1. Importing Packages

In [1]:

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

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

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer
import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

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

from tqdm import tqdm
import os

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

2. Loading Data

In [2]:

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

In [3]:

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

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

In [4]:

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

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

In [5]:

```
resource_data.head()
```

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
2	p069063	Cory Stories: A Kid's Book About Living With Adhd	1	8.45
3	p069063	Dixon Ticonderoga Wood-Cased #2 HB Pencils, Bo...	2	13.59
4	p069063	EDUCATIONAL INSIGHTS FLUORESCENT LIGHT FILTERS...	3	24.95

In [6]:

```
project_data.head()
```

Out[6]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades P
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Grade
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Grades P
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Grades P

In [7]:

```
# we get the cost of the project using resource.csv file
resource_data.head(2)
```

Out[7]:

	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

In [8]:

```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(2)
```

Out[8]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [9]:

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

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	Grades P
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade

In [11]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].replace(np.NaN,'Mrs.')
```

3. Text Preprocessing

3.1. Concatenating all essay text

In [12]:

```
# 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)
```

3.2. Preprocessing Essay text

In [13]:

```
# printing some random essays.
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[49999])
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
==
We have GRIT! If you want to meet tenacious, respectful seven year olds with growth mindsets, you
need to come to our classroom. We give hugs, high-fives, and compliments! We Begin with the End i
n Mind and work hard everyday to reach our goals.\r\n\r\nWe don't believe in making excuses, but t
here are times in life when you just need to ask for help. As a classroom teacher in a low-income
/high poverty school district, my 2nd grade students face real-life struggles both in and out of t
he classroom. Even though, as a visitor to my classroom, you wouldn't know the daily struggle for
some of them. I ask you. How can you learn with your belly growling? How can I provide the absol
ute best learning environment when we do not have the money to buy research-based materials? \r\n
\r\n"Education is not the filling of a pail, but the lighting of a fire," William Butler Yeats.
We are not asking you to fill our pail with \"things,\"but to help provide resources to light the
fire in young minds.Receiving books written by the same author will teach students how to develop
their own Writer's Craft. It will inspire them to think about different ways established authors
have developed successful text that appeal to various audiences. \r\n\r\nWe never forget our
first love. My mother read the Berenstain Bears series to me when I was five and I fell in love w
ith the Berenstain family. She took me to the public library every week and I would hunt for book
s written by Stan and Jan Berenstain. Next, was the curious monkey and the man in the yellow hat,
Curious George! Thank you Margaret and H.A. Rey for creating a series that captured my heart and
attention. \r\n\r\nAs a teacher, it is my hope and dream to inspire the students in my classroom
to find their first love in reading. Help me help them to discover writer's craft, go on
adventures in their minds, and develop a tenacious love for reading for the sake of reading.nannan
==

In [14]:

```
# 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 [15]:

```
sent = decontracted(project_data['essay'].values[16499])
print(sent)
print("="*50)
```

I teach an amazing, energetic, engaged, and kind group of 5th grade students in an inner city high
poverty public school in Indianapolis. Many of my students have parents who work odd hours and hav
e limited time to spend with their wonderfully talented children. My students work hard in class g
iving 110% with everything that they do. They persevere through difficult topics, enjoy being
engaged in their hands-on activities, and they love to laugh while learning. I set high
expectation for my students. They understand that true, authentic learning takes hard work,
dedication, and requires them to take ownership over their education. My goal for my students is t
o leave my class as life long learners. The students work hard to overcome all obstacles in their
path to meet and grow past my expectations.My students love being active while they are learning a
nd wiggling while they are working. I am lucky enough to have one Hokki stools in my classroom. Sa
dly, one is not enough to reach all my students. My students love to use the Hokki stools while th
ey learn and want more! One of my students suggested that I write a project since I \"only have on
e, and we need more.\" These stools help my amazing kiddos get focused while engaging their core t
o keep them happy and healthy.\r\n\r\nMy students love to wiggle so they can not only focus on the
ir work, but engage in a healthy lifestyle.\r\n\r\n\r\nThe Hokki stools would allow my students to
continue to be active throughout the day whether they are in small groups or working at their own
seat.\r\nnannan
==

In [16]:

```
# \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)
```

```
I teach an amazing, energetic, engaged, and kind group of 5th grade students in an inner city high
poverty public school in Indianapolis. Many of my students have parents who work odd hours and hav
e limited time to spend with their wonderfully talented children. My students work hard in class g
iving 110% with everything that they do. They persevere through difficult topics, enjoy being
engaged in their hands-on activities, and they love to laugh while learning. I set high
expectation for my students. They understand that true, authentic learning takes hard work,
dedication, and requires them to take ownership over their education. My goal for my students is t
o leave my class as life long learners. The students work hard to overcome all obstacles in their
path to meet and grow past my expectations.My students love being active while they are learning a
nd wiggling while they are working. I am lucky enough to have one Hokki stools in my classroom. Sa
dly, one is not enough to reach all my students. My students love to use the Hokki stools while th
ey learn and want more! One of my students suggested that I write a project since I  only have one
, and we need more.  These stools help my amazing kiddos get focused while engaging their core to
keep them happy and healthy.    My students love to wiggle so they can not only focus on their wor
k, but engage in a healthy lifestyle.      The Hokki stools would allow my students to continue to
be active throughout the day whether they are in small groups or working at their own seat.
nannan
```

In [17]:

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

```
I teach an amazing energetic engaged and kind group of 5th grade students in an inner city high
poverty public school in Indianapolis Many of my students have parents who work odd hours and have
limited time to spend with their wonderfully talented children My students work hard in class givi
ng 110 with everything that they do They persevere through difficult topics enjoy being engaged in
their hands on activities and they love to laugh while learning I set high expectation for my stud
ents They understand that true authentic learning takes hard work dedication and requires them to
take ownership over their education My goal for my students is to leave my class as life long
learners The students work hard to overcome all obstacles in their path to meet and grow past my e
xpectations My students love being active while they are learning and wiggling while they are work
ing I am lucky enough to have one Hokki stools in my classroom Sadly one is not enough to reach al
l my students My students love to use the Hokki stools while they learn and want more One of my st
udents suggested that I write a project since I only have one and we need more These stools help m
y amazing kiddos get focused while engaging their core to keep them happy and healthy My students
love to wiggle so they can not only focus on their work but engage in a healthy lifestyle The Hokk
i stools would allow my students to continue to be active throughout the day whether they are in s
mall groups or working at their own seat nannan
```

In [18]:

```
# 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 [19]:

```
# Combining all the above statemennts
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 = sent.lower()
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 109248/109248
[01:37<00:00, 1119.77it/s]
```

In [20]:

```
# after preprocesing
preprocessed_essays[20000]
```

Out[20]:

```
'kindergarten students varied disabilities ranging speech language delays cognitive delays gross f
ine motor delays autism eager beavers always strive work hardest working past limitations
materials ones seek students teach title school students receive free reduced price lunch despite
disabilities limitations students love coming school come eager learn explore ever felt like ants
pants needed groove move meeting kids feel time want able move learn say wobble chairs answer love
develop core enhances gross motor turn fine motor skills also want learn games kids not want sit w
orksheets want learn count jumping playing physical engagement key success number toss color shape
mats make happen students forget work fun 6 year old deserves nannan'
```

In [21]:

```
project_data['preprocessed_essays'] = preprocessed_essays
project_data.drop(['essay'], axis=1, inplace=True)
project_data.head(2)
```

Out[21]:

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

3.3. Preprocessing Title text

In [22]:

```
# printing some random essays.
```

```
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
print("="*50)
print(project_data['project_title'].values[20000])
print("="*50)
print(project_data['project_title'].values[49999])
print("="*50)
```

```
Educational Support for English Learners at Home
==================================================
More Movement with Hokki Stools
==================================================
Sailing Into a Super 4th Grade Year
==================================================
We Need To Move It While We Input It!
==================================================
Inspiring Young Authors Through Reading
==================================================
```

In [23]:

```
# 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 [24]:

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

```
We Need To Move It While We Input It!
==================================================
```

In [25]:

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

```
We Need To Move It While We Input It!
```

In [26]:

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

```
We Need To Move It While We Input It
```

In [27]:

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

In [28]:

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

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109248
[00:04<00:00, 24526.04it/s]
```

In [29]:

```
# after preprocesing
preprocessed_titles[20000]
```

Out[29]:

```
'need move input'
```

In [30]:

```
project_data['preprocessed_titles'] = preprocessed_titles
project_data.drop(['project_title'], axis=1, inplace=True)
project_data.head(2)
```

Out[30]:

Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate

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

In [31]:

```
project_data.head()
```

Out[31]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_cate
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades P
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Grade
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	Grade
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	Grades P
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Grades P

4. Preprocessing of Categorical data

4.1. Preprocessing project_grade_category

In [32]:

```
project_grade_clean_category = []

for i in range(len(project_data)):
    a = project_data["project_grade_category"][i].replace(" ", "_").replace("-", "_")
    project_grade_clean_category.append(a)
```

In [33]:

```
project_grade_clean_category[0:5]
```

Out[33]:

```
['Grades_PreK_2', 'Grades_6_8', 'Grades_6_8', 'Grades_PreK_2', 'Grades_PreK_2']
```

In [34]:

```
project_data['project_grade_clean_category'] = project_grade_clean_category
project_data.drop(['project_grade_category'], axis=1, inplace=True)
project_data.head(2)
```

Out[34]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_subject_ca

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_subject_ca
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Literacy & L
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	History & Civics,

4.2. Preprocessing project_subject_categories

In [35]:

```
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())
```

In [36]:

```
cat_list[0:5]
```

Out[36]:

```
['Literacy_Language',
 'History_Civics Health_Sports',
 'Health_Sports',
 'Literacy_Language Math_Science',
 'Math_Science']
```

In [37]:

```
project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)
project_data.head(2)
```

Out[37]:

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

4.3. Preprocessing project_subject_subcategories

In [38]:

```
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())
```

In [39]:

```
sub_cat_list[0:5]
```

Out[39]:

```
['ESL Literacy',
 'Civics_Government TeamSports',
 'Health_Wellness TeamSports',
 'Literacy Mathematics',
 'Mathematics']
```

In [40]:

```
project_data['clean_subcategories'] = sub_cat_list
project_data.drop(['project_subject_subcategories'], axis=1, inplace=True)
project_data.head(2)
```

Out[40]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My students are English learners that are work...
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our students arrive to our school eager to lea...

In [41]:

```
project_data.head()
```

Out[41]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My students are English learners that are work...
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our students arrive to our school eager to lea...

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	\r\n\"True projects aren't always the ones th...
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	I work at a unique school filled with both ESL...
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Our second grade classroom next year will be m...

5. Sentiment score's of each of the essay

In [42]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
```

In [43]:

```
analyser = SentimentIntensityAnalyzer()
```

In [44]:

```
neg = []
pos = []
neu = []
compound = []

for a in tqdm(project_data["preprocessed_essays"]) :
    b = analyser.polarity_scores(a)['neg']
    c = analyser.polarity_scores(a)['pos']
    d = analyser.polarity_scores(a)['neu']
    e = analyser.polarity_scores(a)['compound']
    neg.append(b)
    pos.append(c)
    neu.append(d)
    compound.append(e)
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109248/109248 [19:44<00:00, 110.56it/s]
```

In [45]:

```
project_data["pos"] = pos
```

In [46]:

```
project_data["neg"] = neg
```

In [47]:

```
project_data["neu"] = neu
```

In [48]:

```
project_data["compound"] = compound
```

In [49]:

```
project_data.head()
```

Out[49]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My students are English learners that are work...
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our students arrive to our school eager to lea...
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	2016-08-31 12:03:56	\r\n\"True champions aren't always the ones th...
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	2016-10-06 21:16:17	I work at a unique school filled with both ESL...
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	2016-07-11 01:10:09	Our second grade classroom next year will be m...

5 rows × 24 columns

Counting number of words in the combine essays

In [50]:

```
essay_count = []
for word in project_data['preprocessed_essays']:
    a = len(word.split())
    b = str(a)
    essay_count.append(b)
```

In [51]:

```
essay_count[20000]
```

Out[51]:

```
'112'
```

In [52]:

```
project_data['number_of_words_in_essays'] = essay_count
project_data.head(2)
```

Out[52]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My students are English learners that are work...
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our students arrive to our school eager to lea...

2 rows × 25 columns

Counting number of words in the title

In [53]:

```
title_count = []
for word in project_data['preprocessed_titles']:
```

```
    a = len(word.split())
    b = str(a)
    title_count.append(b)
```

In [54]:

```
title_count[20000]
```

Out[54]:

```
'3'
```

In [55]:

```
project_data['number_of_words_in_the_title'] = title_count
project_data.head(2)
```

Out[55]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essay_1
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	My students are English learners that are work...
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	2016-10-25 09:22:10	Our students arrive to our school eager to lea...

2 rows × 26 columns

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```

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

In [56]:

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(project_data,
project_data['project_is_approved'], test_size=0.33, stratify = project_data['project_is_approved'
])
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

7. Dropping Target values from Train, Test and CV set

In [57]:

```
X_train.drop(['project_is_approved'], axis=1, inplace=True)
X_test.drop(['project_is_approved'], axis=1, inplace=True)
X_cv.drop(['project_is_approved'], axis=1, inplace=True)
```

In [58]:

```
print(X_train.shape)
print(X_test.shape)
print(X_cv.shape)
```

```
(49041, 25)
(36052, 25)
(24155, 25)
```

In [59]:

```
X_train.head()
```

Out[59]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_essa
41885	83330	p089697	59196edf27a58890f996df4f2f1676b5	Ms.	NY	2017-01-23 18:56:58	My students eager, read learn, grow a
52855	168474	p055720	f18160078a6f0d758f14d1b015b1a94a	Mrs.	IN	2016-08-16 13:45:44	Exposure to in a variet methods is
102669	113143	p167006	b99c47794e28fd5906ca41417ceaad7e	Mrs.	AR	2016-08-25 23:42:22	We all hav special spot do our b wo
79353	14200	p252903	17fed52e6081078ab376b3af93b9a1d7	Ms.	LA	2016-08-11 21:07:19	My students inhere creative look
9123	86543	p056139	1b3647fe92d956652cff2459ae4c4c9a	Mr.	WI	2016-08-24 20:12:29	I teach 18 grade students v love

5 rows × 25 columns

In [60]:

```
y_train.head()
```

Out[60]:

```
41885     1
52855     1
102669    1
79353     1
9123      1
Name: project_is_approved, dtype: int64
```

8. Encoding Categorical Data

8.1. One Hot Encoding of clean_categories

In [61]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# cat_dict = dict(my_counter)
# sorted_cat_dict = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
```

In [62]:

```
# we use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(X_train['clean_categories'].values)
print(vectorizer.get_feature_names())


categories_one_hot_Xtrain = vectorizer.transform(X_train['clean_categories'].values)
categories_one_hot_Xtest = vectorizer.transform(X_test['clean_categories'].values)
categories_one_hot_Xcv = vectorizer.transform(X_cv['clean_categories'].values)
print("Shape of matrix after one hot encodig ",categories_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encodig ",categories_one_hot_Xtest.shape)
print("Shape of matrix after one hot encodig ",categories_one_hot_Xcv.shape)
```

```
['AppliedLearning', 'Care_Hunger', 'Health_Sports', 'History_Civics', 'Literacy_Language',
'Math_Science', 'Music_Arts', 'SpecialNeeds', 'Warmth']
Shape of matrix after one hot encodig  (49041, 9)
Shape of matrix after one hot encodig  (36052, 9)
Shape of matrix after one hot encodig  (24155, 9)
```

8.2. One Hot Encoding of clean_subcategories

In [63]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# sub_cat_dict = dict(my_counter)
# sorted_sub_cat_dict = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
```

In [64]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(project_data['clean_subcategories'].values)
print(vectorizer.get_feature_names())


sub_categories_one_hot_Xtrain = vectorizer.transform(X_train['clean_subcategories'].values)
sub_categories_one_hot_Xtest = vectorizer.transform(X_test['clean_subcategories'].values)
sub_categories_one_hot_Xcv = vectorizer.transform(X_cv['clean_subcategories'].values)

print("Shape of matrix after one hot encoding ",sub_categories_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encodig ",sub_categories_one_hot_Xtest.shape)
print("Shape of matrix after one hot encodig ",sub_categories_one_hot_Xcv.shape)
```

```
['AppliedSciences', 'Care_Hunger', 'CharacterEducation', 'Civics_Government',
'College_CareerPrep', 'CommunityService', 'ESL', 'EarlyDevelopment', 'Economics',
'EnvironmentalScience', 'Extracurricular', 'FinancialLiteracy', 'ForeignLanguages', 'Gym_Fitness',
'Health_LifeScience', 'Health_Wellness', 'History_Geography', 'Literacy', 'Literature_Writing', 'M
athematics', 'Music', 'NutritionEducation', 'Other', 'ParentInvolvement', 'PerformingArts', 'Socia
lSciences', 'SpecialNeeds', 'TeamSports', 'VisualArts', 'Warmth']
Shape of matrix after one hot encoding  (49041, 30)
Shape of matrix after one hot encodig  (36052, 30)
Shape of matrix after one hot encodig  (24155, 30)
```

8.3. One Hot Encoding of school_state

In [65]:

```
# # count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
# from collections import Counter
```

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# school_state_dict = dict(my_counter)
# sorted_school_state_dict = dict(sorted(school_state_dict.items(), key=lambda kv: kv[1]))
```

In [66]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(project_data['school_state'].values)
print(vectorizer.get_feature_names())


school_state_one_hot_Xtrain = vectorizer.transform(X_train['school_state'].values)
school_state_one_hot_Xtest = vectorizer.transform(X_test['school_state'].values)
school_state_one_hot_Xcv = vectorizer.transform(X_cv['school_state'].values)

print("Shape of matrix after one hot encoding ",school_state_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encoding ",school_state_one_hot_Xtest.shape)
print("Shape of matrix after one hot encoding ",school_state_one_hot_Xcv.shape)
```

```
['AK', 'AL', 'AR', 'AZ', 'CA', 'CO', 'CT', 'DC', 'DE', 'FL', 'GA', 'HI', 'IA', 'ID', 'IL', 'IN', 'K
S', 'KY', 'LA', 'MA', 'MD', 'ME', 'MI', 'MN', 'MO', 'MS', 'MT', 'NC', 'ND', 'NE', 'NH', 'NJ', 'NM',
'NV', 'NY', 'OH', 'OK', 'OR', 'PA', 'RI', 'SC', 'SD', 'TN', 'TX', 'UT', 'VA', 'VT', 'WA', 'WI', 'WV
', 'WY']
Shape of matrix after one hot encoding  (49041, 51)
Shape of matrix after one hot encoding  (36052, 51)
Shape of matrix after one hot encoding  (24155, 51)
```

8.4. One Hot Encoding of teacher_prefix

In [67]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# teacher_prefix_dict = dict(my_counter)
# sorted_teacher_prefix_dict = dict(sorted(teacher_prefix_dict.items(), key=lambda kv: kv[1]))
```

In [68]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(project_data['teacher_prefix'].values)
print(vectorizer.get_feature_names())


teacher_prefix_one_hot_Xtrain = vectorizer.transform(X_train['teacher_prefix'].values)
teacher_prefix_one_hot_Xtest = vectorizer.transform(X_test['teacher_prefix'].values)
teacher_prefix_one_hot_Xcv = vectorizer.transform(X_cv['teacher_prefix'].values)

print("Shape of matrix after one hot encoding ",teacher_prefix_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_one_hot_Xtest.shape)
print("Shape of matrix after one hot encoding ",teacher_prefix_one_hot_Xcv.shape)
```

```
['Dr', 'Mr', 'Mrs', 'Ms', 'Teacher']
Shape of matrix after one hot encoding  (49041, 5)
Shape of matrix after one hot encoding  (36052, 5)
Shape of matrix after one hot encoding  (24155, 5)
```

8.5. One Hot Encoding of project_grade_clean_category

9.6. One Hot Encoding of project_grade_clean_category

In [69]:

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

# # dict sort by value python: https://stackoverflow.com/a/613218/4084039
# grade_dict = dict(my_counter)
# sorted_grade_dict = dict(sorted(grade_dict.items(), key=lambda kv: kv[1]))
```

In [70]:

```
# we use count vectorizer to convert the values into one hot encoded features
vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(project_data['project_grade_clean_category'].values)
print(vectorizer.get_feature_names())


grade_one_hot_Xtrain = vectorizer.transform(X_train['project_grade_clean_category'].values)
grade_one_hot_Xtest = vectorizer.transform(X_test['project_grade_clean_category'].values)
grade_one_hot_Xcv = vectorizer.transform(X_cv['project_grade_clean_category'].values)

print("Shape of matrix after one hot encoding ",grade_one_hot_Xtrain.shape)
print("Shape of matrix after one hot encoding ",grade_one_hot_Xtest.shape)
print("Shape of matrix after one hot encoding ",grade_one_hot_Xcv.shape)
```

```
['Grades_3_5', 'Grades_6_8', 'Grades_9_12', 'Grades_PreK_2']
Shape of matrix after one hot encoding  (49041, 4)
Shape of matrix after one hot encoding  (36052, 4)
Shape of matrix after one hot encoding  (24155, 4)
```

9. Encoding of Text Data

9.1.1. BOW with bi-grams with (min_df=10 and max_features=5000) Encoding on preprocessed_essays

In [71]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(ngram_range = (2,2) , min_df=10 , max_features = 5000)
text_bow_Xtrain = vectorizer.fit_transform(X_train['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xtrain.shape)
text_bow_Xtest = vectorizer.transform(X_test['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xtest.shape)
text_bow_Xcv = vectorizer.transform(X_cv['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_bow_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (49041, 5000)
Shape of matrix after one hot encodig  (36052, 5000)
Shape of matrix after one hot encodig  (24155, 5000)
```

9.1.2. BOW Encoding on preprocessed_titles

In [72]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
title_bow_Xtrain = vectorizer.fit_transform(X_train['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xtrain.shape)
title_bow_Xtest = vectorizer.transform(X_test['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xtest.shape)
title_bow_Xcv = vectorizer.transform(X_cv['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_bow_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (49041, 2022)
Shape of matrix after one hot encodig  (36052, 2022)
Shape of matrix after one hot encodig  (24155, 2022)
```

9.2.1. TFIDF with bi-grams with (min_df=10 and max_features=5000) Encoding on preprocessed_essays

In [73]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(ngram_range = (2,2) , min_df=10 , max_features = 5000)
text_tfidf_Xtrain = vectorizer.fit_transform(X_train['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xtrain.shape)
text_tfidf_Xtest = vectorizer.transform(X_test['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xtest.shape)
text_tfidf_Xcv = vectorizer.transform(X_cv['preprocessed_essays'].values)
print("Shape of matrix after one hot encodig ",text_tfidf_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (49041, 5000)
Shape of matrix after one hot encodig  (36052, 5000)
Shape of matrix after one hot encodig  (24155, 5000)
```

9.2.2. TFIDF Encoding on preprocessed_titles

In [74]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
title_tfidf_Xtrain = vectorizer.fit_transform(X_train['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xtrain.shape)
title_tfidf_Xtest = vectorizer.transform(X_test['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xtest.shape)
title_tfidf_Xcv = vectorizer.transform(X_cv['preprocessed_titles'].values)
print("Shape of matrix after one hot encodig ",title_tfidf_Xcv.shape)
```

```
Shape of matrix after one hot encodig  (49041, 2022)
Shape of matrix after one hot encodig  (36052, 2022)
Shape of matrix after one hot encodig  (24155, 2022)
```

9.3.1. Average Word2Vec encoding of preprocessed_essays on Train Data

In [75]:

```
# 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('D:\glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [76]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xtrain = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
```

```
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_Xtrain.append(vector)

print(len(avg_w2v_vectors_essays_Xtrain))
print(len(avg_w2v_vectors_essays_Xtrain[2]))
```

```
100%|████████████████████████████████████████████████████████████████████████| 49041/49041
[00:22<00:00, 2181.49it/s]
```

```
49041
300
```

In [77]:

```
average_w2v_on_essay_Xtrain = np.vstack(avg_w2v_vectors_essays_Xtrain)
print(average_w2v_on_essay_Xtrain.shape)
```

```
(49041, 300)
```

9.3.2. Average Word2Vec encoding of preprocessed_essays on Test Data

In [78]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xtest = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_Xtest.append(vector)

print(len(avg_w2v_vectors_essays_Xtest))
print(len(avg_w2v_vectors_essays_Xtest[2]))
```

```
100%|████████████████████████████████████████████████████████████████████████| 36052/36052
[00:16<00:00, 2170.56it/s]
```

```
36052
300
```

In [79]:

```
average_w2v_on_essay_Xtest = np.vstack(avg_w2v_vectors_essays_Xtest)
print(average_w2v_on_essay_Xtest.shape)
```

```
(36052, 300)
```

9.3.3. Average Word2Vec encoding of preprocessed_essays on CV Data

In [80]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_essays_Xcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
```

```
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_Xcv.append(vector)

print(len(avg_w2v_vectors_essays_Xcv))
print(len(avg_w2v_vectors_essays_Xcv[2]))
```

```
100%|████████████████████████████████████████████████████████████████| 24155/24155
[00:11<00:00, 2019.04it/s]
```

```
24155
300
```

In [81]:

```
average_w2v_on_essay_Xcv = np.vstack(avg_w2v_vectors_essays_Xcv)
print(average_w2v_on_essay_Xcv.shape)
```

```
(24155, 300)
```

9.4.1. Average Word2Vec encoding of preprocessed_titles on Train Data

In [82]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xtrain = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_train['preprocessed_titles'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in t.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_Xtrain.append(vector)

print(len(avg_w2v_vectors_titles_Xtrain))
print(len(avg_w2v_vectors_titles_Xtrain[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 49041/49041
[00:01<00:00, 38636.98it/s]
```

```
49041
300
```

In [83]:

```
average_w2v_on_titles_Xtrain = np.vstack(avg_w2v_vectors_titles_Xtrain)
print(average_w2v_on_titles_Xtrain.shape)
```

```
(49041, 300)
```

9.4.2. Average Word2Vec encoding of preprocessed_titles on Test Data

In [84]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xtest = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_test['preprocessed_titles'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in t.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_Xtest.append(vector)

print(len(avg_w2v_vectors_titles_Xtest))
print(len(avg_w2v_vectors_titles_Xtest[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052
[00:01<00:00, 32733.74it/s]
```

```
36052
300
```

In [85]:

```
average_w2v_on_titles_Xtest = np.vstack(avg_w2v_vectors_titles_Xtest)
print(average_w2v_on_titles_Xtest.shape)
```

```
(36052, 300)
```

9.4.3. Average Word2Vec encoding of preprocessed_titles on CV Data

In [86]:

```
#t-title
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_titles_Xcv = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_cv['preprocessed_titles'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in t.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_titles_Xcv.append(vector)

print(len(avg_w2v_vectors_titles_Xcv))
print(len(avg_w2v_vectors_titles_Xcv[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 24155/24155
[00:00<00:00, 34526.86it/s]
```

```
24155
300
```

In [87]:

```
average_w2v_on_titles_Xcv = np.vstack(avg_w2v_vectors_titles_Xcv)
print(average_w2v_on_titles_Xcv.shape)
```

```
(24155, 300)
```

9.5.1. TFIDF weighted Word2Vec encoding of preprocessed_essays on Train Data

In [88]:

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

In [90]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xtrain = []; # the avg-w2v for each sentence/review is stored i
n this list
for sentence in tqdm(X_train['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xtrain.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xtrain))
print(len(tfidf_weighted_w2v_vectors_eassays_Xtrain[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 49041/49041 [02:
38<00:00, 309.89it/s]
```

```
49041
300
```

In [91]:

```
tfidf_weighted_w2v_on_essay_matrix_Xtrain = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xtrain)
print(tfidf_weighted_w2v_on_essay_matrix_Xtrain.shape)
```

```
(49041, 300)
```

9.5.2. TFIDF weighted Word2Vec encoding of preprocessed_essays on Test Data

In [92]:

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

In [93]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xtest = []; # the avg-w2v for each sentence/review is stored in
this list
for sentence in tqdm(X_test['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xtest.append(vector)

print(len(tfidf_weighted_w2v_vectors_eassays_Xtest))
print(len(tfidf_weighted_w2v_vectors_eassays_Xtest[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052 [01:
54<00:00, 313.92it/s]
```

```
36052
300
```

In [94]:

```
tfidf_weighted_w2v_on_essay_matrix_Xtest = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xtest)
print(tfidf_weighted_w2v_on_essay_matrix_Xtest.shape)
```

```
(36052, 300)
```

9.5.3. TFIDF weighted Word2Vec encoding of preprocessed_essays on CV Data

In [95]:

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

In [96]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_eassays_Xcv = []; # the avg-w2v for each sentence/review is stored in t
his list
for sentence in tqdm(X_cv['preprocessed_essays'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_eassays_Xcv.append(vector)
```

```
print(len(tfidf_weighted_w2v_vectors_eassays_Xcv))
print(len(tfidf_weighted_w2v_vectors_eassays_Xcv[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████| 24155/24155 [01:11<00:00, 338.10it/s]
```

```
24155
300
```

In [97]:

```
tfidf_weighted_w2v_on_essay_matrix_Xcv = np.vstack(tfidf_weighted_w2v_vectors_eassays_Xcv)
print(tfidf_weighted_w2v_on_essay_matrix_Xcv.shape)
```

```
(24155, 300)
```

9.6.1. TFIDF Weighted Word2Vec encoding of preprocessed_titles on Train Data

In [100]:

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

In [101]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_title_Xtrain = []; # the avg-w2v for each sentence/review is stored in this list
for t in tqdm(X_train['preprocessed_titles'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in t.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]*(t.count(word)/len(t.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xtrain.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xtrain))
print(len(tfidf_weighted_w2v_vectors_title_Xtrain[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████| 49041/49041 [00:02<00:00, 18702.95it/s]
```

```
49041
300
```

In [102]:

```
tfidf_weighted_w2v_on_title_matrix_Xtrain = np.vstack(tfidf_weighted_w2v_vectors_title_Xtrain)
print(tfidf_weighted_w2v_on_title_matrix_Xtrain.shape)
```

```
(49041, 300)
```

9.6.2. TFIDF Weighted Word2Vec encoding of preprocessed_titles on Test Data

In [103]:

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

In [104]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_weighted_w2v_vectors_title_Xtest = []; # the avg-w2v for each sentence/review is stored in t
his list
for t in tqdm(X_test['preprocessed_titles'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in t.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]*(t.count(word)/len(t.split())) # getting the tfidf value for
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xtest.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xtest))
print(len(tfidf_weighted_w2v_vectors_title_Xtest[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 36052/36052
[00:01<00:00, 18983.67it/s]
```

```
36052
300
```

In [105]:

```
tfidf_weighted_w2v_on_title_matrix_Xtest = np.vstack(tfidf_weighted_w2v_vectors_title_Xtest)
print(tfidf_weighted_w2v_on_title_matrix_Xtest.shape)
```

```
(36052, 300)
```

9.6.3. TFIDF Weighted Word2Vec encoding of preprocessed_titles on CV Data

In [106]:

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

In [107]:

```
# average Word2Vec
# compute average word2vec for each review.
```

```
tfidf_weighted_w2v_vectors_title_Xcv = []; # the avg-w2v for each sentence/review is stored in thi
s list
for t in tqdm(X_cv['preprocessed_titles'].values): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in t.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]*(t.count(word)/len(t.split())) # getting the tfidf value for
each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_weighted_w2v_vectors_title_Xcv.append(vector)

print(len(tfidf_weighted_w2v_vectors_title_Xcv))
print(len(tfidf_weighted_w2v_vectors_title_Xcv[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████████| 24155/24155
[00:01<00:00, 19603.52it/s]
```

```
24155
300
```

In [108]:

```
tfidf_weighted_w2v_on_title_matrix_Xcv = np.vstack(tfidf_weighted_w2v_vectors_title_Xcv)
print(tfidf_weighted_w2v_on_title_matrix_Xcv.shape)
```

```
(24155, 300)
```

10. Encoding of Numerical Data

10.1. Encoding of price on Train,Test and CV data

In [109]:

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


scalar = MinMaxScaler()

price_standardized_Xtrain = scalar.fit_transform(X_train['price'].values.reshape(-1, 1))
price_standardized_Xtest = scalar.transform(X_test['price'].values.reshape(-1,1))
price_standardized_Xcv = scalar.transform(X_cv['price'].values.reshape(-1, 1))
```

In [110]:

```
price_standardized_Xtrain
```

Out[110]:

```
array([[0.03870735],
       [0.03481662],
       [0.0079065 ],
       ...,
       [0.01636711],
       [0.04439443],
       [0.01786139]])
```

In [111]:

```
print(price_standardized_Xtrain.shape)
print(price_standardized_Xtest.shape)
print(price_standardized_Xcv.shape)
```

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

10.2. Encoding of quantity on Train,Test and CV data

In [112]:

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

scalar = MinMaxScaler()

quantity_standardized_Xtrain = scalar.fit_transform(X_train['quantity'].values.reshape(-1, 1))
quantity_standardized_Xtest = scalar.transform(X_test['quantity'].values.reshape(-1, 1))
quantity_standardized_Xcv = scalar.transform(X_cv['quantity'].values.reshape(-1, 1))
```

In [113]:

```
quantity_standardized_Xtrain
```

Out[113]:

```
array([[0.01001112],
       [0.00111235],
       [0.00333704],
       ...,
       [0.00556174],
       [0.        ],
       [0.00222469]])
```

In [114]:

```
print(quantity_standardized_Xtrain.shape)
print(quantity_standardized_Xtest.shape)
print(quantity_standardized_Xcv.shape)
```

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

10.3. Encoding of teacher_number_of_previously_posted_projects on Train,Test and CV data

In [115]:

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

scalar = MinMaxScaler()

# Now standardize the data with above maen and variance.
teacher_number_of_previously_posted_projects_standardized_Xtrain = scalar.fit_transform(X_train['t
eacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
teacher_number_of_previously_posted_projects_standardized_Xtest =
scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
teacher_number_of_previously_posted_projects_standardized_Xcv =
scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1, 1))
```

In [116]:

```
teacher_number_of_previously_posted_projects_standardized_Xtrain
```

Out[116]:

```
array([[0.00665188],
       [0.00221729],
       [0.03104213],
       ...,
       [0.00443459],
       [0.00443459],
       [0.0886918 ]])
```

In [117]:

```
print(teacher_number_of_previously_posted_projects_standardized_Xtrain.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtest.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xcv.shape)
```

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

10.4.1. Encoding of pos on Train,Test and CV data

In [118]:

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

scalar = MinMaxScaler()

essay_pos_standardized_Xtrain = scalar.fit_transform(X_train['pos'].values.reshape(-1, 1))
essay_pos_standardized_Xtest = scalar.transform(X_test['pos'].values.reshape(-1, 1))
essay_pos_standardized_Xcv = scalar.transform(X_cv['pos'].values.reshape(-1, 1))
```

In [119]:

```
essay_pos_standardized_Xtrain
```

Out[119]:

```
array([[0.52786885],
       [0.33770492],
       [0.41639344],
       ...,
       [0.15901639],
       [0.26557377],
       [0.49344262]])
```

In [120]:

```
print(essay_pos_standardized_Xtrain.shape)
print(essay_pos_standardized_Xtest.shape)
print(essay_pos_standardized_Xcv.shape)
```

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

10.5.1. Encoding of neg on Train,Test and CV data

In [121]:

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

```
from sklearn.preprocessing import MinMaxScaler

scalar = MinMaxScaler()

essay_neg_standardized_Xtrain = scalar.fit_transform(X_train['neg'].values.reshape(-1, 1))
essay_neg_standardized_Xtest = scalar.transform(X_test['neg'].values.reshape(-1, 1))
essay_neg_standardized_Xcv = scalar.transform(X_cv['neg'].values.reshape(-1, 1))
```

In [122]:

```
essay_neg_standardized_Xtrain
```

Out[122]:

```
array([[0.13888889],
       [0.04938272],
       [0.        ],
       ...,
       [0.59567901],
       [0.15432099],
       [0.24382716]])
```

In [123]:

```
print(essay_neg_standardized_Xtrain.shape)
print(essay_neg_standardized_Xtest.shape)
print(essay_neg_standardized_Xcv.shape)
```

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

10.6.1. Encoding of neu on Train,Test and CV data

In [124]:

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

scalar = MinMaxScaler()

essay_neu_standardized_Xtrain = scalar.fit_transform(X_train['neu'].values.reshape(-1, 1))
essay_neu_standardized_Xtest = scalar.transform(X_test['neu'].values.reshape(-1, 1))
essay_neu_standardized_Xcv = scalar.transform(X_cv['neu'].values.reshape(-1, 1))
```

In [125]:

```
essay_neu_standardized_Xtrain
```

Out[125]:

```
array([[0.42204724],
       [0.6503937 ],
       [0.6       ],
       ...,
       [0.54173228],
       [0.66771654],
       [0.4015748 ]])
```

In [126]:

```
print(essay_neu_standardized_Xtrain.shape)
print(essay_neu_standardized_Xtest.shape)
print(essay_neu_standardized_Xcv.shape)
```

```
(49041, 1)
(36052, 1)
```

```
(24155, 1)
```

10.7.1. Encoding of compound on Train,Test and CV data

In [127]:

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

scalar = MinMaxScaler()

essay_compound_standardized_Xtrain = scalar.fit_transform(X_train['compound'].values.reshape(-1, 1)
)
essay_compound_standardized_Xtest = scalar.transform(X_test['compound'].values.reshape(-1, 1))
essay_compound_standardized_Xcv = scalar.transform(X_cv['compound'].values.reshape(-1, 1))
```

In [128]:

```
essay_compound_standardized_Xtrain
```

Out[128]:

```
array([[0.9943823 ],
       [0.99001856],
       [0.99563625],
       ...,
       [0.01394392],
       [0.97968601],
       [0.98906556]])
```

In [129]:

```
print(essay_compound_standardized_Xtrain.shape)
print(essay_compound_standardized_Xtest.shape)
print(essay_compound_standardized_Xcv.shape)
```

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

10.8.1. Encoding of number_of_words_in_essays on Train,Test and CV data

In [130]:

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

scalar = MinMaxScaler()

number_of_words_in_essays_standardized_Xtrain =
scalar.fit_transform(X_train['number_of_words_in_essays'].values.reshape(-1, 1))
number_of_words_in_essays_standardized_Xtest = scalar.transform(X_test['number_of_words_in_essays'
].values.reshape(-1, 1))
number_of_words_in_essays_standardized_Xcv = scalar.transform(X_cv['number_of_words_in_essays'].va
lues.reshape(-1, 1))
```

In [131]:

```
number_of_words_in_essays_standardized_Xtrain
```

Out[131]:

```
array([[0.14741036],
       [0.26693227],
```

```
       [0.31075697],
       ...,
       [0.37848606],
       [0.44621514],
       [0.12749004]])
```

In [132]:

```
print(number_of_words_in_essays_standardized_Xtrain.shape)
print(number_of_words_in_essays_standardized_Xtest.shape)
print(number_of_words_in_essays_standardized_Xcv.shape)
```

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

10.9.1. Encoding of number_of_words_in_the_title on Train,Test and CV data

In [133]:

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

scalar = MinMaxScaler()

number_of_words_in_the_title_standardized_Xtrain =
scalar.fit_transform(X_train['number_of_words_in_the_title'].values.reshape(-1, 1))
number_of_words_in_the_title_standardized_Xtest =
scalar.transform(X_test['number_of_words_in_the_title'].values.reshape(-1, 1))
number_of_words_in_the_title_standardized_Xcv =
scalar.transform(X_cv['number_of_words_in_the_title'].values.reshape(-1, 1))
```

In [134]:

```
number_of_words_in_the_title_standardized_Xtrain
```

Out[134]:

```
array([[0.2       ],
       [0.4       ],
       [0.4       ],
       ...,
       [0.2       ],
       [0.26666667],
       [0.26666667]])
```

In [135]:

```
print(number_of_words_in_the_title_standardized_Xtrain.shape)
print(number_of_words_in_the_title_standardized_Xtest.shape)
print(number_of_words_in_the_title_standardized_Xcv.shape)
```

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

11. Printing Dimensions of all Preprocessed Data

In [136]:

```
print(categories_one_hot_Xtrain.shape)
print(categories_one_hot_Xtest.shape)
print(categories_one_hot_Xcv.shape)
print(sub_categories_one_hot_Xtrain.shape)
```

```
print(sub_categories_one_hot_Xtest.shape)
print(sub_categories_one_hot_Xcv.shape)
print(school_state_one_hot_Xtrain.shape)
print(school_state_one_hot_Xtest.shape)
print(school_state_one_hot_Xcv.shape)
print(teacher_prefix_one_hot_Xtrain.shape)
print(teacher_prefix_one_hot_Xtest.shape)
print(teacher_prefix_one_hot_Xcv.shape)
print(grade_one_hot_Xtrain.shape)
print(grade_one_hot_Xtest.shape)
print(grade_one_hot_Xcv.shape)
print(text_bow_Xtrain.shape)
print(text_bow_Xtest.shape)
print(text_bow_Xcv.shape)
print(title_bow_Xtrain.shape)
print(title_bow_Xtest.shape)
print(title_bow_Xcv.shape)
print(text_tfidf_Xtrain.shape)
print(text_tfidf_Xtest.shape)
print(text_tfidf_Xcv.shape)
print(title_tfidf_Xtrain.shape)
print(title_tfidf_Xtest.shape)
print(title_tfidf_Xcv.shape)
print(average_w2v_on_essay_Xtrain.shape)
print(average_w2v_on_essay_Xtest.shape)
print(average_w2v_on_essay_Xcv.shape)
print(average_w2v_on_titles_Xtrain.shape)
print(average_w2v_on_titles_Xtest.shape)
print(average_w2v_on_titles_Xcv.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xtrain.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xtest.shape)
print(tfidf_weighted_w2v_on_essay_matrix_Xcv.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xtrain.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xtest.shape)
print(tfidf_weighted_w2v_on_title_matrix_Xcv.shape)
print(price_standardized_Xtrain.shape)
print(price_standardized_Xtest.shape)
print(price_standardized_Xcv.shape)
print(quantity_standardized_Xtrain.shape)
print(quantity_standardized_Xtest.shape)
print(quantity_standardized_Xcv.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtrain.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xtest.shape)
print(teacher_number_of_previously_posted_projects_standardized_Xcv .shape)
print(essay_pos_standardized_Xtrain.shape)
print(essay_pos_standardized_Xtest.shape)
print(essay_pos_standardized_Xcv.shape)
print(essay_neg_standardized_Xtrain.shape)
print(essay_neg_standardized_Xtest.shape)
print(essay_neg_standardized_Xcv.shape)
print(essay_neu_standardized_Xtrain.shape)
print(essay_neu_standardized_Xtest.shape)
print(essay_neu_standardized_Xcv.shape)
print(essay_compound_standardized_Xtrain.shape)
print(essay_compound_standardized_Xtest.shape)
print(essay_compound_standardized_Xcv.shape)
print(number_of_words_in_essays_standardized_Xtrain.shape)
print(number_of_words_in_essays_standardized_Xtest.shape)
print(number_of_words_in_essays_standardized_Xcv.shape)
print(number_of_words_in_the_title_standardized_Xtrain.shape)
print(number_of_words_in_the_title_standardized_Xtest.shape)
print(number_of_words_in_the_title_standardized_Xcv.shape)
```

```
(49041, 9)
(36052, 9)
(24155, 9)
(49041, 30)
(36052, 30)
(24155, 30)
(49041, 51)
(36052, 51)
(24155, 51)
(49041, 5)
(36052, 5)
(24155, 5)
(49041, 4)
```

```
(36052, 4)
(24155, 4)
(49041, 5000)
(36052, 5000)
(24155, 5000)
(49041, 2022)
(36052, 2022)
(24155, 2022)
(49041, 5000)
(36052, 5000)
(24155, 5000)
(49041, 2022)
(36052, 2022)
(24155, 2022)
(49041, 300)
(36052, 300)
(24155, 300)
(49041, 300)
(36052, 300)
(24155, 300)
(49041, 300)
(36052, 300)
(24155, 300)
(49041, 300)
(36052, 300)
(24155, 300)
(49041, 1)
(36052, 1)
(24155, 1)
(49041, 1)
(36052, 1)
(24155, 1)
(49041, 1)
(36052, 1)
(24155, 1)
(49041, 1)
(36052, 1)
(24155, 1)
(49041, 1)
(36052, 1)
(24155, 1)
(49041, 1)
(36052, 1)
(24155, 1)
(49041, 1)
(36052, 1)
(24155, 1)
(49041, 1)
(36052, 1)
(24155, 1)
```

12. Creating Different Sets of Data for Training Model

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

In [137]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain1 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrair
,teacher_number_of_previously_posted_projects_standardized_Xtrain,text_bow_Xtrain,title_bow_Xtrain
)).tocsr()
Xtest1 = hstack(( categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest
,teacher_prefix_one_hot_Xtest,grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xt
est,teacher_number_of_previously_posted_projects_standardized_Xtest,text_bow_Xtest,title_bow_Xtest
```

```
est,teacher_number_of_previously_posted_projects_standardized_Xtest,text_bow_Xtest,title_bow_Xtest
)).tocsr()
Xcv1 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_c
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,text_bow_Xcv,title_bow_Xcv)).tocsr()

print(Xtrain1.shape,y_train.shape)
print(Xtest1.shape,y_test.shape)
print(Xcv1.shape,y_cv.shape)
```

```
(49041, 7124) (49041,)
(36052, 7124) (36052,)
(24155, 7124) (24155,)
```

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

In [138]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain2 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,text_tfidf_Xtrain,title_tfidf_Xtr
ain)).tocsr()
Xtest2 = hstack(( categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest
,teacher_prefix_one_hot_Xtest,grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xt
est,teacher_number_of_previously_posted_projects_standardized_Xtest,text_tfidf_Xtest,title_tfidf_Xt
est)).tocsr()
Xcv2 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_c
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,text_tfidf_Xcv,title_tfidf_Xcv)).tocsr()

print(Xtrain2.shape,y_train.shape)
print(Xtest2.shape,y_test.shape)
print(Xcv2.shape,y_cv.shape)
```

```
(49041, 7124) (49041,)
(36052, 7124) (36052,)
(24155, 7124) (24155,)
```

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

In [139]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain3 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,average_w2v_on_essay_Xtrain,aver
age_w2v_on_titles_Xtrain)).tocsr()
Xtest3 = hstack(( categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest
,teacher_prefix_one_hot_Xtest,grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xt
est,teacher_number_of_previously_posted_projects_standardized_Xtest,average_w2v_on_essay_Xtest,ave
rage_w2v_on_titles_Xtest)).tocsr()
Xcv3 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_c
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,average_w2v_on_essay_Xcv,average_w2v_on_titles_Xcv)).tocs
r()

print(Xtrain3.shape,y_train.shape)
print(Xtest3.shape,y_test.shape)
```

```
print(Xcv3.shape,y_cv.shape)
```

```
(49041, 702) (49041,)
(36052, 702) (36052,)
(24155, 702) (24155,)
```

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

In [140]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain4 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,tfidf_weighted_w2v_on_essay_matri
_Xtrain,tfidf_weighted_w2v_on_title_matrix_Xtrain)).tocsr()
Xtest4 = hstack((categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest,
teacher_prefix_one_hot_Xtest,
grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xtest,teacher_number_of_previous
ly_posted_projects_standardized_Xtest,tfidf_weighted_w2v_on_essay_matrix_Xtest,tfidf_weighted_w2v_o
n_title_matrix_Xtest)).tocsr()
Xcv4 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_o
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,tfidf_weighted_w2v_on_essay_matrix_Xcv,tfidf_weighted_w2v_
on_title_matrix_Xcv)).tocsr()

print(Xtrain4.shape,y_train.shape)
print(Xtest4.shape,y_test.shape)
print(Xcv4.shape,y_cv.shape)
```

```
(49041, 702) (49041,)
(36052, 702) (36052,)
(24155, 702) (24155,)
```

Set 5: categorical + numerical features

In [141]:

```
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
Xtrain5 =
hstack((categories_one_hot_Xtrain,sub_categories_one_hot_Xtrain,school_state_one_hot_Xtrain,teache
r_prefix_one_hot_Xtrain,grade_one_hot_Xtrain,price_standardized_Xtrain,quantity_standardized_Xtrain
,teacher_number_of_previously_posted_projects_standardized_Xtrain,essay_pos_standardized_Xtrain,es
say_neg_standardized_Xtrain,essay_neu_standardized_Xtrain,essay_compound_standardized_Xtrain,numbe
r_of_words_in_essays_standardized_Xtrain,number_of_words_in_the_title_standardized_Xtrain)).tocsr(
)
Xtest5 = hstack(( categories_one_hot_Xtest,sub_categories_one_hot_Xtest,school_state_one_hot_Xtest
,teacher_prefix_one_hot_Xtest,grade_one_hot_Xtest,price_standardized_Xtest,quantity_standardized_Xt
est,teacher_number_of_previously_posted_projects_standardized_Xtest,essay_pos_standardized_Xtest,e
ssay_neg_standardized_Xtest,essay_neu_standardized_Xtest,essay_compound_standardized_Xtest,number_
of_words_in_essays_standardized_Xtest,number_of_words_in_the_title_standardized_Xtest)).tocsr()
Xcv5 =
hstack((categories_one_hot_Xcv,sub_categories_one_hot_Xcv,school_state_one_hot_Xcv,teacher_prefix_o
ne_hot_Xcv,grade_one_hot_Xcv,price_standardized_Xcv,quantity_standardized_Xcv,teacher_number_of_pre
viously_posted_projects_standardized_Xcv,essay_pos_standardized_Xcv,essay_neg_standardized_Xcv,ess
ay_neu_standardized_Xcv,essay_compound_standardized_Xcv,number_of_words_in_essays_standardized_Xcv
,number_of_words_in_the_title_standardized_Xcv)).tocsr()

print(Xtrain5.shape,y_train.shape)
print(Xtest5.shape,y_test.shape)
print(Xcv5.shape,y_cv.shape)
```

```
(49041, 108) (49041,)
(36052, 108) (36052,)
(24155, 108) (24155,)
```

13. Appling Logistic Regression on different kind of featurization

13.1. Appling Logistic Regression on BOW, SET 1

Function for predicting Target values Batchwise

In [142]:

```
# def batch_predict(clf, data):
#     # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the po
sitive 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
```

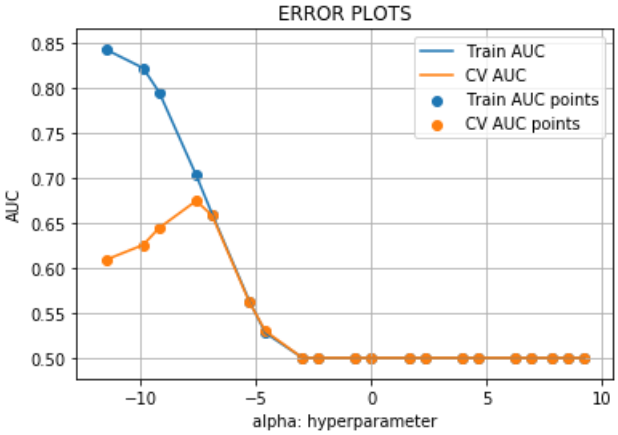
13.1.1. Finding The Best Hyperparameter "alpha"with penalty = 'l1'

In [143]:

```
import math
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR1 = SGDClassifier(loss = 'log', penalty = 'l1', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR1.fit(Xtrain1, y_train)

    y_train_pred_bow = LR1.predict_proba(Xtrain1)[:,1]
    y_cv_pred_bow = LR1.predict_proba(Xcv1)[:,1]

    # 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_train,y_train_pred_bow))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_bow))
```

```
for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

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

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

plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████████████████████████████████████| 20/20
[01:46<00:00,  2.64it/s]
100%|██████████████████████████████████████████████████████████████████████████████████████████████████| 20/20
[00:00<00:00, 146.48it/s]
```



13.1.2. Finding The Best Hyperparameter "alpha" with penalty = 'l1'

We are not able to find the best hyperparameter using penalty = 'l1' regularization so we try it with l2 regularization

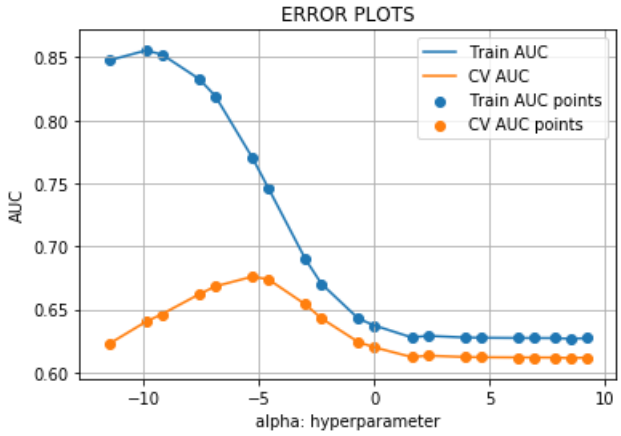
13.1.3. Finding The Best Hyperparameter "alpha" with penalty = 'l2'

In [144]:

```
import math
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
```

```
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR1 = SGDClassifier(loss = 'log', penalty = 'l2', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR1.fit(Xtrain1, y_train)

    y_train_pred_bow = LR1.predict_proba(Xtrain1)[:,1]
    y_cv_pred_bow = LR1.predict_proba(Xcv1)[:,1]

    # 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_train,y_train_pred_bow))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_bow))

for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

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

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

plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████████████████████████| 20/20
[00:11<00:00,  3.89it/s]
100%|██████████████████████████████████████████████████████████████████████████████████████| 20/20
[00:00<00:00, 1106.55it/s]
```



In [145]:

```
score_cv = [x for x in cv_auc]
optimal_alpha_cv = alpha[score_cv.index(max(score_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_cv)))
print("Corresponding alpha value of cv is:",optimal_alpha_cv, '\n')
best_alpha_bow = optimal_alpha_cv
print(best_alpha_bow)
```

```
Maximum AUC score of cv is: 0.676036075523138
Corresponding alpha value of cv is: 0.005

0.005
```

13.1.4 Testing the performance of the model on test data, plotting

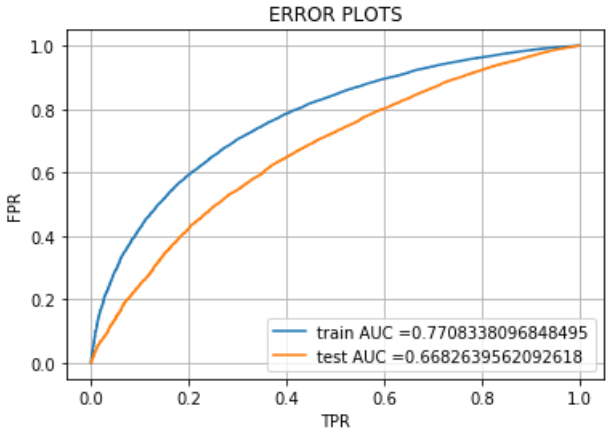
13.1.4. Testing the performance of the model on test data, plotting ROC Curves

In [146]:

```
# best_alpha_bow = 0.001
```

In [147]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


LR1 = SGDClassifier(loss = 'log', penalty = 'l2', alpha = best_alpha_bow , max_iter = 1000,class_we
ight='balanced')
LR1.fit(Xtrain1, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_bow = LR1.predict_proba(Xtrain1)[:,1]
y_test_pred_bow =  LR1.predict_proba(Xtest1)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_bow)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_bow)

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("TPR")
plt.ylabel("FPR")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



13.1.5. Building Confusion Matrix

In [148]:

```
# 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))]
    # (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 [149]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_bow, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_bow, best_t)))
```

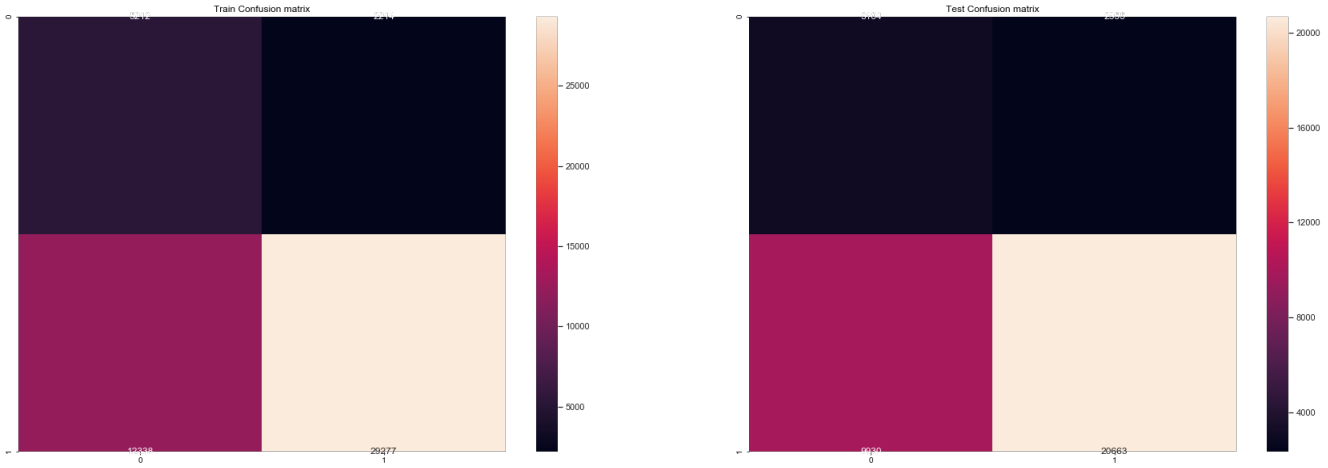
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.4937716326014255 for threshold 0.496
Train confusion matrix
[[ 5212  2214]
 [12338 29277]]
Test confusion matrix
[[ 3104  2355]
 [ 9930 20663]]
```

In [150]:

```
confusion_matrix_train_bow = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_bow, best_t)))
confusion_matrix_test_bow = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_bow, best_t)))
```

In [151]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
sns.set()
sns.heatmap(confusion_matrix_train_bow,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_bow,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



13.2. Appling Logistic Regression on TFIDF, SET 2

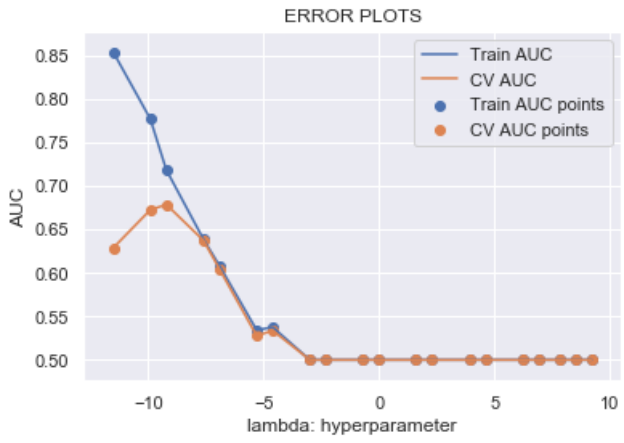
13.2.1. Finding The Best Hyperparameter "alpha" with penalty = 'l1'

In [152]:

```
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
```

```
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR2 = SGDClassifier(loss = 'log', penalty = 'l1', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR2.fit(Xtrain2, y_train)

    y_train_pred_tfidf = LR2.predict_proba(Xtrain2)[:,1]
    y_cv_pred_tfidf = LR2.predict_proba(Xcv2)[:,1]

    # 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_train,y_train_pred_tfidf))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_tfidf))

for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)


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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████| 20/20 [00:14<00:00,  3.80it/s]
100%|██████████| 20/20 [00:00<?, ?it/s]
```



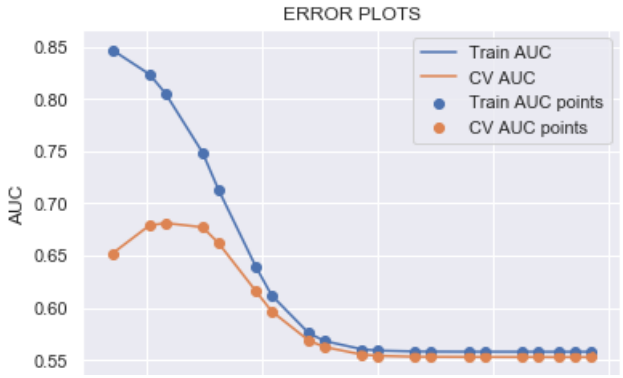
13.2.1. Finding The Best Hyperparameter "alpha" with penalty =

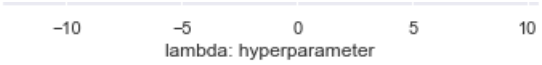
'l2'

In [153]:

```
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR2 = SGDClassifier(loss = 'log', penalty = 'l2', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR2.fit(Xtrain2, y_train)

    y_train_pred_tfidf = LR2.predict_proba(Xtrain2)[:,1]
    y_cv_pred_tfidf = LR2.predict_proba(Xcv2)[:,1]

    # 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_train,y_train_pred_tfidf))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_tfidf))

for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)


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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████| 20/20
[00:06<00:00,  5.00it/s]
100%|██████████| 20/20
[00:00<00:00, 869.09it/s]
```





In [154]:

```
score_cv = [x for x in cv_auc]
optimal_alpha_cv = alpha[score_cv.index(max(score_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_cv)))
print("Corresponding alpha value of cv is:",optimal_alpha_cv, '\n')
best_alpha_tfidf = optimal_alpha_cv
print(best_alpha_tfidf)
```

```
Maximum AUC score of cv is: 0.6810397183417028
Corresponding alpha value of cv is: 0.0001

0.0001
```

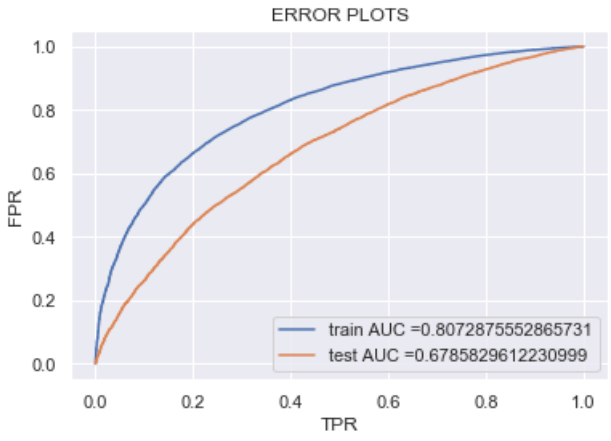
13.2.2. Testing the performance of the model on test data, plotting ROC Curves

In [155]:

```
# best_alpha_tfidf = 0.05
```

In [156]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


LR2 =SGDClassifier(loss = 'log', penalty = 'l2', alpha = best_alpha_tfidf , max_iter = 1000,class_w
eight='balanced')
LR2.fit(Xtrain2, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_tfidf = LR2.predict_proba(Xtrain2)[:,1]
y_test_pred_tfidf = LR2.predict_proba(Xtest2)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf)

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("TPR")
plt.ylabel("FPR")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



13.2.3. Building Confusion Matrix

In [157]:

```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    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 [158]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidf, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidf, best_t)))
```

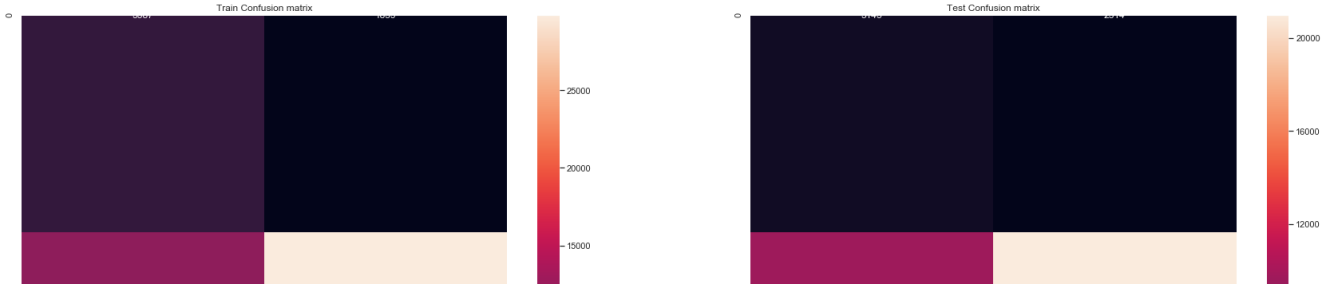
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.5389885105794044 for threshold 0.471
Train confusion matrix
[[ 5587  1839]
 [11802 29813]]
Test confusion matrix
[[ 3145  2314]
 [ 9635 20958]]
```

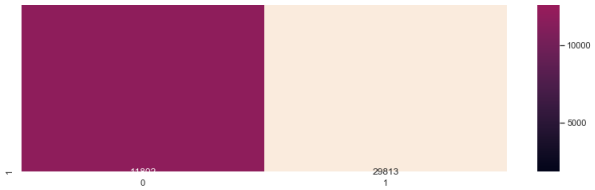
In [159]:

```
confusion_matrix_train_tfidf = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidf, best_t)))
confusion_matrix_test_tfidf = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidf, best_t)))
```

In [160]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidf,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidf,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```





13.3. Appling Logistic Regression on Average Word2Vec, SET3

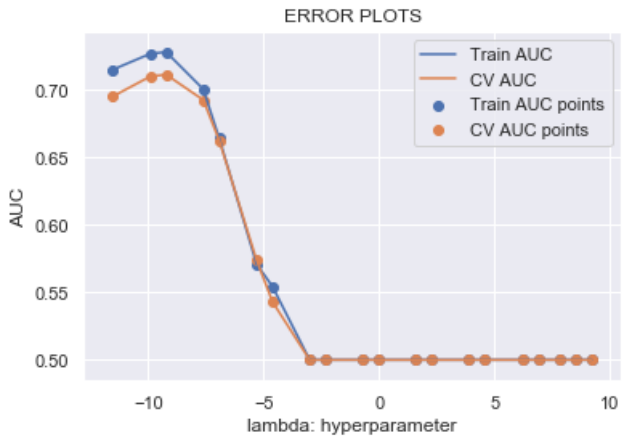
13.3.1. Finding The Best Hyperparameter "alpha" with penalty = 'l1'

In [161]:

```
import math
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR3 = SGDClassifier(loss = 'log', penalty = 'l1', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR3.fit(Xtrain3, y_train)

    y_train_pred_avgw2v = LR3.predict_proba(Xtrain3)[:,1]
    y_cv_pred_avgw2v = LR3.predict_proba(Xcv3)[:,1]

    # 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_train,y_train_pred_avgw2v))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_avgw2v))

for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████| 20/20
[02:55<00:00,  2.67s/it]
100%|██████████| 20/20
```

```
[00:00<00:00, 19953.87it/s]
```



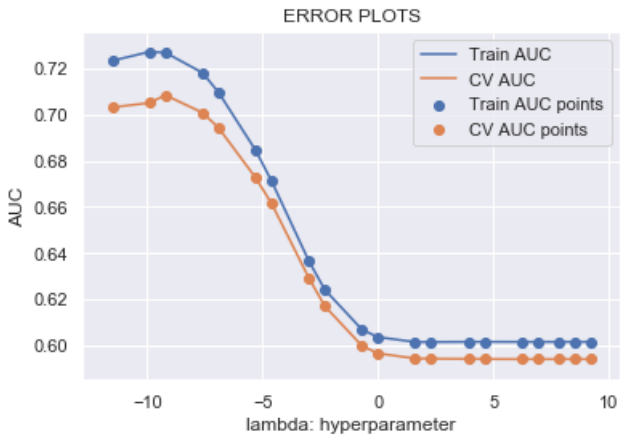
13.3.1. Finding The Best Hyperparameter "alpha" with penalty = 'l2'

In [162]:

```
import math
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR3 = SGDClassifier(loss = 'log', penalty = 'l2', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR3.fit(Xtrain3, y_train)

    y_train_pred_avgw2v = LR3.predict_proba(Xtrain3)[:,1]
    y_cv_pred_avgw2v = LR3.predict_proba(Xcv3)[:,1]

    # 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_train,y_train_pred_avgw2v))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_avgw2v))
for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
```

```
plt.grid(True)
plt.show()
```

```
100%|████████████████████████████████████████████████████████████████████████████| 20/20
[01:46<00:00,  1.06it/s]
100%|████████████████████████████████████████████████████████████████████████████| 2
0/20 [00:00<?, ?it/s]
```



In [163]:

```
score_cv = [x for x in cv_auc]
optimal_alpha_cv = alpha[score_cv.index(max(score_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_cv)))
print("Corresponding alpha value of cv is:",optimal_alpha_cv, '\n')
best_alpha_avgw2v = optimal_alpha_cv
print(best_alpha_avgw2v)
```

```
Maximum AUC score of cv is: 0.708466552276801
Corresponding alpha value of cv is: 0.0001

0.0001
```

13.3.2. Testing the performance of the model on test data, plotting ROC Curves

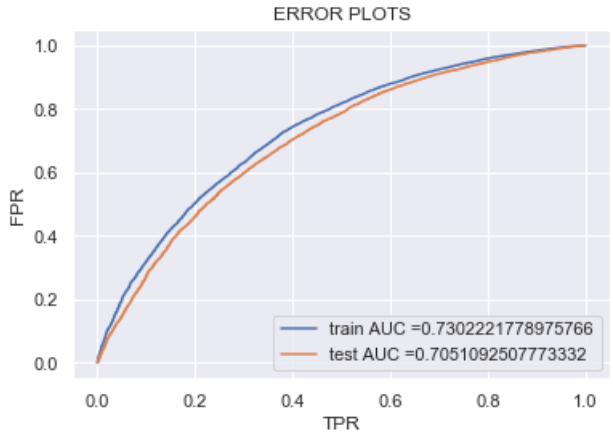
In [164]:

```
# best_alpha_avgw2v = 0.1
```

In [165]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


LR3 =SGDClassifier(loss = 'log', penalty = 'l2', alpha = best_alpha_avgw2v , max_iter = 1000,class_
weight='balanced')
LR3.fit(Xtrain3, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_avgw2v = LR3.predict_proba(Xtrain3)[:,1]
y_test_pred_avgw2v = LR3.predict_proba(Xtest3)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_avgw2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_avgw2v)

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("TPR")
```

```
plt.ylabel("FPR")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



13.3.3. Building Confusion Matrix

In [166]:

```
# 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))]
    # (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 [167]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_avgw2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_avgw2v, best_t)))
```

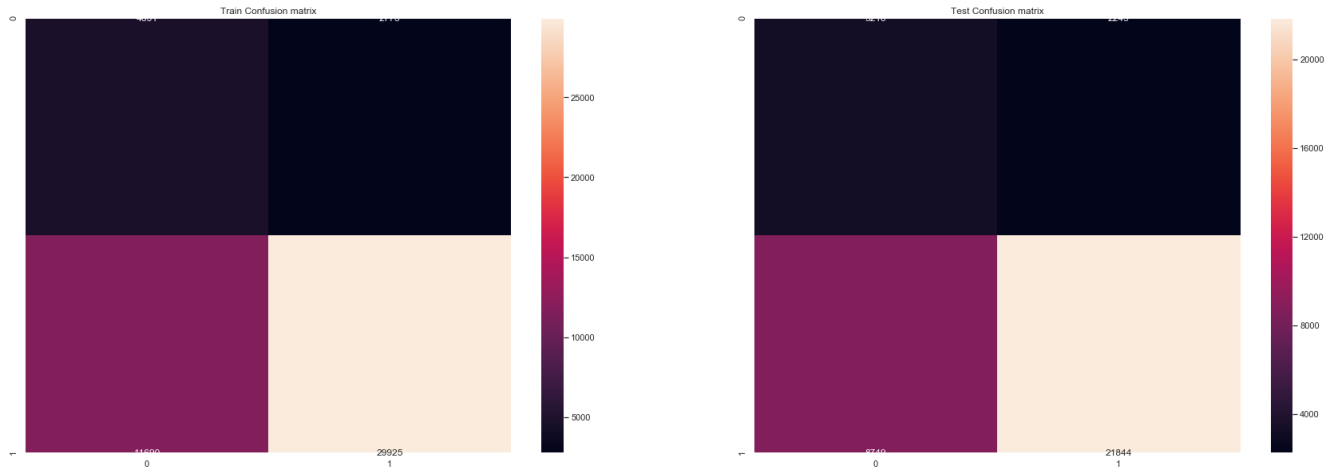
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.45037643068463334 for threshold 0.403
Train confusion matrix
[[ 4651  2775]
 [11690 29925]]
Test confusion matrix
[[ 3210  2249]
 [ 8749 21844]]
```

In [168]:

```
confusion_matrix_train_avgw2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_avgw2v, best_t)))
confusion_matrix_test_avgw2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_avgw2v, best_t)))
```

In [169]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_avgw2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_avgw2v,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



13.4. Appling Logistic Regression on TFIDF Word2Vec, SET4

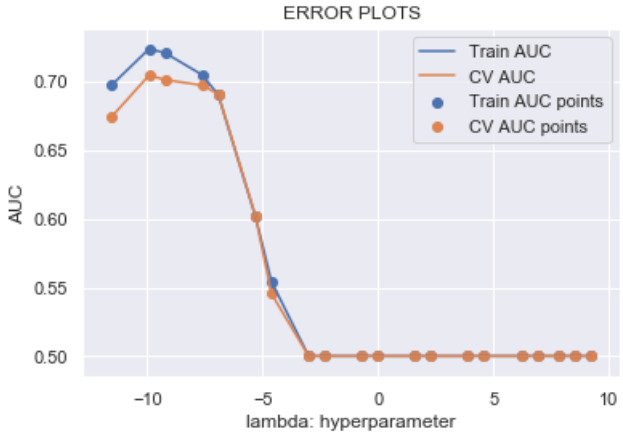
13.4.1. Finding The Best Hyperparameter "alpha" with penalty = 'l1'

In [170]:

```
import math
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR4 = SGDClassifier(loss = 'log', penalty = 'l1', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR4.fit(Xtrain4, y_train)

    y_train_pred_tfidfw2v = LR4.predict_proba(Xtrain4)[:,1]
    y_cv_pred_tfidfw2v = LR4.predict_proba(Xcv4)[:,1]

    # 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_train,y_train_pred_tfidfw2v))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_tfidfw2v))
```

```
for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|████████████████████████████████████████████████████████████████████████████| 20/20
[02:54<00:00,  2.65s/it]
100%|████████████████████████████████████████████████████████████████████████████| 2
0/20 [00:00<?, ?it/s]
```



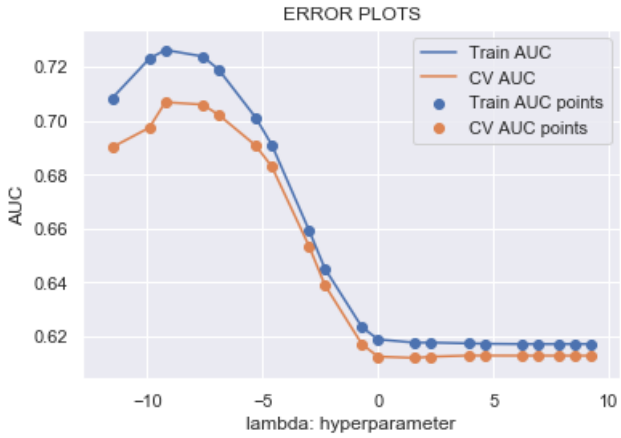
13.4.1. Finding The Best Hyperparameter "alpha" with penalty = 'l2'

In [171]:

```
import math
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR4 = SGDClassifier(loss = 'log', penalty = 'l2', alpha = i , max_iter = 1000,class_weight='bal
anced')
    LR4.fit(Xtrain4, y_train)

    y_train_pred_tfidfw2v = LR4.predict_proba(Xtrain4)[:,1]
```

```
    y_cv_pred_tfidfw2v = LR4.predict_proba(Xcv4)[:,1]

    # 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_train,y_train_pred_tfidfw2v))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_tfidfw2v))

for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████████████████████████| 20/20
[00:50<00:00,  1.12it/s]
100%|██████████████████████████████████████████████████████████████████████████████████████| 20/20
[00:00<00:00, 20006.22it/s]
```



In [172]:

```
score_cv = [x for x in cv_auc]
optimal_alpha_cv = alpha[score_cv.index(max(score_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_cv)))
print("Corresponding alpha value of cv is:",optimal_alpha_cv, '\n')
best_alpha_tfidfw2v = optimal_alpha_cv
print(best_alpha_tfidfw2v)
```

```
Maximum AUC score of cv is: 0.7067997029822874
Corresponding alpha value of cv is: 0.0001

0.0001
```

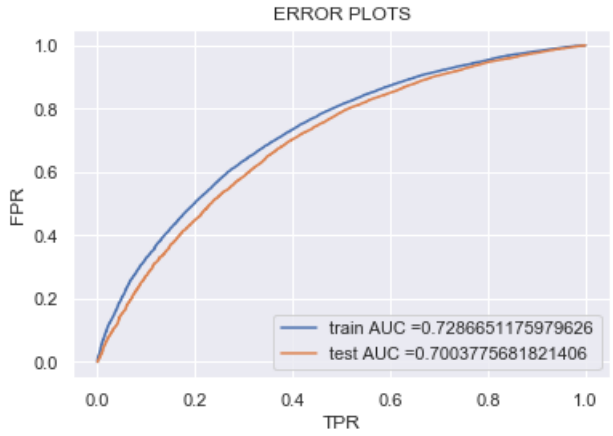
13.4.2. Testing the performance of the model on test data, plotting ROC Curves

In [173]:

```
# best_alpha_tfidfw2v = 0.007
```

In [174]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


LR4 =SGDClassifier(loss = 'log', penalty = 'l2', alpha = best_alpha_tfidfw2v , max_iter = 1000,clas
s_weight='balanced')
LR4.fit(Xtrain4, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_tfidfw2v = LR4.predict_proba(Xtrain4)[:,1]
y_test_pred_tfidfw2v = LR4.predict_proba(Xtest4)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidfw2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidfw2v)

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("TPR")
plt.ylabel("FPR")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



13.4.3. Building Confusion Matrix

In [175]:

```
# 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))]
    # (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 [176]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidfw2v, best_t)))
```

```
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidfw2v, best_t)))
```

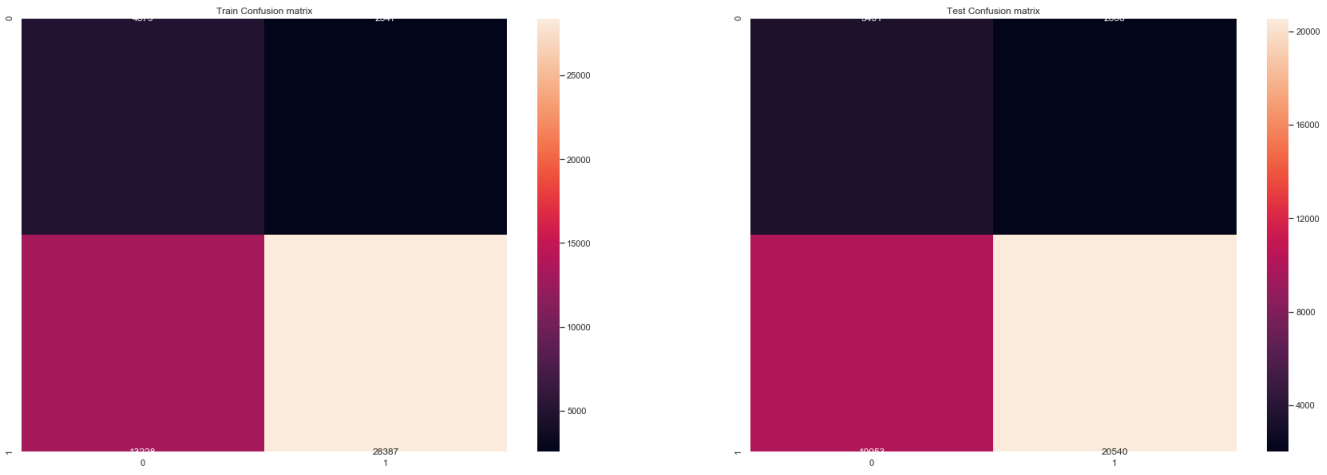
```
==================================================================================================

the maximum value of tpr*(1-fpr) 0.44817277598744387 for threshold 0.481
Train confusion matrix
[[ 4879  2547]
 [13228 28387]]
Test confusion matrix
[[ 3451  2008]
 [10053 20540]]
```

In [177]:

```
confusion_matrix_train_tfidfw2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidfw2v, best_t)))
confusion_matrix_test_tfidfw2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidfw2v, best_t)))
```

In [178]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidfw2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidfw2v,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



13.4.4. Finding The Best Hyperparameter "alpha" with penalty = 'l2' using LogisticRegression classifier

In [179]:

```
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
```

```
cv_auc = []
C = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
          500, 1000, 2500, 5000, 10000]
log_C =[]
for i in tqdm(alpha):
    LR4 = LogisticRegression(penalty = 'l2', C = i,class_weight='balanced')
    LR4.fit(Xtrain4, y_train)

    y_train_pred_tfidfw2v = LR4.predict_proba(Xtrain4)[:,1]
    y_cv_pred_tfidfw2v = LR4.predict_proba(Xcv4)[:,1]

    # 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_train,y_train_pred_tfidfw2v))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_tfidfw2v))

for a in tqdm(alpha):
    b = math.log(a)
    log_C.append(b)


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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████████████████████████| 20/20
[08:34<00:00, 42.13s/it]
100%|██████████████████████████████████████████████████████████████████████████████████████| 20/20
[00:00<00:00, 1243.49it/s]
```

In [180]:

```
score_cv = [x for x in cv_auc]
optimal_alpha_cv = alpha[score_cv.index(max(score_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_cv)))
print("Corresponding alpha value of cv is:",optimal_alpha_cv, '\n')
best_alpha_C = optimal_alpha_cv
print(best_alpha_C)
```

```
Maximum AUC score of cv is: 0.7111344796492414
Corresponding alpha value of cv is: 0.5

0.5
```

12.4.5 Testing the performance of the model on test data, and

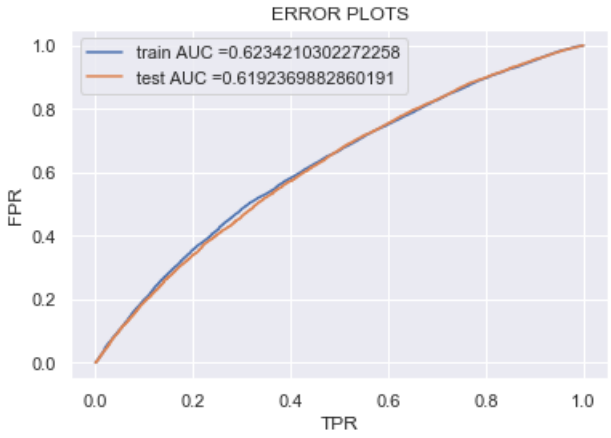
13.4.5. Testing the performance of the model on test data, plotting ROC Curves

In [181]:

```
# best_alpha_lr_tfidfw2v = 0.01
```

In [182]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


LR4 =SGDClassifier(loss = 'log', penalty = 'l2', alpha = best_alpha_C, max_iter = 1000,class_weight
='balanced')
LR4.fit(Xtrain4, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_tfidfw2v = LR4.predict_proba(Xtrain4)[:,1]
y_test_pred_tfidfw2v = LR4.predict_proba(Xtest4)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidfw2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidfw2v)

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("TPR")
plt.ylabel("FPR")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



13.4.6. Building Confusion Matrix

In [183]:

```
# 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))]
    # (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)
```

```
            predictions.append(0)
    return predictions
```

In [184]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_tfidfw2v, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_tfidfw2v, best_t)))
```

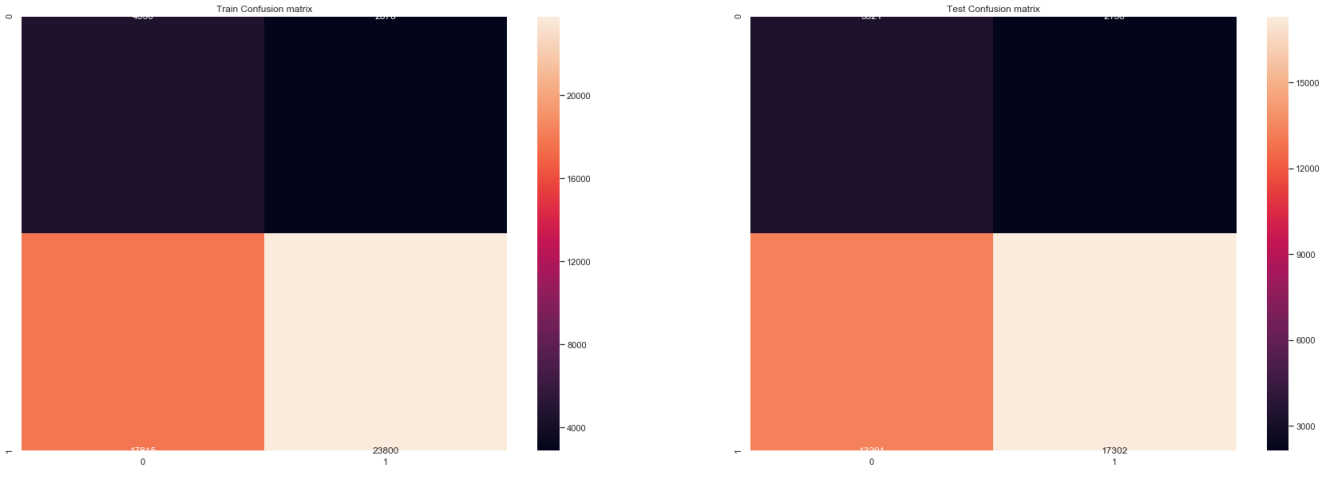
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.35041566274202635 for threshold 0.496
Train confusion matrix
[[ 4550  2876]
 [17815 23800]]
Test confusion matrix
[[ 3321  2138]
 [13291 17302]]
```

In [185]:

```
confusion_matrix_train_tfidfw2v = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_tfidfw2v, best_t)))
confusion_matrix_test_tfidfw2v = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_tfidfw2v, best_t)))
```

In [186]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_tfidfw2v,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_tfidfw2v,annot = True , ax = axes[1],fmt ='g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



13.5. Appling Logistic Regression on SET5

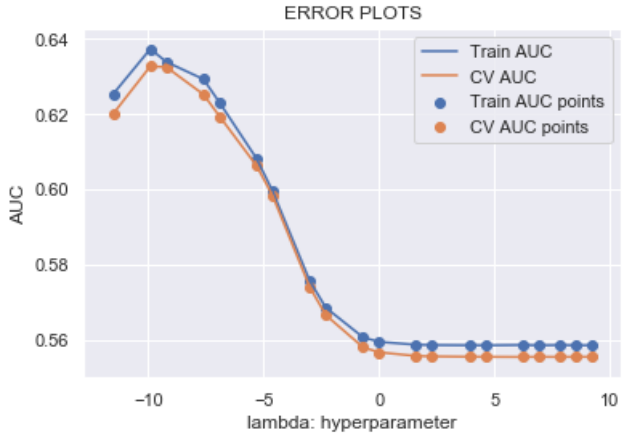
13.5.1. Finding The Best Hyperparameter "alpha" with penalty = 'l2'

In [187]:

```
import matplotlib.pyplot as plt
from sklearn.linear_model import SGDClassifier
```

```
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
# alpha = [1, 0.7, 0.6,0.5,0.4,0.3,0.2,1]
alpha = [0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1, 5, 10, 50, 100,
         500, 1000, 2500, 5000, 10000]
log_alpha = []
for i in tqdm(alpha):
    LR5 = SGDClassifier(loss = 'log', penalty = 'l2', alpha = i , max_iter = 1000,class_weight = 'b
alanced')
    LR5.fit(Xtrain5, y_train)

    y_train_pred_scores = LR5.predict_proba(Xtrain5)[:,1]
    y_cv_pred_scores = LR5.predict_proba(Xcv5)[:,1]

    # 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_train,y_train_pred_scores))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred_scores))

for a in tqdm(alpha):
    b = math.log(a)
    log_alpha.append(b)

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

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

plt.legend()
plt.xlabel("lambda: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```

```
100%|██████████████████████████████████████████████████████████████████████████████████████| 20/20
[00:08<00:00,  5.32it/s]
100%|██████████████████████████████████████████████████████████████████████████████████████| 2
0/20 [00:00<?, ?it/s]
```



In [188]:

```
score_cv = [x for x in cv_auc]
optimal_alpha_cv = alpha[score_cv.index(max(score_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_cv)))
print("Corresponding alpha value of cv is:",optimal_alpha_cv, '\n')
best_alpha_score = optimal_alpha_cv
print(best_alpha_score)
```

```
Maximum AUC score of cv is: 0.632679984545602
Corresponding alpha value of cv is: 5e-05

5e-05
```

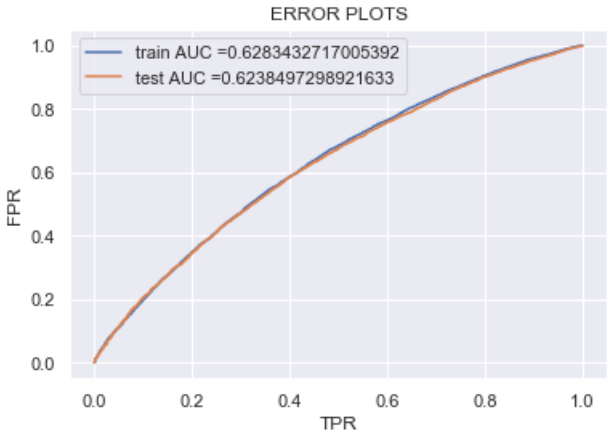
13.5.2. Testing the performance of the model on test data, plotting ROC Curves

In [189]:

```
# best_alpha_score = 0.2
```

In [190]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


LR5 =SGDClassifier(loss = 'log', penalty = 'l2', alpha = best_alpha_tfidfw2v , max_iter = 1000,clas
s_weight='balanced')
LR5.fit(Xtrain5, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred_scores = LR5.predict_proba(Xtrain5)[:,1]
y_test_pred_scores = LR5.predict_proba(Xtest5)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_scores)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_scores)

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("TPR")
plt.ylabel("FPR")
plt.title("ERROR PLOTS")
plt.grid(True)
plt.show()
```



13.5.3. Building Confusion Matrix

In [191]:

```
# 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))]
    # (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 [192]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred_scores, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred_scores, best_t)))
```

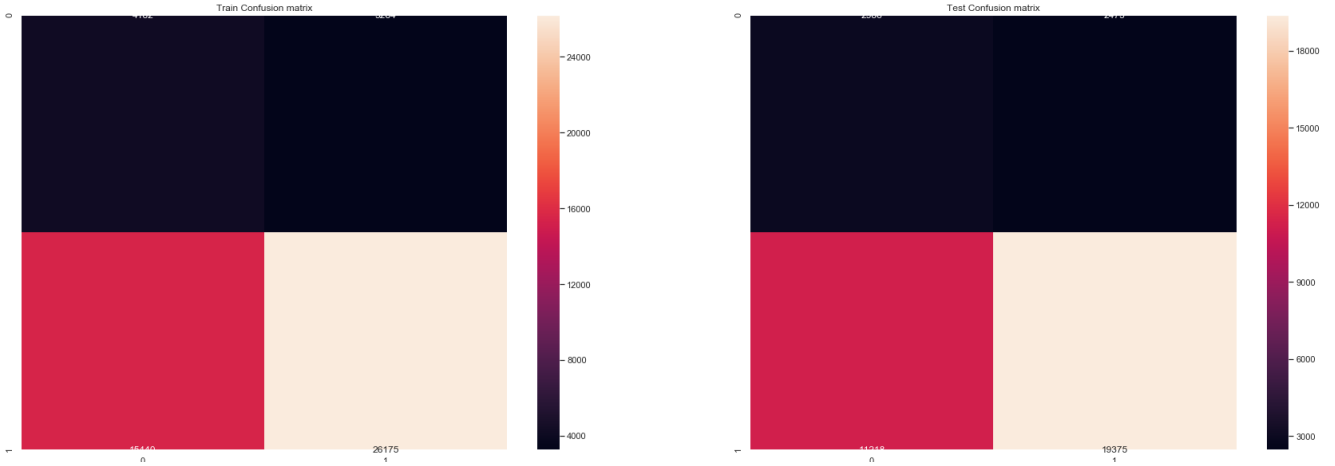
```
====================================================================================================

the maximum value of tpr*(1-fpr) 0.35252013061776993 for threshold 0.55
Train confusion matrix
[[ 4162  3264]
 [15440 26175]]
Test confusion matrix
[[ 2986  2473]
 [11218 19375]]
```

In [193]:

```
confusion_matrix_train_scores = pd.DataFrame(confusion_matrix(y_train,
predict_with_best_t(y_train_pred_scores, best_t)))
confusion_matrix_test_scores = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred_scores, best_t)))
```

In [194]:

```
import seaborn as sns
fig, axes = plt.subplots(nrows=1, ncols=2,figsize=(30,10))
# sns.set(font_scale = 4)
sns.heatmap(confusion_matrix_train_scores,annot = True ,ax = axes[0],fmt='g')
sns.heatmap(confusion_matrix_test_scores,annot = True , ax = axes[1],fmt = 'g')
axes[0].set_title('Train Confusion matrix')
axes[1].set_title('Test Confusion matrix')
plt.show()
```



14. Conclusion

In [195]:

```
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "Hyper parameter", "Train AUC","Test AUC"]

x.add_row(["BOW", "SGD Classifier using l2 regularization", 0.005, 0.7708,0.6682])
x.add_row(["TFIDF", "SGD Classifier using l2 regularization", 0.0001, 0.8072,0.6785])
x.add_row(["Average W2V", "SGD Classifier using l2 regularization", 0.0001 , 0.7302,0.7051])
x.add_row(["TFIDF W2V","SGD Classifier using l2 regularization", 0.0001, 0.7286,0.7003])
x.add_row(["TFIDF W2V","Logistic Regression Classifier with l2 regularization", 0.5, 0.6234,0.6192]
)
x.add_row(["Numerical + Categorical","SGD Classifier using l2 regularization", 5e-05,
0.6283,0.6238])
```

In [196]:

```
print(x)
```

```
+-------------------------+------------------------------------------------------------+----------------
---------+----------+
|        Vectorizer       |                           Model                            | Hyper parameter
Train AUC | Test AUC |
+-------------------------+------------------------------------------------------------+----------------
---------+----------+
|           BOW           |         SGD Classifier using l2 regularization             |      0.005
|   0.7708  |  0.6682  |
|          TFIDF          |         SGD Classifier using l2 regularization             |      0.0001
|   0.8072  |  0.6785  |
|       Average W2V       |         SGD Classifier using l2 regularization             |      0.0001
|   0.7302  |  0.7051  |
|        TFIDF W2V        |         SGD Classifier using l2 regularization             |      0.0001
|   0.7286  |  0.7003  |
|        TFIDF W2V        | Logistic Regression Classifier with l2 regularization      |       0.5
|   0.6234  |  0.6192  |
| Numerical + Categorical |         SGD Classifier using l2 regularization             |      5e-05
|   0.6283  |  0.6238  |
+-------------------------+------------------------------------------------------------+----------------
---------+----------+
```

In [ ]: