_3', 'project_essay_4'], axi
s=1, inplace=True)
```

Handling missing values

In [22]:

```
#https://stackoverflow.com/questions/29530232/how-to-check-if-any-value-is-nan-in-a-pandas-datafra
me

project_data[project_data['teacher_prefix'].isnull()]
#Handle null values in pandas https://www.geeksforgeeks.org/python-pandas-dataframe-fillna-to-repl
ace-null-values-in-dataframe/

project_data['teacher_prefix'].fillna( method ='ffill', inplace = True)
```

Counting the words in Essay

In [23]:

```
essay_word_count = []
for ess in project_data["essay"] :
    c = len(ess.split())
    essay_word_count.append(c)
project_data['essay_word_count'] = essay_word_count
```

Counting the words in Title

In [24]:

```
title_word_count = []
for tit in project_data["project_title"] :
    c = len(tit.split())
    title_word_count.append(c)
project_data['title_word_count'] = title_word_count
```

Computing Sentiment Scores

In [25]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
sid = SentimentIntensityAnalyzer()
sentiment_scores_essays = []
for sentance in tqdm(project_data['essay'].values):
    ss = sid.polarity_scores(sentance)
    sentiment_scores_essays.append(ss)
scores = pd.DataFrame(sentiment_scores_essays)
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[07:04<00:00, 257.12it/s]
```

In [26]:

```
project_data["pos"] = scores["pos"]
project_data["neg"] = scores["neg"]
project_data["neu"] = scores["neu"]
project_data["compound"] = scores["compound"]
```

1.5 Preparing data for models

In [27]:

```
project_data.columns
```

Out[27]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'essay_word_count',
       'title_word_count', 'pos', 'neg', 'neu', 'compound'],
       'title_word_count', 'pos', 'neg', 'neu', 'compound'],
      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
```

In [28]:

```
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')
project_data.columns
```

Out[28]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'essay_word_count',
       'title_word_count', 'pos', 'neg', 'neu', 'compound', 'price',
       'quantity'],
      dtype='object')
```

In [29]:

```
# move columns in pandas dataframe https://stackoverflow.com/questions/35321812/move-column-in-pan
das-dataframe/35321983
project_data = project_data[[c for c in project_data if c not in ['project_is_approved']]
       + ['project_is_approved']]
project_data.columns
```

Out[29]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'clean_categories',
       'clean_subcategories', 'essay', 'essay_word_count', 'title_word_count',
       'pos', 'neg', 'neu', 'compound', 'price', 'quantity',
       'project_is_approved'],
      dtype='object')
```

Assignment 5: Logistic Regression

1. **[Task-1] Logistic Regression(either SGDClassifier with log loss, or LogisticRegression) on these feature sets**
    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (`BOW with bi-grams` with `min_df=10` and `max_features=5000`)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (`TFIDF with bi-grams` with `min_df=10` and `max_features=5000`)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)

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

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

- Find the best hyper parameter which will give the maximum AUC 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 Logistic Regression on the below feature set Set 5 by finding the best hyper parameter as suggested in step 2 and step 3.**
5. Consider these set of features Set 5 :

- **school_state** : categorical data
- **clean_categories** : categorical data
- **clean_subcategories** : categorical data
- **project_grade_category** :categorical data
- **teacher_prefix** : categorical data
- **quantity** : numerical data
- **teacher_number_of_previously_posted_projects** : numerical data
- **price** : numerical data
- **sentiment score's of each of the essay** : numerical data
- **number of words in the title** : numerical data
- **number of words in the combine essays** : numerical data

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

6. **Conclusion**

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

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. Logistic Regression

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

In [30]:

```
# 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

#importing necessary modules

from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from collections import Counter
from sklearn.metrics import accuracy_score

# Splitting the data into X , Y labels

# create design matrix X and target vector y
X = np.array(project_data.iloc[:, :-1]) # end index is exclusive
y = np.array(project_data['project_is_approved']) # showing you two ways of indexing a pandas df
# split the data set into train and test
X_1, X_test, y_1, y_test = train_test_split(X, y, test_size=0.3, random_state=0, stratify = y)

# split the train data set into cross validation train and cross validation test
X_tr, X_cv, y_tr, y_cv = train_test_split(X_1, y_1, test_size=0.3, stratify = y_1)
```

In [31]:

```
print(len(X_tr))
print(len(X_cv))
print(len(X_test))
```

```
53531
22942
32775
```

In [32]:

```
X_tr = pd.DataFrame(data=X_tr[0:,0:], columns=project_data.columns[0:-1])
X_cv = pd.DataFrame(data=X_cv[0:,0:], columns=project_data.columns[0:-1])
X_test = pd.DataFrame(data=X_test[0:,0:], columns=project_data.columns[0:-1])
```

2.2 Make Data Model Ready: encoding numerical, categorical features

One Hot Encoding for Categorial features

In [33]:

```
# 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 neededtHuWDX6yizwIhai
    # c. X-axis label
    # d. Y-axis label
print("="*25+"encoding categorical features"+"="*25)
#Vectorizing categorical data :
# 1 Clean_Categories

# 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
)
vectorizer.fit(X_tr['clean_categories'].values)

categories_one_hot_train = vectorizer.transform(X_tr['clean_categories'].values)
categories_one_hot_test = vectorizer.transform(X_test['clean_categories'].values)
categories_one_hot_cv = vectorizer.transform(X_cv['clean_categories'].values)

print(vectorizer.get_feature_names())
print("Shape of train matrix after one hot encodig ",categories_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",categories_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",categories_one_hot_cv.shape)
print("="*100)
print("="*100)
```

```
=========================encoding categorical features=========================
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of train matrix after one hot encodig  (53531, 9)
Shape of test matrix after one hot encodig  (32775, 9)
Shape of cv matrix after one hot encodig  (22942, 9)
====================================================================================================
```

In [34]:

```
# 2 clean_subcategories

vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=
True)
vectorizer.fit(X_tr['clean_subcategories'].values)
print(vectorizer.get_feature_names())

sub_categories_one_hot_train = vectorizer.transform(X_tr['clean_subcategories'].values)
sub_categories_one_hot_test = vectorizer.transform(X_test['clean_subcategories'].values)
sub_categories_one_hot_cv = vectorizer.transform(X_cv['clean_subcategories'].values)

print("Shape of train matrix after one hot encodig ",sub_categories_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",sub_categories_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",sub_categories_one_hot_cv.shape)
print("="*100)
```

```
['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 train matrix after one hot encodig  (53531, 30)
Shape of test matrix after one hot encodig  (32775, 30)
Shape of cv matrix after one hot encodig  (22942, 30)
====================================================================================================
```

In [35]:

```
my_counter = Counter()
for state in project_data['school_state'].values:
    my_counter.update(state.split())
school_state_cat_dict = dict(my_counter)
sorted_school_state_cat_dict = dict(sorted(school_state_cat_dict.items(), key=lambda kv: kv[1]))
```

In [36]:

```
# 3 school_state

vectorizer = CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys()),lowercase=False,
binary=True)
vectorizer.fit(X_tr['school_state'].values)
print(vectorizer.get_feature_names())
school_state_one_hot_train = vectorizer.transform(X_tr['school_state'].values)
school_state_one_hot_test = vectorizer.transform(X_test['school_state'].values)
school_state_one_hot_cv = vectorizer.transform(X_cv['school_state'].values)

print("Shape of train matrix after one hot encodig ",school_state_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",school_state_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",school_state_one_hot_cv.shape)
print("="*100)
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME', 'HI', 'DC', 'NM', 'KS', 'I
A', 'ID', 'AR', 'CO', 'MN', 'OR', 'KY', 'MS', 'NV', 'MD', 'CT', 'TN', 'UT', 'AL', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'WA', 'MA', 'LA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'NY', 'TX
', 'CA']
Shape of train matrix after one hot encodig  (53531, 51)
Shape of test matrix after one hot encodig  (32775, 51)
Shape of test matrix after one hot encodig  (32775, 51)
Shape of cv matrix after one hot encodig  (22942, 51)
====================================================================================================
```

In [37]:

```
my_counter = Counter()
for teacher in project_data['teacher_prefix'].values:
    my_counter.update(teacher.split())
teacher_prefix_cat_dict = dict(my_counter)
sorted_teacher_prefix_cat_dict = dict(sorted(teacher_prefix_cat_dict.items(), key=lambda kv: kv[1])
)
```

In [38]:

```
# 4 teacher_prefix

#one hot encoding for teacher_prefix feature

vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()),lowercase=Fals
e, binary=True)
vectorizer.fit(X_tr['teacher_prefix'].values)
print(vectorizer.get_feature_names())
teacher_prefix_one_hot_train = vectorizer.transform(X_tr['teacher_prefix'].values)
teacher_prefix_one_hot_test = vectorizer.transform(X_test['teacher_prefix'].values)
teacher_prefix_one_hot_cv = vectorizer.transform(X_cv['teacher_prefix'].values)

print("Shape of train matrix after one hot encodig ",teacher_prefix_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",teacher_prefix_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",teacher_prefix_one_hot_cv.shape)
print("="*100)
```

```
['Dr.', 'Teacher', 'Mr.', 'Ms.', 'Mrs.']
Shape of train matrix after one hot encodig  (53531, 5)
Shape of test matrix after one hot encodig  (32775, 5)
Shape of cv matrix after one hot encodig  (22942, 5)
====================================================================================================
```

In [39]:

```
print(teacher_prefix_one_hot_train.toarray()[0:5,:])
```

```
[[0 0 0 0 0]
 [0 0 0 0 0]
 [0 0 0 0 0]
 [0 0 0 0 0]
 [0 0 0 0 0]]
```

In [40]:

```
# 5 project_grade_category

vectorizer = CountVectorizer(vocabulary=list(sorted_grade_dict.keys()),lowercase=False, binary=Tru
e)
vectorizer.fit(X_tr['project_grade_category'].values)
print(vectorizer.get_feature_names())
project_grade_one_hot_train = vectorizer.transform(X_tr['project_grade_category'].values)
project_grade_one_hot_test = vectorizer.transform(X_test['project_grade_category'].values)
project_grade_one_hot_cv = vectorizer.transform(X_cv['project_grade_category'].values)

print("Shape of train matrix after one hot encodig ",project_grade_one_hot_train.shape)
print("Shape of test matrix after one hot encodig ",project_grade_one_hot_test.shape)
print("Shape of cv matrix after one hot encodig ",project_grade_one_hot_cv.shape)
print("="*100)
```

```
['9-12', '6-8', '3-5', 'PreK-2']
Shape of train matrix after one hot encodig  (53531, 4)
Shape of test matrix after one hot encodig  (32775, 4)
Shape of cv matrix after one hot encodig  (22942, 4)
====================================================================================================
====================================================================================================
```

Encoding numerical features

In [41]:

```python
print("_"*25+"encoding numerical features"+"_"*25)
# 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)

#1 price
price_scalar = StandardScaler()
price_scalar.fit(X_tr['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_train = price_scalar.transform(X_tr['price'].values.reshape(-1, 1))
price_standardized_test = price_scalar.transform(X_test['price'].values.reshape(-1, 1))
price_standardized_cv = price_scalar.transform(X_cv['price'].values.reshape(-1, 1))


print("Shape of train matrix ",price_standardized_train.shape)
print("Shape of test matrix ",price_standardized_test.shape)
print("Shape of cv matrix ",price_standardized_cv.shape)
print("="*100)
```

```
_________________________encoding numerical features_________________________
Mean : 298.3808426892829, Standard deviation : 356.6414506792702
Shape of train matrix  (53531, 1)
Shape of test matrix  (32775, 1)
Shape of cv matrix  (22942, 1)
====================================================================================================
```

In [42]:

```python
previous_project_scalar = StandardScaler()
previous_project_scalar.fit(X_tr['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {previous_project_scalar.mean_[0]}, Standard deviation : {np.sqrt(previous_project_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
previous_project_standardized_train = previous_project_scalar.transform(X_tr['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
previous_project_standardized_test = previous_project_scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
previous_project_standardized_cv = previous_project_scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))

print("Shape of train matrix  ",previous_project_standardized_train.shape)
print("Shape of test matrix  ",previous_project_standardized_test.shape)
print("Shape of cv matrix  ",previous_project_standardized_cv.shape)
```

```
Mean : 11.163475369412117, Standard deviation : 27.66427020504765
Shape of train matrix   (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix   (22942, 1)
```

In [43]:

```
essay_word_scalar = StandardScaler()
essay_word_scalar.fit(X_tr['essay_word_count'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {essay_word_scalar.mean_[0]}, Standard deviation : {np.sqrt(essay_word_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
essay_word_standardized_train = essay_word_scalar.transform(X_tr['essay_word_count'].values.reshape(-1, 1))
essay_word_standardized_test = essay_word_scalar.transform(X_test['essay_word_count'].values.reshape(-1, 1))
essay_word_standardized_cv = essay_word_scalar.transform(X_cv['essay_word_count'].values.reshape(-1, 1))

print("Shape of train matrix ",essay_word_standardized_train.shape)
print("Shape of test matrix  ",essay_word_standardized_test.shape)
print("Shape of cv matrix ",essay_word_standardized_cv.shape)
```

```
Mean : 151.49750611795034, Standard deviation : 39.04735941446581
Shape of train matrix  (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix  (22942, 1)
```

In [44]:

```
title_word_scalar = StandardScaler()
title_word_scalar.fit(X_tr['title_word_count'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {title_word_scalar.mean_[0]}, Standard deviation : {np.sqrt(title_word_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
title_word_standardized_train = title_word_scalar.transform(X_tr['title_word_count'].values.reshape(-1, 1))
title_word_standardized_test = title_word_scalar.transform(X_test['title_word_count'].values.reshape(-1, 1))
title_word_standardized_cv = title_word_scalar.transform(X_cv['title_word_count'].values.reshape(-1, 1))

print("Shape of train matrix ",title_word_standardized_train.shape)
print("Shape of test matrix  ",title_word_standardized_test.shape)
print("Shape of cv matrix ",title_word_standardized_cv.shape)
```

```
Mean : 4.33223739515421, Standard deviation : 1.7836826898412486
Shape of train matrix  (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix  (22942, 1)
```

In [45]:

```
pos_scalar = StandardScaler()
pos_scalar.fit(X_tr['pos'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {pos_scalar.mean_[0]}, Standard deviation : {np.sqrt(pos_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
pos_standardized_train = pos_scalar.transform(X_tr['pos'].values.reshape(-1, 1))
pos_standardized_test = pos_scalar.transform(X_test['pos'].values.reshape(-1, 1))
pos_standardized_cv = pos_scalar.transform(X_cv['pos'].values.reshape(-1, 1))

print("Shape of train matrix ",pos_standardized_train.shape)
print("Shape of test matrix  ",pos_standardized_test.shape)
print("Shape of cv matrix ",pos_standardized_cv.shape)
```

```
Mean : 0.26637099998131925, Standard deviation : 0.07377281603799392
Shape of train matrix  (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix  (22942, 1)
```

In [46]:

```
neu_scalar = StandardScaler()
neu_scalar.fit(X_tr['pos'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {neu_scalar.mean_[0]}, Standard deviation : {np.sqrt(neu_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
neu_standardized_train = neu_scalar.transform(X_tr['neu'].values.reshape(-1, 1))
neu_standardized_test = neu_scalar.transform(X_test['neu'].values.reshape(-1, 1))
neu_standardized_cv = neu_scalar.transform(X_cv['neu'].values.reshape(-1, 1))

print("Shape of train matrix ",neu_standardized_train.shape)
print("Shape of test matrix  ",neu_standardized_test.shape)
print("Shape of cv matrix ",neu_standardized_cv.shape)
```

```
Mean : 0.26637099998131925, Standard deviation : 0.07377281603799392
Shape of train matrix  (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix  (22942, 1)
```

In [47]:

```
neg_scalar = StandardScaler()
neg_scalar.fit(X_tr['pos'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {neg_scalar.mean_[0]}, Standard deviation : {np.sqrt(neg_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
neg_standardized_train = neg_scalar.transform(X_tr['neg'].values.reshape(-1, 1))
neg_standardized_test = neg_scalar.transform(X_test['neg'].values.reshape(-1, 1))
neg_standardized_cv = neg_scalar.transform(X_cv['neg'].values.reshape(-1, 1))

print("Shape of train matrix ",neg_standardized_train.shape)
print("Shape of test matrix  ",neg_standardized_test.shape)
print("Shape of cv matrix ",neg_standardized_cv.shape)
```

```
Mean : 0.26637099998131925, Standard deviation : 0.07377281603799392
Shape of train matrix  (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix  (22942, 1)
```

In [48]:

```
compound_scalar = StandardScaler()
compound_scalar.fit(X_tr['pos'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {compound_scalar.mean_[0]}, Standard deviation : {np.sqrt(compound_scalar.var_[0])}")

# Now standardize the data with above maen and variance.
compound_standardized_train = compound_scalar.transform(X_tr['compound'].values.reshape(-1, 1))
compound_standardized_test = compound_scalar.transform(X_test['compound'].values.reshape(-1, 1))
compound_standardized_cv = compound_scalar.transform(X_cv['compound'].values.reshape(-1, 1))

print("Shape of train matrix ",compound_standardized_train.shape)
print("Shape of test matrix  ",compound_standardized_test.shape)
print("Shape of cv matrix ",compound_standardized_cv.shape)
```

```
Mean : 0.26637099998131925, Standard deviation : 0.07377281603799392
Shape of train matrix  (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix  (22942, 1)
```

In [49]:

```
quantity_scalar = StandardScaler()
quantity_scalar.fit(X_tr['quantity'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation : {np.sqrt(quantity_scalar.var_[0])}")
```

```
# Now standardize the data with above maen and variance.
quantity_standardized_train = quantity_scalar.transform(X_tr['quantity'].values.reshape(-1, 1))
quantity_standardized_test = quantity_scalar.transform(X_test['quantity'].values.reshape(-1, 1))
quantity_standardized_cv = quantity_scalar.transform(X_cv['quantity'].values.reshape(-1, 1))

print("Shape of train matrix ",quantity_standardized_train.shape)
print("Shape of test matrix  ",quantity_standardized_test.shape)
print("Shape of cv matrix ",quantity_standardized_cv.shape)
```

```
Mean : 17.097214698025443, Standard deviation : 26.93954470387181
Shape of train matrix  (53531, 1)
Shape of test matrix   (32775, 1)
Shape of cv matrix  (22942, 1)
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [50]:

```
# 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

# 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
print("_"*25+"Essay BOW"+"_"*25)
vectorizer = CountVectorizer(min_df=10, ngram_range=(1, 2), max_features=5000)
vectorizer.fit(X_tr['essay'])
essay_bow_train = vectorizer.transform(X_tr['essay'])
essay_bow_test = vectorizer.transform(X_test['essay'])
essay_bow_cv = vectorizer.transform(X_cv['essay'])
print("Shape of train matrix after one hot encodig ",essay_bow_train.shape)
print("Shape of test matrix after one hot encodig ",essay_bow_test.shape)
print("Shape of cv matrix after one hot encodig ",essay_bow_cv.shape)
print("="*100)
print("_"*25+"Project_Title BOW"+"_"*25)
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(X_tr['project_title'])
title_bow_train = vectorizer.transform(X_tr['project_title'])
title_bow_test = vectorizer.transform(X_test['project_title'])
title_bow_cv = vectorizer.transform(X_cv['project_title'])
print("Shape of train matrix after one hot encodig ",title_bow_train.shape)
print("Shape of test matrix after one hot encodig ",title_bow_test.shape)
print("Shape of cv matrix after one hot encodig ",title_bow_cv.shape)
```

```
_________________________Essay BOW_________________________
Shape of train matrix after one hot encodig  (53531, 5000)
Shape of test matrix after one hot encodig  (32775, 5000)
Shape of cv matrix after one hot encodig  (22942, 5000)
====================================================================================================
_________________________Project_Title BOW_________________________
Shape of train matrix after one hot encodig  (53531, 2191)
Shape of test matrix after one hot encodig  (32775, 2191)
Shape of cv matrix after one hot encodig  (22942, 2191)
```

In [51]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
print("_"*25+"Essay TFIDF"+"_"*25)
vectorizer = TfidfVectorizer(min_df=10, ngram_range=(1, 2), max_features=5000)
vectorizer.fit(X_tr['essay'])
essay_tfidf_train = vectorizer.transform(X_tr['essay'])
essay_tfidf_test = vectorizer.transform(X_test['essay'])
essay_tfidf_cv = vectorizer.transform(X_cv['essay'])
print("Shape of train matrix after one hot encodig ",essay_tfidf_train.shape)
print("Shape of test matrix after one hot encodig ",essay_tfidf_test.shape)
print("Shape of cv matrix after one hot encodig ",essay_tfidf_cv.shape)
print("="*100)
print("_"*25+"Project_Title TFIDF"+"_"*25)
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit_transform(X_tr['project_title'])
title_tfidf_train = vectorizer.transform(X_tr['project_title'])
title_tfidf_test = vectorizer.transform(X_test['project_title'])
title_tfidf_cv = vectorizer.transform(X_cv['project_title'])
print("Shape of train matrix after one hot encodig ",title_tfidf_train.shape)
print("Shape of test matrix after one hot encodig ",title_tfidf_test.shape)
print("Shape of cv matrix after one hot encodig ",title_tfidf_cv.shape)
```

```
_________________________Essay TFIDF_________________________
Shape of train matrix after one hot encodig  (53531, 5000)
Shape of test matrix after one hot encodig  (32775, 5000)
Shape of cv matrix after one hot encodig  (22942, 5000)
====================================================================================================
_________________________Project_Title TFIDF_________________________
Shape of train matrix after one hot encodig  (53531, 2191)
Shape of test matrix after one hot encodig  (32775, 2191)
Shape of cv matrix after one hot encodig  (22942, 2191)
```

In [52]:

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

In [53]:

```
words = []
for i in X_tr['essay']:
    words.extend(i.split(' '))

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

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

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


# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/

#import pickle
#with open('./My Drive/glove_vectors', 'wb') as f:
   # pickle.dump(words_courpus, f)
```

```
all the words in the coupus 8341722
the unique words in the coupus 44489
The number of words that are present in both glove vectors and our coupus 28991 ( 65.164 %)
word 2 vec length 28991
```

Encoding Essay column using AVG WORD2VEC

In [54]:

```
# Similarly you can vectorize for title also
print("_"*25+"Essay AVG_W2V"+"_"*25)
essay_avg_w2v_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_tr['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
    essay_avg_w2v_train.append(vector)

print(len(essay_avg_w2v_train))
print(len(essay_avg_w2v_train[0]))
```

```
_________________________Essay AVG_W2V_________________________
```

```
100%|██████████████████████████████████████████████████████| 53531/53531
[00:36<00:00, 1448.29it/s]
```

```
53531
300
```

In [55]:

```
# Similarly you can vectorize for title also
print("_"*25+"Essay AVG_W2V"+"_"*25)
essay_avg_w2v_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_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
    essay_avg_w2v_test.append(vector)

print(len(essay_avg_w2v_test))
print(len(essay_avg_w2v_test[0]))
```

```
_________________________Essay AVG_W2V_________________________
```

```
100%|██████████████████████████████████████████████████████| 32775/32775
[00:20<00:00, 1566.65it/s]
```

```
32775
300
```

In [56]:

```
# Similarly you can vectorize for title also
print("_"*25+"Essay AVG_W2V"+"_"*25)
essay_avg_w2v_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['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
    essay_avg_w2v_cv.append(vector)

print(len(essay_avg_w2v_cv))
print(len(essay_avg_w2v_cv[0]))
```

```
_________________________Essay AVG_W2V_________________________
```

```
100%|██████████████████████████████████████████████████████████████████████████| 22942/22942
[00:15<00:00, 1470.99it/s]
```

```
22942
300
```

Encoding Project_title column using AVG WORD2VEC

In [57]:

```
print("_"*25+"Title AVG_W2V"+"_"*25)
title_avg_w2v_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_tr['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
    title_avg_w2v_train.append(vector)

print(len(title_avg_w2v_train))
print(len(title_avg_w2v_train[0]))
```

```
_________________________Title AVG_W2V_________________________
```

```
100%|█████████████████████████████████████████████████████████████████████████| 53531/53531
[00:02<00:00, 23727.55it/s]
```

```
53531
300
```

In [58]:

```
print("_"*25+"Title AVG_W2V"+"_"*25)
title_avg_w2v_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_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
    title_avg_w2v_test.append(vector)

print(len(title_avg_w2v_test))
print(len(title_avg_w2v_test[0]))
```

```
_________________________Title AVG_W2V_________________________
```

```
100%|████████████████████████████████████████████████████████████| 32775/32775
[00:01<00:00, 28850.67it/s]
```

```
32775
300
```

In [59]:

```python
print("_"*25+"Title AVG_W2V"+"_"*25)
title_avg_w2v_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['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
    title_avg_w2v_cv.append(vector)

print(len(title_avg_w2v_cv))
print(len(title_avg_w2v_cv[0]))
```

```
_________________________Title AVG_W2V_________________________
```

```
100%|████████████████████████████████████████████████████████████| 22942/22942
[00:00<00:00, 26309.33it/s]
```

```
22942
300
```

Encoding Essay column using TFIDF WORD2VEC

In [60]:

```python
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_tr['essay'])
# 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())
essay_tfidf_w2v_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_tr['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
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    essay_tfidf_w2v_train.append(vector)

print(len(essay_tfidf_w2v_train))
print(len(essay_tfidf_w2v_train[0]))
```

```
100%|██████████████████████████████████████████████████████████████| 53531/53531 [04:
18<00:00, 207.25it/s]
```

```
53531
300
```

In [61]:

```
essay_tfidf_w2v_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_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
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    essay_tfidf_w2v_test.append(vector)

print(len(essay_tfidf_w2v_test))
print(len(essay_tfidf_w2v_test[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 32775/32775 [02:
39<00:00, 205.62it/s]
```

```
32775
300
```

In [62]:

```
essay_tfidf_w2v_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['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
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    essay_tfidf_w2v_cv.append(vector)

print(len(essay_tfidf_w2v_cv))
print(len(essay_tfidf_w2v_cv[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 22942/22942 [01:
52<00:00, 204.65it/s]
```

```
22942
300
```

Encoding Project_title column using TFIDF WORD2VEC

In [63]:

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_tr['project_title'])
# 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())
title_tfidf_w2v_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_tr['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
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    title_tfidf_w2v_train.append(vector)

print(len(title_tfidf_w2v_train))
print(len(title_tfidf_w2v_train[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████| 53531/53531
[00:04<00:00, 11749.58it/s]
```

```
53531
300
```

In [64]:

```
title_tfidf_w2v_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_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
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    title_tfidf_w2v_test.append(vector)

print(len(title_tfidf_w2v_test))
print(len(title_tfidf_w2v_test[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████| 32775/32775
[00:02<00:00, 12014.31it/s]
```

```
32775
300
```

In [65]:

```
title_tfidf_w2v_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['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
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    title_tfidf_w2v_cv.append(vector)

print(len(title_tfidf_w2v_cv))
print(len(title_tfidf_w2v_cv[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████| 22942/22942
[00:01<00:00, 11540.25it/s]
```

```
22942
300
```

2.4 Appling Logistic Regression on different kind of featurization as mentioned in the instructions

Apply Logistic Regression 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

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

In [66]:

```
# Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)

from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_tr = hstack((school_state_one_hot_train,categories_one_hot_train, sub_categories_one_hot_train,
teacher_prefix_one_hot_train, project_grade_one_hot_train,essay_bow_train,title_bow_train,
price_standardized_train,previous_project_standardized_train))
X_cv = hstack((school_state_one_hot_cv,categories_one_hot_cv, sub_categories_one_hot_cv,
teacher_prefix_one_hot_cv, project_grade_one_hot_cv,essay_bow_cv,title_bow_cv,
price_standardized_cv,previous_project_standardized_cv))
X_test = hstack((school_state_one_hot_test,categories_one_hot_test, sub_categories_one_hot_test, t
eacher_prefix_one_hot_test, project_grade_one_hot_test,essay_bow_test,title_bow_test,
price_standardized_test,previous_project_standardized_test))
X_tr = X_tr.tocsr()
X_cv = X_cv.tocsr()
X_test = X_test.tocsr()
```

In [67]:

```
print(X_tr.shape , y_tr.shape)
print(X_cv.shape , y_cv.shape)
print(X_test.shape , y_test.shape)
```

```
(53531, 7292) (53531,)
(22942, 7292) (22942,)
(32775, 7292) (32775,)
```

In [68]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

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

    return y_data_pred
```

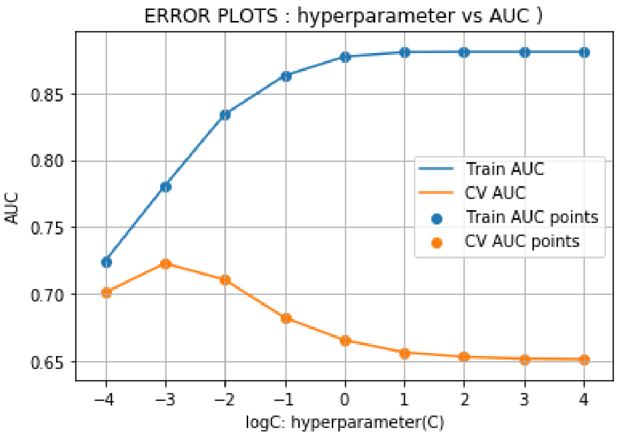
In [70]:

```
import math

C = [0.0001, 0.001, 0.01, 0.1, 1.0, 10,100, 1000, 10000]
logC = list(map(lambda x : math.log10(x), C))
```

In [71]:

```
from sklearn.linear_model import LogisticRegression
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []

for i in tqdm(C):
    neigh = LogisticRegression(C=i, class_weight='balanced', n_jobs=-1)
    neigh.fit(X_tr, y_tr)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_tr,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.plot(logC, train_auc, label='Train AUC')
plt.plot(logC, cv_auc, label='CV AUC')

plt.scatter(logC, train_auc, label='Train AUC points')
plt.scatter(logC, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("logC: hyperparameter(C)")
plt.ylabel("AUC")
plt.title("ERROR PLOTS : hyperparameter vs AUC )")
plt.grid()
plt.show()
```

```
100%|████████████████████████████████████████████████████████████| 9/9 [20:
08<00:00, 259.51s/it]
```



In the above case the hyperparameter is choosen to be C=0.001 because at C=0.001 the cv_auc is maximum and the distance between train_auc and cv_auc is less. If the C is further increased it may lead to underfit state.

In [72]:

```
for i in range(len(train_auc)):
    print(C[i])
    print(logC[i])
    print(train_auc[i]-cv_auc[i])
```

```
0.0001
-4.0
0.023531057288868173
0.001
-3.0
0.05797739464873808
0.01
-2.0
```

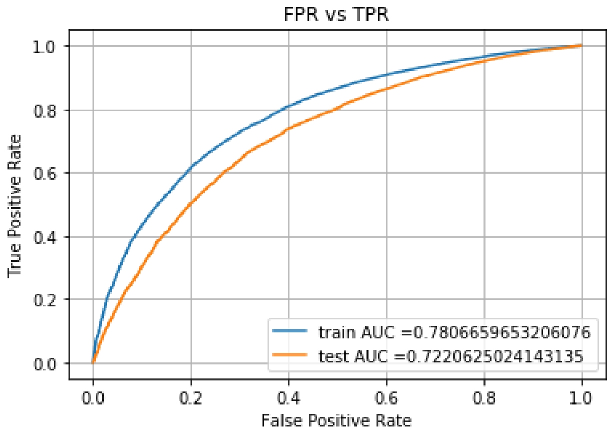
```
-2.0
0.1234327451144197
0.1
-1.0
0.1805360255823727
1.0
0.0
0.21153159370295826
10
1.0
0.2240168523472157
100
2.0
0.22762741379975182
1000
3.0
0.22891912232454825
10000
4.0
0.22940284504932607
```

In [73]:

```
best_c1 = 0.001
```

In [74]:

```
from sklearn.metrics import roc_curve, auc


neigh = LogisticRegression(C=best_c1, class_weight='balanced', n_jobs=-1)
neigh.fit(X_tr, y_tr)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_test)

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

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



In [75]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    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))
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

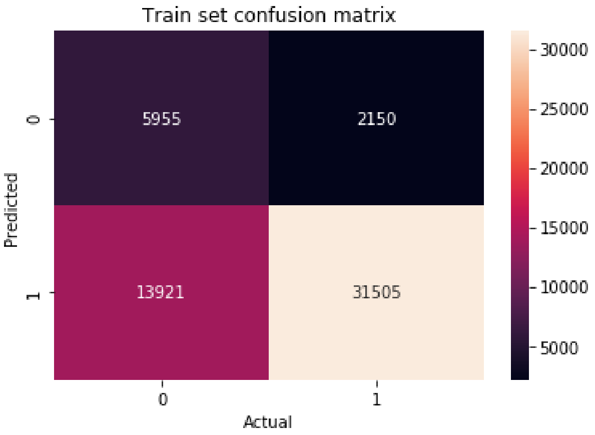
In [76]:

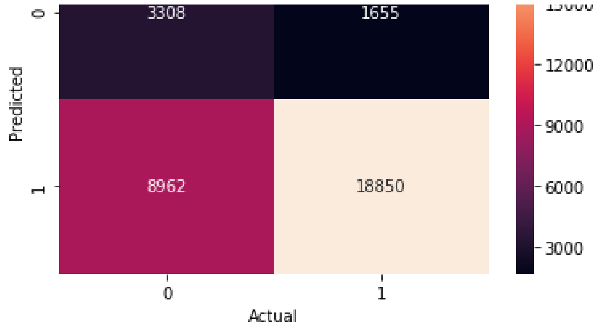
```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t1 = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_tr, predict_with_best_t(y_train_pred, best_t1)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t1)))
```

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

the maximum value of tpr*(1-fpr) 0.5095698618164657 for threshold 0.506
Train confusion matrix
[[ 5955  2150]
 [13921 31505]]
Test confusion matrix
[[ 3308  1655]
 [ 8962 18850]]
```

In [77]:

```
# Heatmap for train set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_tr, predict_with_best_t(y_train_pred,best_t1)),
annot=True, fmt="d")
plt.title("Train set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()

# Heatmap for test set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t1)), an
not=True, fmt="d")
plt.title("Test set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()
```





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

In [78]:

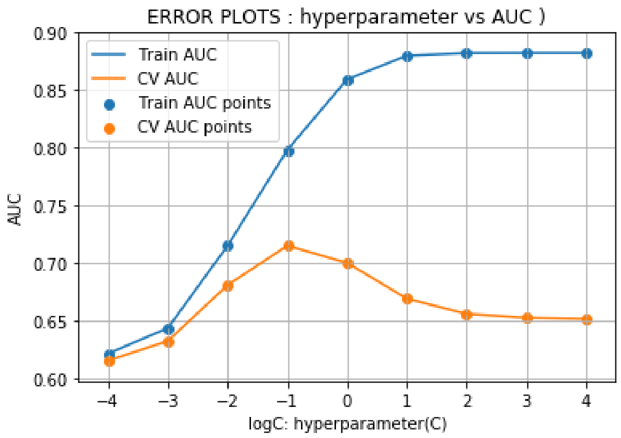
```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_tr = hstack((school_state_one_hot_train,categories_one_hot_train, sub_categories_one_hot_train,
teacher_prefix_one_hot_train, project_grade_one_hot_train,essay_tfidf_train,title_tfidf_train, pri
ce_standardized_train,previous_project_standardized_train))
X_cv = hstack((school_state_one_hot_cv,categories_one_hot_cv, sub_categories_one_hot_cv,
teacher_prefix_one_hot_cv, project_grade_one_hot_cv,essay_tfidf_cv,title_tfidf_cv,
price_standardized_cv,previous_project_standardized_cv))
X_test = hstack((school_state_one_hot_test,categories_one_hot_test, sub_categories_one_hot_test, t
eacher_prefix_one_hot_test, project_grade_one_hot_test,essay_tfidf_test,title_tfidf_test,
price_standardized_test,previous_project_standardized_test))
X_tr = X_tr.tocsr()
X_cv = X_cv.tocsr()
X_test = X_test.tocsr()
print(X_tr.shape , y_tr.shape)
print(X_cv.shape , y_cv.shape)
print(X_test.shape , y_test.shape)
```

```
(53531, 7292) (53531,)
(22942, 7292) (22942,)
(32775, 7292) (32775,)
```

In [79]:

```
from sklearn.linear_model import LogisticRegression
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []

for i in tqdm(C):
    neigh = LogisticRegression(C=i, class_weight='balanced', n_jobs=-1)
    neigh.fit(X_tr, y_tr)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_tr,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.plot(logC, train_auc, label='Train AUC')
plt.plot(logC, cv_auc, label='CV AUC')

plt.scatter(logC, train_auc, label='Train AUC points')
plt.scatter(logC, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("logC: hyperparameter(C)")
plt.ylabel("AUC")
plt.title("ERROR PLOTS : hyperparameter vs AUC )")
plt.grid()
plt.show()
plt.show()
```

```
100%|████████████████████████████████████████████████████████████████████████| 9/9 [09:
59<00:00, 139.04s/it]
```



In the above case the hyperparameter is choosen to be C=0.1 because at C=0.1 the cv_auc is maximum and the distance between train_auc and cv_auc is less. If the C is further increased it may lead to underfit state.

In [80]:

```
for i in range(len(train_auc)):
    print(C[i])
    print(logC[i])
    print(train_auc[i]-cv_auc[i])
```

```
0.0001
-4.0
0.006072402252759845
0.001
-3.0
0.011188874291097273
0.01
-2.0
0.03407977609560042
0.1
-1.0
0.08302495722889502
1.0
0.0
0.15904247141282768
10
1.0
0.2104680471816044
100
2.0
0.2260544147164718
1000
3.0
0.22950079418491354
10000
4.0
0.23044258368319337
```

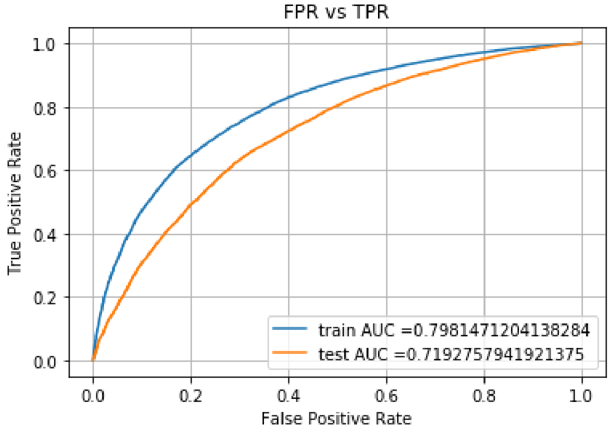
In [81]:

```
best_c2 = 0.1
```

In [82]:

```
from sklearn.metrics import roc_curve, auc


neigh = LogisticRegression(C=best_c2, class_weight='balanced', n_jobs=-1)
neigh.fit(X_tr, y_tr)
```

```
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_test)

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

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



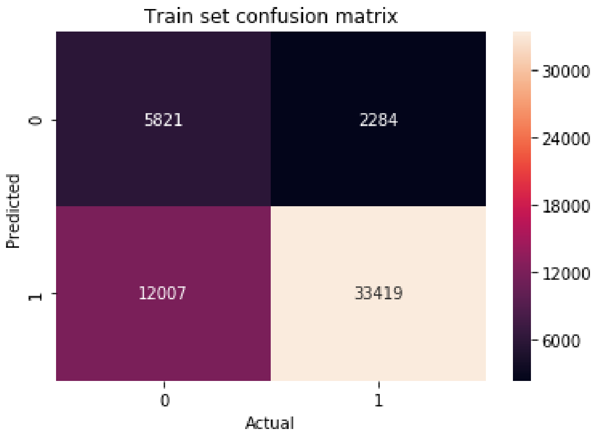
In [83]:

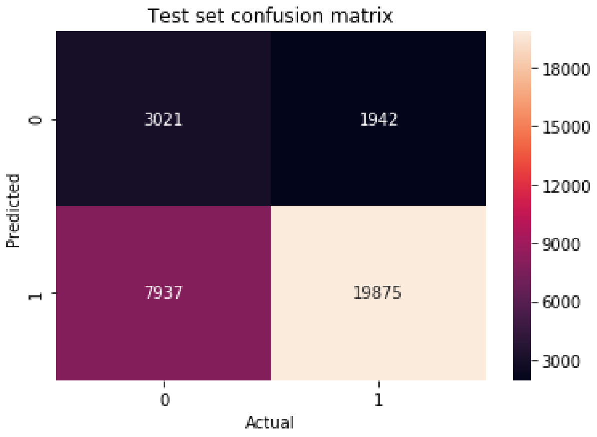
```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t2 = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_tr, predict_with_best_t(y_train_pred, best_t2)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t2)))
```

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

the maximum value of tpr*(1-fpr) 0.5283643826040212 for threshold 0.49
Train confusion matrix
[[ 5821  2284]
 [12007 33419]]
Test confusion matrix
[[ 3021  1942]
 [ 7937 19875]]
```

In [84]:

```
# Heatmap for train set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_tr, predict_with_best_t(y_train_pred,best_t2)),
annot=True, fmt="d")
plt.title("Train set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()

# Heatmap for test set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t2)), an
not=True, fmt="d")
plt.title("Test set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()
```





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

In [85]:

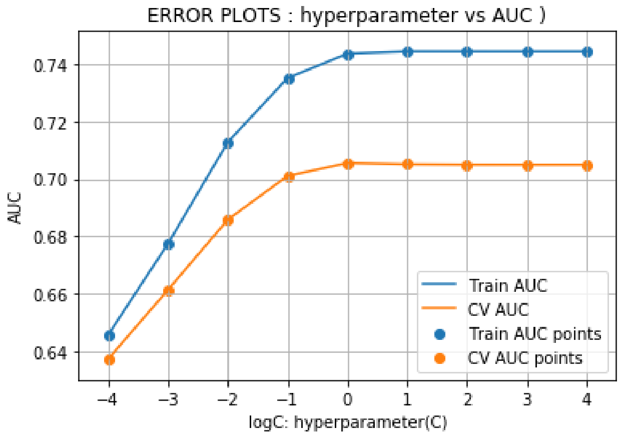
```
# Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_tr = hstack((school_state_one_hot_train,categories_one_hot_train, sub_categories_one_hot_train,
teacher_prefix_one_hot_train, project_grade_one_hot_train,essay_avg_w2v_train,title_avg_w2v_train,
price_standardized_train,previous_project_standardized_train))
X_cv = hstack((school_state_one_hot_cv,categories_one_hot_cv, sub_categories_one_hot_cv,
teacher_prefix_one_hot_cv, project_grade_one_hot_cv,essay_avg_w2v_cv,title_avg_w2v_cv,
price_standardized_cv,previous_project_standardized_cv))
X_test = hstack((school_state_one_hot_test,categories_one_hot_test, sub_categories_one_hot_test, t
eacher_prefix_one_hot_test, project_grade_one_hot_test,essay_avg_w2v_test,title_avg_w2v_test,
price_standardized_test,previous_project_standardized_test))
X_tr = X_tr.tocsr()
X_cv = X_cv.tocsr()
X_test = X_test.tocsr()
print(X_tr.shape , y_tr.shape)
print(X_cv.shape , y_cv.shape)
print(X_test.shape , y_test.shape)
```

```
(53531, 701) (53531,)
(22942, 701) (22942,)
(32775, 701) (32775,)
```

In [86]:

```
from sklearn.linear_model import LogisticRegression
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []

for i in tqdm(C):
    neigh = LogisticRegression(C=i, class_weight='balanced', n_jobs=-1)
    neigh = LogisticRegression(C=i, class_weight='balanced', n_jobs=-1)
    neigh.fit(X_tr, y_tr)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_tr,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.plot(logC, train_auc, label='Train AUC')
plt.plot(logC, cv_auc, label='CV AUC')

plt.scatter(logC, train_auc, label='Train AUC points')
plt.scatter(logC, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("logC: hyperparameter(C)")
plt.ylabel("AUC")
plt.title("ERROR PLOTS : hyperparameter vs AUC )")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████| 9/9 [09
:08<00:00, 89.81s/it]
```



In the above case the hyperparameter is choosen to be C=1 because at C=1 the cv_auc is maximum and the distance between train_auc and cv_auc is less. If the C is further increased the cv_auc almost remains same.

In [87]:

```
for i in range(len(train_auc)):
    print(C[i])
    print(logC[i])
    print(train_auc[i]-cv_auc[i])
```

```
0.0001
-4.0
0.00843389851729115
0.001
-3.0
0.0161132663417477
0.01
-2.0
0.02707375759191144
0.1
-1.0
0.034173231248214364
1.0
0.0
0.03817162705801125
10
1.0
0.03940767743580842
100
```

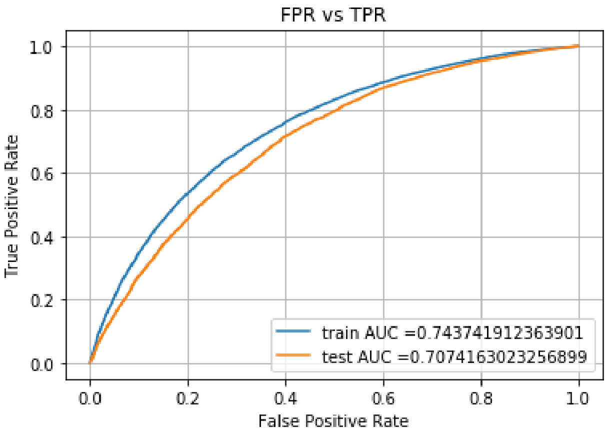
```
100
2.0
0.03951524610693746
1000
3.0
0.03952844566655478
10000
4.0
0.03952988410012237
```

In [88]:

```
best_c3 = 1
```

In [89]:

```
from sklearn.metrics import roc_curve, auc


neigh = LogisticRegression(C=best_c3, class_weight='balanced', n_jobs=-1)
neigh.fit(X_tr, y_tr)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_test)

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

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



In [90]:

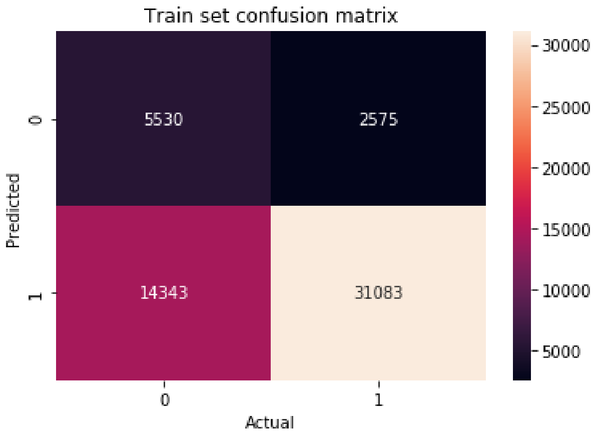
```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t3 = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_tr, predict_with_best_t(y_train_pred, best_t3)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t3)))
```

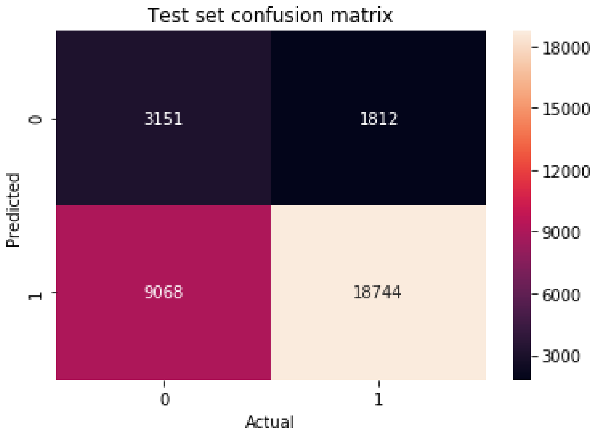
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.4668641691065888 for threshold 0.494
Train confusion matrix
[[ 5530  2575]
 [14343 31083]]
```

```
Test confusion matrix
[[ 3151  1812]
 [ 9068 18744]]
```

In [91]:

```
# Heatmap for train set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_tr, predict_with_best_t(y_train_pred,best_t3)),
annot=True, fmt="d")
plt.title("Train set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()

# Heatmap for test set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t3)), an
not=True, fmt="d")
plt.title("Test set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()
```





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

In [92]:

```
# Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V
)

from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_tr = hstack((school_state_one_hot_train,categories_one_hot_train, sub_categories_one_hot_train,
teacher_prefix_one_hot_train,
project_grade_one_hot_train,essay_tfidf_w2v_train,title_tfidf_w2v_train, price_standardized_train,
previous_project_standardized_train))
X_cv = hstack((school_state_one_hot_cv,categories_one_hot_cv, sub_categories_one_hot_cv,
teacher_prefix_one_hot_cv, project_grade_one_hot_cv,essay_tfidf_w2v_cv,title_tfidf_w2v_cv,
price_standardized_cv,previous_project_standardized_cv))
```

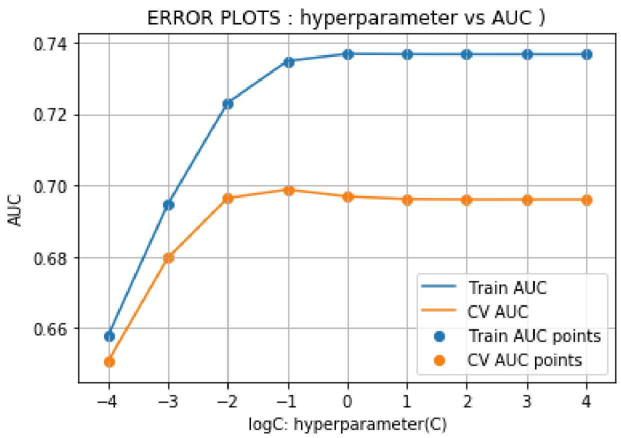
```
X_test = hstack((school_state_one_hot_test,categories_one_hot_test, sub_categories_one_hot_test, teacher_prefix_one_hot_test, project_grade_one_hot_test,essay_tfidf_w2v_test,title_tfidf_w2v_test,
price_standardized_test,previous_project_standardized_test))
X_tr = X_tr.tocsr()
X_cv = X_cv.tocsr()
X_test = X_test.tocsr()
print(X_tr.shape , y_tr.shape)
print(X_cv.shape , y_cv.shape)
print(X_test.shape , y_test.shape)
```

```
(53531, 701) (53531,)
(22942, 701) (22942,)
(32775, 701) (32775,)
```

In [93]:

```
from sklearn.linear_model import LogisticRegression
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []

for i in tqdm(C):
    neigh = LogisticRegression(C=i, class_weight='balanced', n_jobs=-1)
    neigh.fit(X_tr, y_tr)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_tr,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.plot(logC, train_auc, label='Train AUC')
plt.plot(logC, cv_auc, label='CV AUC')

plt.scatter(logC, train_auc, label='Train AUC points')
plt.scatter(logC, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("logC: hyperparameter(C)")
plt.ylabel("AUC")
plt.title("ERROR PLOTS : hyperparameter vs AUC )")
plt.grid()
plt.show()
```

```
100%|██████████████████████████████████████████████████| 9/9 [06:36<00:00, 60.12s/it]
```



In the above case the hyperparameter is choosen to be C=0.1 because at C=0.1 the cv_auc is maximum and the distance between train_auc and cv_auc is less. If the C is further increased the train_auc increases and cv_auc decreases which leads to the underfit state

In [94]:

```
for i in range(len(train_auc)):
    print(C[i])
    print(logC[i])
    print(train_auc[i]-cv_auc[i])
```

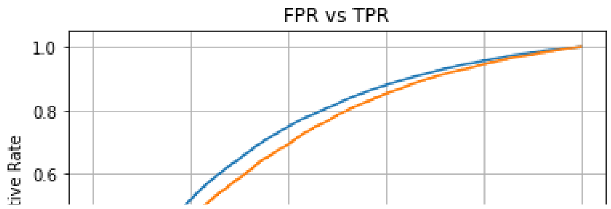
```
0.0001
-4.0
0.007177436971694817
0.001
-3.0
0.015020838970281836
0.01
-2.0
0.02669735346027724
0.1
-1.0
0.03597079908721601
1.0
0.0
0.03993819305426294
10
1.0
0.04057916226802416
100
2.0
0.04064603624105634
1000
3.0
0.040653867051676396
10000
4.0
0.040655396873548466
```

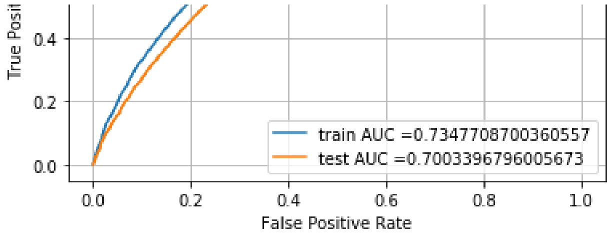
In [95]:

```
best_c4 = 0.1
```

In [96]:

```
from sklearn.metrics import roc_curve, auc


neigh = LogisticRegression(C=best_c4, class_weight='balanced', n_jobs=-1)
neigh.fit(X_tr, y_tr)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_test)

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

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





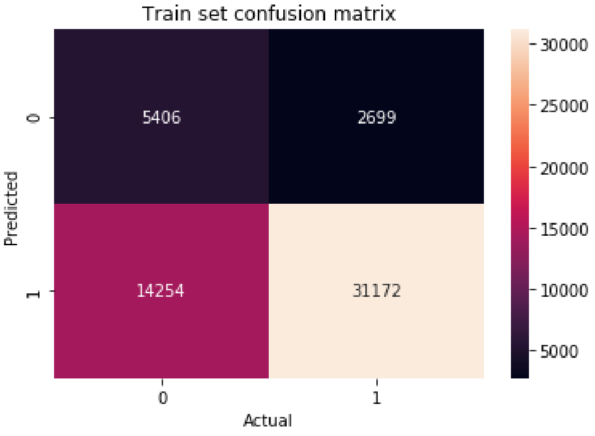
In [97]:

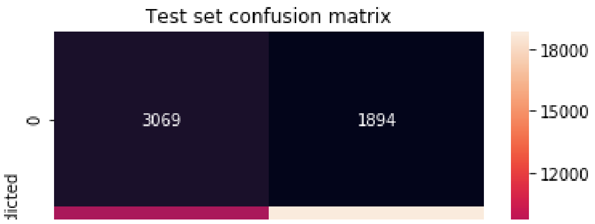
```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t4 = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_tr, predict_with_best_t(y_train_pred, best_t4)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t4)))
```

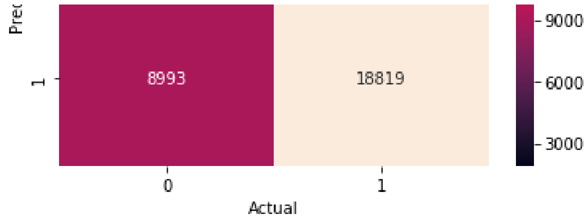
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.4577024036733563 for threshold 0.483
Train confusion matrix
[[ 5406  2699]
 [14254 31172]]
Test confusion matrix
[[ 3069  1894]
 [ 8993 18819]]
```

In [98]:

```
# Heatmap for train set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_tr, predict_with_best_t(y_train_pred,best_t4)),
annot=True, fmt="d")
plt.title("Train set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()

# Heatmap for test set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t4)), an
not=True, fmt="d")
plt.title("Test set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()
```







2.5 Logistic Regression with added Features `Set 5`

In [99]:

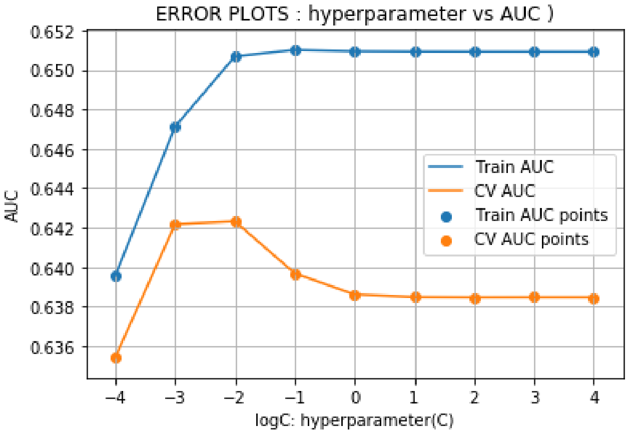
```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_tr = hstack((school_state_one_hot_train,categories_one_hot_train, sub_categories_one_hot_train,
teacher_prefix_one_hot_train, project_grade_one_hot_train,essay_word_standardized_train,
title_word_standardized_train, pos_standardized_train, neu_standardized_train,
neg_standardized_train, compound_standardized_train, quantity_standardized_train,
price_standardized_train,previous_project_standardized_train))
X_cv = hstack((school_state_one_hot_cv,categories_one_hot_cv, sub_categories_one_hot_cv,
teacher_prefix_one_hot_cv, project_grade_one_hot_cv,essay_word_standardized_cv,
title_word_standardized_cv, pos_standardized_cv, neu_standardized_cv, neg_standardized_cv, compound
_standardized_cv, quantity_standardized_cv, price_standardized_cv,previous_project_standardized_cv
))
X_test = hstack((school_state_one_hot_test,categories_one_hot_test, sub_categories_one_hot_test, t
eacher_prefix_one_hot_test, project_grade_one_hot_test,essay_word_standardized_test,
title_word_standardized_test, pos_standardized_test, neu_standardized_test, neg_standardized_test,
compound_standardized_test, quantity_standardized_test,
price_standardized_test,previous_project_standardized_test))
X_tr = X_tr.tocsr()
X_cv = X_cv.tocsr()
X_test = X_test.tocsr()
print(X_tr.shape , y_tr.shape)
print(X_cv.shape , y_cv.shape)
print(X_test.shape , y_test.shape)
```

```
(53531, 108) (53531,)
(22942, 108) (22942,)
(32775, 108) (32775,)
```

In [100]:

```
from sklearn.linear_model import LogisticRegression
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score

train_auc = []
cv_auc = []

for i in tqdm(C):
    neigh = LogisticRegression(C=i, class_weight='balanced', n_jobs=-1)
    neigh.fit(X_tr, y_tr)

    y_train_pred = batch_predict(neigh, X_tr)
    y_cv_pred = batch_predict(neigh, X_cv)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_tr,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.plot(logC, train_auc, label='Train AUC')
plt.plot(logC, cv_auc, label='CV AUC')

plt.scatter(logC, train_auc, label='Train AUC points')
plt.scatter(logC, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("logC: hyperparameter(C)")
plt.ylabel("AUC")
plt.title("ERROR PLOTS : hyperparameter vs AUC )")
plt.title("ERROR PLOTS : hyperparameter vs AUC )")
plt.grid()
plt.show()
```

```
100%|████████████████████████████████████████████████████████████████| 9/9 [00
:21<00:00,  3.56s/it]
```



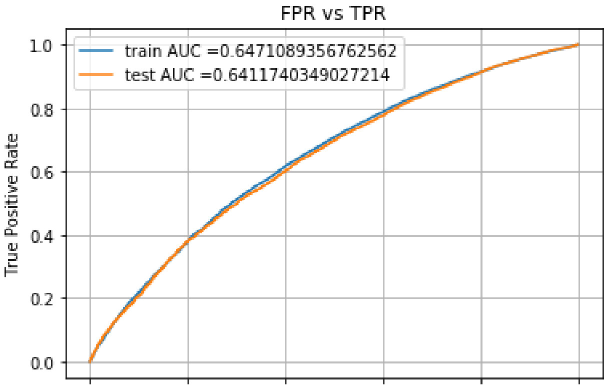
In the above case the hyperparameter is choosen to be C=0.001 because at C=0.001 the cv_auc is almost maximum and the distance between train_auc and cv_auc is less. If the C is further increased the train_auc increases and cv_auc decreases which leads to the underfit state

In [101]:

```
best_c5 = 0.001
```

In [102]:

```
from sklearn.metrics import roc_curve, auc


neigh = LogisticRegression(C=best_c5, class_weight='balanced', n_jobs=-1)
neigh.fit(X_tr, y_tr)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, X_test)

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

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



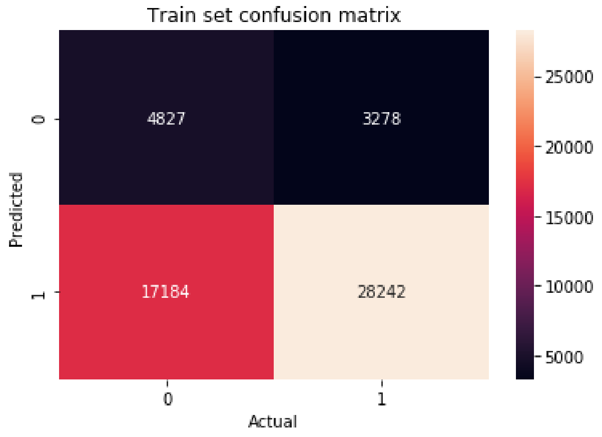
In [103]:

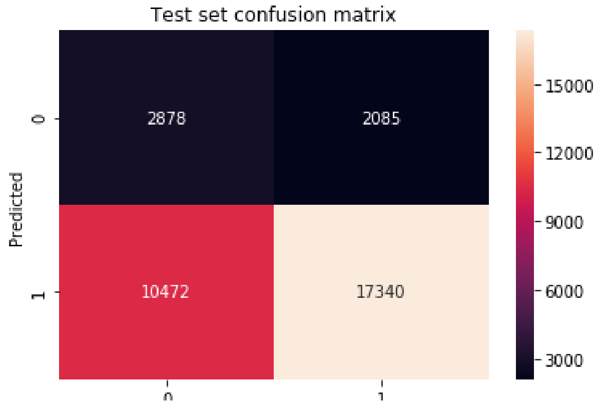
```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t5 = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_tr, predict_with_best_t(y_train_pred, best_t5)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t5)))
```

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

the maximum value of tpr*(1-fpr) 0.37026719133718383 for threshold 0.497
Train confusion matrix
[[ 4827  3278]
 [17184 28242]]
Test confusion matrix
[[ 2878  2085]
 [10472 17340]]
```

In [104]:

```
# Heatmap for train set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_tr, predict_with_best_t(y_train_pred,best_t5)),
annot=True, fmt="d")
plt.title("Train set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()

# Heatmap for test set confusion matrix(Select K best)
heatmap_train = sns.heatmap(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t5)), an
not=True, fmt="d")
plt.title("Test set confusion matrix")
plt.xlabel("Actual")
plt.ylabel("Predicted")
plt.show()
```





3. Conclusion

In [105]:

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

from prettytable import PrettyTable

model_compare = PrettyTable()
model_compare.field_names = ["Feature_sets", "Best_c_value", "Best_threshold"]
model_compare.add_row(["Bag of words", best_c1, np.round(best_t1,3)])
model_compare.add_row(["TF-IDF", best_c2, np.round(best_t2,3)])
model_compare.add_row(["Average word2vector", best_c3, np.round(best_t3,3)])
model_compare.add_row(["TF-IDF Average word2vector", best_c4, np.round(best_t4,3)])
model_compare.add_row(["Set 5", best_c5, np.round(best_t5,3)])

print(model_compare)
```

```
+----------------------------+--------------+----------------+
|        Feature_sets        | Best_c_value | Best_threshold |
+----------------------------+--------------+----------------+
|        Bag of words        |    0.001     |     0.506      |
|           TF-IDF           |     0.1      |      0.49      |
|    Average word2vector     |      1       |     0.494      |
| TF-IDF Average word2vector |     0.1      |     0.483      |
|           Set 5            |    0.001     |     0.497      |
+----------------------------+--------------+----------------+
```

1) The Best Hyperparameter K is found to be different in all the cases based on the features.

2) The Best threshold value is found to be different in all the cases based on the features that are used to train the model.