DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

In [1]:

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

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
```

```
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

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

In [3]:

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

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

In [4]:

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

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

Out[4]:

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

Preprocessing of Project Subject Categories

In [5]:

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

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

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

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

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

Preprocessing of Project Subject Subcategories

In [6]:

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

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

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

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

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

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

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

Text preprocessing

In [7]:

```
# merge two column text dataframe:
project_data["essay"] = project_data["project_essay_1"].map(str) +\
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
```

In [8]:

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

Out[8]:

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

In [9]:

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

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

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

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

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

==========

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

==========

FEATURES

FEATURES

categorical data : school_state, clean_categories , clean_subcategories, project_grade_category, teacher_prefix

numerical data : quantity, teacher_number_of_previously_posted_projects, price

New Features :

sentiment score's of each of the essay : numerical data

number of words in the title : numerical data

number of words in the combine essays : numerical data

In [10]:

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

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

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

In [11]:

```
new_title = []
for i in tqdm(project_data['project_title']):
    j = decontracted(i)
    new_title.append(j)
```

```
100%|██████████| 109248/109248 [00:02<00:00, 44791.21it/s]
```

In [12]:

```
title_word_count = []
#for i in project_data['project_title']:
for i in tqdm(new_title):
    j = len(i.split())
    title_word_count.append(j)
    #print(j)
project_data['title_word_count'] = title_word_count
```

```
100%|██████████| 109248/109248 [00:00<00:00, 464155.41it/s]
```

In [13]:

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

Out[13]:

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 [14]:

```
new_essay = []
for i in tqdm(project_data['essay']):
    j = decontracted(i)
    new_essay.append(j)
```

```
100%|██████████| 109248/109248 [00:04<00:00, 24313.18it/s]
```

In [15]:

```
essay_word_count = []
for i in tqdm(new_essay):
    j = len(i.split())
    essay_word_count.append(j)
    #print(j)
project_data['essay_word_count'] = essay_word_count
```

```
100%|██████████| 109248/109248 [00:02<00:00, 39511.08it/s]
```

In [16]:

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

Out[16]:

	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

Computing sentimental scores from essay reviews :

In [17]:

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

In [18]:

```
sia = SentimentIntensityAnalyzer()
#There is NEGITIVE and POSITIVE and NEUTRAL and COMPUND SCORES
#http://www.nltk.org/howto/sentiment.html

negitive = []
positive = []
```

```
neutral = []
compound = []
for i in tqdm(project_data['essay']):
    j = sia.polarity_scores(i)['neg']
    k = sia.polarity_scores(i)['neu']
    l = sia.polarity_scores(i)['pos']
    m = sia.polarity_scores(i)['compound']
    negitive.append(j)
    positive.append(k)
    neutral.append(l)
    compound.append(m)
```

```
100%|██████████| 109248/109248 [38:09<00:00, 47.71it/s]
```

In [19]:

```
project_data['negative'] = negitive
project_data['positive'] = positive
project_data['neutral'] = neutral
project_data['compound'] = compound
```

In [20]:

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

Out[20]:

	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 rows × 24 columns

In [21]:

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

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

In [22]:

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

```
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

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

In [23]:

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

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

In [24]:

```
# 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"]
```

Preprocessing Essays

Preprocessing Essays

In [25]:

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

```
100%|██████████| 109248/109248 [02:05<00:00, 873.28it/s]
```

In [26]:

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

Out[26]:

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

Preprocessing Of Project Title

In [27]:

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

```
100%|██████████| 109248/109248 [00:06<00:00, 17842.13it/s]
```

In [28]:

```
preprocessed_titles[10]
```

Out[28]:

```
'reading changes lives'
```

In [29]:

```
project_data.columns
```

Out[29]:

Out[29]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay', 'title_word_count',
       'essay_word_count', 'negative', 'positive', 'neutral', 'compound'],
      dtype='object')
```

In [30]:

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

In [31]:

```
project_data['clean_essay'] = preprocessed_essays
project_data['clean_project_title'] = preprocessed_titles
project_data.head(1)
```

Out[31]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_categ
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	2016-12-05 13:43:57	Grades Pre

1 rows × 24 columns

In [32]:

```
project_data['teacher_prefix'].value_counts()
```

Out[32]:

```
Mrs.       57269
Ms.        38955
Mr.        10648
Teacher     2360
Dr.           13
Name: teacher_prefix, dtype: int64
```

In [33]:

```
project_data = project_data.fillna(project_data['teacher_prefix'].value_counts().index[0])
```

Splitting The Data Set :

In [34]:

```
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"],random_state = 42)
x_train, x_cv, y_train, y_cv = train_test_split(x_train, y_train,stratify=y_train,test_size=0.33)
```

In [35]:

```
print(x_test.columns)
print(x_cv.columns)
print(x_train.columns)
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
```

```
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'title_word_count',
       'essay_word_count', 'negative', 'positive', 'neutral', 'compound',
       'clean_essay', 'clean_project_title'],
      dtype='object')
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'title_word_count',
       'essay_word_count', 'negative', 'positive', 'neutral', 'compound',
       'clean_essay', 'clean_project_title'],
      dtype='object')
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'title_word_count',
       'essay_word_count', 'negative', 'positive', 'neutral', 'compound',
       'clean_essay', 'clean_project_title'],
      dtype='object')
```

Using Response Coding (Probality Values)

In [36]:

```
project_data['school_state'].unique()
```

Out[36]:

```
array(['IN', 'FL', 'AZ', 'KY', 'TX', 'CT', 'GA', 'SC', 'NC', 'CA', 'NY',
       'OK', 'MA', 'NV', 'OH', 'PA', 'AL', 'LA', 'VA', 'AR', 'WA', 'WV',
       'ID', 'TN', 'MS', 'CO', 'UT', 'IL', 'MI', 'HI', 'IA', 'RI', 'NJ',
       'MO', 'DE', 'MN', 'ME', 'WY', 'ND', 'OR', 'AK', 'MD', 'WI', 'SD',
       'NE', 'NM', 'DC', 'KS', 'MT', 'NH', 'VT'], dtype=object)
```

In [37]:

```
def Responsetable(table, col) :
    cat = table[col].unique()

    freq_Pos = []
    for i in cat :
        freq_Pos.append(len(table.loc[(table[col] == i) & (table['project_is_approved'] == 1)]))


    freq_Neg = []
    for i in cat :
        freq_Neg.append(len(table.loc[(table[col] == i) & (table['project_is_approved'] == 0)]))


    encoded_Pos = []
    for i in range(len(cat)) :
        encoded_Pos.append(freq_Pos[i]/(freq_Pos[i] + freq_Neg[i]))

    encoded_Neg = []
    encoded_Neg[:] = [1 - x for x in encoded_Pos]

    encoded_Pos_val = dict(zip(cat, encoded_Pos))
    encoded_Neg_val = dict(zip(cat, encoded_Neg))

    return encoded_Pos_val, encoded_Neg_val
```

In [38]:

```
pos_cleancat, neg_cleancat = Responsetable(x_train,'clean_categories')
pos_cleansubcat, neg_cleansubcat = Responsetable(x_train,'clean_subcategories')
pos_schoolstate, neg_schoolstate = Responsetable(x_train, 'school_state')
```

```
pos_teacherprefix, neg_teacherprefix = Responsetable(x_train, 'teacher_prefix')
pos_projgradecat, neg_projgradecat = Responsetable(x_train, 'project_grade_category')
```

In [39]:

```
type(pos_cleancat)
type(neg_cleancat)
type(pos_cleansubcat)
type(neg_cleansubcat)
type(pos_schoolstate)
type(neg_schoolstate)
type(pos_teacherprefix)
type(neg_teacherprefix)
type(pos_projgradecat)
type(neg_projgradecat)
```

Out[39]:

```
dict
```

In [40]:

```
pos_cleancat
```

Out[40]:


```
{'AppliedLearning Health_Sports': 0.8297101449275363,
 'Literacy_Language': 0.865115842791483,
 'Literacy_Language Math_Science': 0.8682218445852,
 'Math_Science': 0.814227695532556,
 'Math_Science Music_Arts': 0.8319672131147541,
 'Health_Sports': 0.8471797114123306,
 'Health_Sports SpecialNeeds': 0.8794212218649518,
 'AppliedLearning Math_Science': 0.796078431372549,
 'AppliedLearning Literacy_Language': 0.8594704684317719,
 'AppliedLearning': 0.8210093896713615,
 'Math_Science Health_Sports': 0.7789473684210526,
 'SpecialNeeds': 0.8244897959183674,
 'Math_Science AppliedLearning': 0.8370786516853933,
 'Literacy_Language SpecialNeeds': 0.8566610455311973,
 'History_Civics Literacy_Language': 0.89375,
 'Music_Arts': 0.8535637149028078,
 'Math_Science SpecialNeeds': 0.8454882571075402,
 'Literacy_Language Music_Arts': 0.8416988416988417,
 'Math_Science Literacy_Language': 0.8480531813865148,
 'AppliedLearning SpecialNeeds': 0.839258114374034,
 'History_Civics': 0.8483080513418904,
 'Health_Sports Math_Science': 0.8489208633093526,
 'AppliedLearning Music_Arts': 0.8292682926829268,
 'Health_Sports Literacy_Language': 0.850828729281768,
 'Warmth Care_Hunger': 0.9220563847429519,
 'Math_Science History_Civics': 0.8518518518518519,
 'History_Civics SpecialNeeds': 0.7768595041322314,
 'Health_Sports AppliedLearning': 0.8351648351648352,
 'Literacy_Language AppliedLearning': 0.8848920863309353,
 'History_Civics Music_Arts': 0.8380281690140845,
 'AppliedLearning History_Civics': 0.8369565217391305,
 'Health_Sports Music_Arts': 0.8169014084507042,
 'History_Civics Math_Science': 0.8865248226950354,
 'SpecialNeeds Music_Arts': 0.8695652173913043,
 'Literacy_Language History_Civics': 0.8870056497175142,
 'Health_Sports History_Civics': 0.875,
 'Math_Science Warmth Care_Hunger': 0.0,
 'Music_Arts History_Civics': 0.7777777777777778,
 'Music_Arts SpecialNeeds': 0.875,
 'History_Civics AppliedLearning': 0.7857142857142857,
 'Music_Arts Health_Sports': 0.42857142857142855,
 'Literacy_Language Health_Sports': 0.8055555555555556,
 'Music_Arts AppliedLearning': 1.0,
 'SpecialNeeds Health_Sports': 0.9473684210526315,
 'SpecialNeeds Warmth Care_Hunger': 0.8181818181818182,
 'History_Civics Health_Sports': 0.8333333333333334,
 'Health_Sports Warmth Care_Hunger': 1.0,
 'AppliedLearning Warmth Care_Hunger': 1.0,
 'Music_Arts Warmth Care_Hunger': 0.5,
```

```
 'Literacy_Language Warmth Care_Hunger': 1.0,
 'History_Civics Warmth Care_Hunger': 0.0}
```

In [41]:

```
x_train['clean_cat_pos'] = x_train['clean_categories'].map(pos_cleancat)
x_train['clean_cat_neg'] = x_train['clean_categories'].map(neg_cleancat)
x_train['clean_subcat_pos'] = x_train['clean_subcategories'].map(pos_cleansubcat)
x_train['clean_subcat_neg'] = x_train['clean_subcategories'].map(neg_cleansubcat)
x_train['school_state_pos'] = x_train['school_state'].map(pos_schoolstate)
x_train['school_state_neg'] = x_train['school_state'].map(neg_schoolstate)
x_train['teacher_prefix_pos'] = x_train['teacher_prefix'].map(pos_teacherprefix)
x_train['teacher_prefix_neg'] = x_train['teacher_prefix'].map(neg_teacherprefix)
x_train['proj_grade_cat_pos'] = x_train['project_grade_category'].map(pos_projgradecat)
x_train['proj_grade_cat_neg'] = x_train['project_grade_category'].map(neg_projgradecat)
```

In [42]:

```
x_cv['clean_cat_pos'] = x_cv['clean_categories'].map(pos_cleancat)
x_cv['clean_cat_neg'] = x_cv['clean_categories'].map(neg_cleancat)
x_cv['clean_subcat_pos'] = x_cv['clean_subcategories'].map(pos_cleansubcat)
x_cv['clean_subcat_neg'] = x_cv['clean_subcategories'].map(neg_cleansubcat)
x_cv['school_state_pos'] = x_cv['school_state'].map(pos_schoolstate)
x_cv['school_state_neg'] = x_cv['school_state'].map(neg_schoolstate)
x_cv['teacher_prefix_pos'] = x_cv['teacher_prefix'].map(pos_teacherprefix)
x_cv['teacher_prefix_neg'] = x_cv['teacher_prefix'].map(neg_teacherprefix)
x_cv['proj_grade_cat_pos'] = x_cv['project_grade_category'].map(pos_projgradecat)
x_cv['proj_grade_cat_neg'] = x_cv['project_grade_category'].map(neg_projgradecat)
```

In [43]:

```
x_test['clean_cat_pos'] = x_test['clean_categories'].map(pos_cleancat)
x_test['clean_cat_neg'] = x_test['clean_categories'].map(neg_cleancat)
x_test['clean_subcat_pos'] = x_test['clean_subcategories'].map(pos_cleansubcat)
x_test['clean_subcat_neg'] = x_test['clean_subcategories'].map(neg_cleansubcat)
x_test['school_state_pos'] = x_test['school_state'].map(pos_schoolstate)
x_test['school_state_neg'] = x_test['school_state'].map(neg_schoolstate)
x_test['teacher_prefix_pos'] = x_test['teacher_prefix'].map(pos_teacherprefix)
x_test['teacher_prefix_neg'] = x_test['teacher_prefix'].map(neg_teacherprefix)
x_test['proj_grade_cat_pos'] = x_test['project_grade_category'].map(pos_projgradecat)
x_test['proj_grade_cat_neg'] = x_test['project_grade_category'].map(neg_projgradecat)
```

In [44]:

```
x_cv.isnull().sum()
```

Out[44]:

```
Unnamed: 0                                      0
id                                              0
teacher_id                                      0
teacher_prefix                                  0
school_state                                    0
project_submitted_datetime                      0
project_grade_category                          0
project_essay_1                                 0
project_essay_2                                 0
project_essay_3                                 0
project_essay_4                                 0
project_resource_summary                        0
teacher_number_of_previously_posted_projects    0
project_is_approved                             0
clean_categories                                0
clean_subcategories                             0
title_word_count                                0
essay_word_count                                0
negative                                        0
positive                                        0
neutral                                         0
compound                                        0
clean_essay                                     0
clean_project_title                             0
clean_cat_pos                                   0
```

```
clean_cat_pos                                   0
clean_cat_neg                                   0
clean_subcat_pos                               13
clean_subcat_neg                               13
school_state_pos                                0
school_state_neg                                0
teacher_prefix_pos                              0
teacher_prefix_neg                              0
proj_grade_cat_pos                              0
proj_grade_cat_neg                              0
dtype: int64
```

In [45]:

```
x_cv["clean_subcat_pos"].fillna(value=0.5,inplace = True)
x_cv["clean_subcat_neg"].fillna(value=0.5,inplace = True)
```

In [46]:

```
x_test.isnull().sum()
```

Out[46]:

```
Unnamed: 0                                      0
id                                              0
teacher_id                                      0
teacher_prefix                                  0
school_state                                    0
project_submitted_datetime                      0
project_grade_category                          0
project_essay_1                                 0
project_essay_2                                 0
project_essay_3                                 0
project_essay_4                                 0
project_resource_summary                        0
teacher_number_of_previously_posted_projects    0
project_is_approved                             0
clean_categories                                0
clean_subcategories                             0
title_word_count                                0
essay_word_count                                0
negative                                        0
positive                                        0
neutral                                         0
compound                                        0
clean_essay                                     0
clean_project_title                             0
clean_cat_pos                                   0
clean_cat_neg                                   0
clean_subcat_pos                               23
clean_subcat_neg                               23
school_state_pos                                0
school_state_neg                                0
teacher_prefix_pos                              0
teacher_prefix_neg                              0
proj_grade_cat_pos                              0
proj_grade_cat_neg                              0
dtype: int64
```

In [47]:

```
x_test["clean_subcat_pos"].fillna(value=0.5,inplace = True)
x_test["clean_subcat_neg"].fillna(value=0.5,inplace = True)
```

Bag Of Words :

In [48]:

```
from sklearn.feature_extraction.text import CountVectorizer
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(x_train['clean_essay'])
```

```
train_text_bow = vectorizer.fit_transform(x_train['clean_essay'])
cv_text_bow = vectorizer.transform(x_cv['clean_essay'])
test_text_bow = vectorizer.transform(x_test['clean_essay'])
print("Shape of matrix after one hot encodig ",train_text_bow.shape, y_train.shape)
print("Shape of matrix after one hot encodig ",test_text_bow.shape, y_test.shape)
print("Shape of matrix after one hot encodig ",cv_text_bow.shape, y_cv.shape)
```

```
Shape of matrix after one hot encodig  (49041, 12178) (49041,)
Shape of matrix after one hot encodig  (36052, 12178) (36052,)
Shape of matrix after one hot encodig  (24155, 12178) (24155,)
```

Bag Of Words(Project_Title)

In [49]:

```
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(x_train['clean_project_title'])
train_title_bow = vectorizer.transform(x_train['clean_project_title'])
cv_title_bow = vectorizer.transform(x_cv['clean_project_title'])
test_title_bow = vectorizer.transform(x_test['clean_project_title'])
print("Shape of matrix ",train_title_bow.shape)
print("Shape of matrix ",cv_title_bow.shape)
print("Shape of matrix ",test_title_bow.shape)
```

```
Shape of matrix  (49041, 2106)
Shape of matrix  (24155, 2106)
Shape of matrix  (36052, 2106)
```

TF-IDF(Project_Essay)

In [50]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(x_train['clean_essay'])
train_text_tfidf = vectorizer.transform(x_train['clean_essay'])
cv_text_tfidf = vectorizer.transform(x_cv['clean_essay'])
test_text_tfidf = vectorizer.transform(x_test['clean_essay'])
print("Shape of matrix ",train_text_tfidf.shape)
print("Shape of matrix ",cv_text_tfidf.shape)
print("Shape of matrix ",test_text_tfidf.shape)
```

```
Shape of matrix  (49041, 12178)
Shape of matrix  (24155, 12178)
Shape of matrix  (36052, 12178)
```

TF-IDF(Project_Title)

In [51]:

```
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(x_train['clean_project_title'])
train_title_tfidf = vectorizer.transform(x_train['clean_project_title'])
cv_title_tfidf = vectorizer.transform(x_cv['clean_project_title'])
test_title_tfidf = vectorizer.transform(x_test['clean_project_title'])
print("Shape of matrix ",test_title_tfidf.shape)
print("Shape of matrix ",cv_title_tfidf.shape)
print("Shape of matrix ",train_title_tfidf.shape)
```

```
Shape of matrix  (36052, 2106)
Shape of matrix  (24155, 2106)
Shape of matrix  (49041, 2106)
```

Avg W2V(Project_Essay)

In [52]:

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

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

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


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

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

```
Loading Glove Model
```

```
1917495it [08:33, 3733.18it/s]
```

```
Done. 1917495  words loaded!
all the words in the coupus 17014413
the unique words in the coupus 58968
The number of words that are present in both glove vectors and our coupus 51503 ( 87.341 %)
word 2 vec length 51503
```

In [53]:

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

In [54]:

```
# compute average word2vec for each review.
train_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
```

```
    train_avg_w2v_vectors.append(vector)

print(len(train_avg_w2v_vectors))
print(len(train_avg_w2v_vectors[0]))
```

```
100%|██████████| 49041/49041 [00:31<00:00, 1572.38it/s]
```

```
49041
300
```

In [55]:

```
# compute average word2vec for each review.
cv_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_cv['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    cv_avg_w2v_vectors.append(vector)

print(len(cv_avg_w2v_vectors))
print(len(cv_avg_w2v_vectors[0]))
```

```
100%|██████████| 24155/24155 [00:15<00:00, 1580.92it/s]
```

```
24155
300
```

In [56]:

```
# average Word2Vec
# compute average word2vec for each review.
test_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    test_avg_w2v_vectors.append(vector)

print(len(test_avg_w2v_vectors))
print(len(test_avg_w2v_vectors[0]))
```

```
100%|██████████| 36052/36052 [00:22<00:00, 1578.67it/s]
```

```
36052
300
```

Avg W2V(Project_Title)

In [57]:

```
# average Word2Vec
# compute average word2vec for each review.
train_title_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['clean_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
```

```
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_title_avg_w2v_vectors.append(vector)

print(len(train_title_avg_w2v_vectors))
print(len(train_title_avg_w2v_vectors[0]))
```

```
100%|██████████| 49041/49041 [00:01<00:00, 29458.19it/s]
```

```
49041
300
```

In [58]:

```
# average Word2Vec
# compute average word2vec for each review.
cv_title_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_cv['clean_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    cv_title_avg_w2v_vectors.append(vector)

print(len(cv_title_avg_w2v_vectors))
print(len(cv_title_avg_w2v_vectors[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 33199.01it/s]
```

```
24155
300
```

In [59]:

```
# average Word2Vec
# compute average word2vec for each review.
test_title_avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['clean_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    test_title_avg_w2v_vectors.append(vector)

print(len(test_title_avg_w2v_vectors))
print(len(test_title_avg_w2v_vectors[0]))
```

```
100%|██████████| 36052/36052 [00:01<00:00, 33366.83it/s]
```

```
36052
300
```

TF-IDF weighted Avg W2V

In [60]:

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(x_train['clean_essay'])
```

```
tfidf_model.fit(x_train['clean_essay'])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [61]:

```
# average Word2Vec
# compute average word2vec for each review.
train_essay_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    train_essay_tfidf_w2v_vectors.append(vector)

print(len(train_essay_tfidf_w2v_vectors))
print(len(train_essay_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 49041/49041 [03:44<00:00, 218.53it/s]
```

```
49041
300
```

In [62]:

```
# average Word2Vec
# compute average word2vec for each review.
cv_essay_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_cv['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    cv_essay_tfidf_w2v_vectors.append(vector)

print(len(cv_essay_tfidf_w2v_vectors))
print(len(cv_essay_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 24155/24155 [01:48<00:00, 221.94it/s]
```

```
24155
300
```

In [63]:

```
# Similarly you can vectorize for title also
# average Word2Vec
# compute average word2vec for each review.
test_essay_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['clean_essay']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
```

```
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    test_essay_tfidf_w2v_vectors.append(vector)

print(len(test_essay_tfidf_w2v_vectors))
print(len(test_essay_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 36052/36052 [02:45<00:00, 218.15it/s]
```

```
36052
300
```

Project Title(TF-IDF weighted Average Word2Vec)

In [64]:

```
# average Word2Vec
# compute average word2vec for each review.
train_title_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_train['clean_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    train_title_tfidf_w2v_vectors.append(vector)

print(len(train_title_tfidf_w2v_vectors))
print(len(train_title_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 49041/49041 [00:03<00:00, 15615.72it/s]
```

```
49041
300
```

In [65]:

```
# average Word2Vec
# compute average word2vec for each review.
cv_title_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_cv['clean_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
```

```
    cv_title_tfidf_w2v_vectors.append(vector)

print(len(cv_title_tfidf_w2v_vectors))
print(len(cv_title_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 24155/24155 [00:01<00:00, 16408.41it/s]
```

```
24155
300
```

In [66]:

```
# average Word2Vec
# compute average word2vec for each review.
test_title_tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(x_test['clean_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    test_title_tfidf_w2v_vectors.append(vector)

print(len(test_title_tfidf_w2v_vectors))
print(len(test_title_tfidf_w2v_vectors[0]))
```

```
100%|██████████| 36052/36052 [00:02<00:00, 15444.12it/s]
```

```
36052
300
```

In [67]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
print(price_data.head())
#print(project_data.columns)
print(x_train.columns)
```

```
        id    price  quantity
0  p000001   459.56         7
1  p000002   515.89        21
2  p000003   298.97         4
3  p000004  1113.69        98
4  p000005   485.99         8
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'title_word_count',
       'essay_word_count', 'negative', 'positive', 'neutral', 'compound',
       'clean_essay', 'clean_project_title', 'clean_cat_pos', 'clean_cat_neg',
       'clean_subcat_pos', 'clean_subcat_neg', 'school_state_pos',
       'school_state_neg', 'teacher_prefix_pos', 'teacher_prefix_neg',
       'proj_grade_cat_pos', 'proj_grade_cat_neg'],
      dtype='object')
```

In [68]:

```
x_train = pd.merge(x_train, price_data, on = "id", how = "left")
x_cv = pd.merge(x_cv, price_data, on = "id", how = "left")
```

```
x_test = pd.merge(x_test, price_data, on = "id", how = "left")
```

In [69]:

```
print(x_train.columns)
```

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'title_word_count',
       'essay_word_count', 'negative', 'positive', 'neutral', 'compound',
       'clean_essay', 'clean_project_title', 'clean_cat_pos', 'clean_cat_neg',
       'clean_subcat_pos', 'clean_subcat_neg', 'school_state_pos',
       'school_state_neg', 'teacher_prefix_pos', 'teacher_prefix_neg',
       'proj_grade_cat_pos', 'proj_grade_cat_neg', 'price', 'quantity'],
      dtype='object')
```

Numerical Features Not to be scaled for RandomForest :

In [70]:

```
price_train= x_train['price'].values.reshape(-1, 1)
price_test= x_test['price'].values.reshape(-1, 1)
price_cv = x_cv['price'].values.reshape(-1,1)
quantity_train = x_train['quantity'].values.reshape(-1,1)
quantity_test = x_test['quantity'].values.reshape(-1,1)
quantity_cv = x_cv['quantity'].values.reshape(-1,1)
prev_projects_train = x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
prev_projects_test = x_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
prev_projects_cv = x_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1)
```

In [71]:

```
essay_neg_test=x_test['negative'].values.reshape(-1,1)
essay_pos_test=x_test['positive'].values.reshape(-1,1)
essay_neu_test=x_test['neutral'].values.reshape(-1,1)
essay_com_test=x_test['compound'].values.reshape(-1,1)
essay_neg_cv=x_cv['negative'].values.reshape(-1,1)
essay_pos_cv=x_cv['positive'].values.reshape(-1,1)
essay_neu_cv=x_cv['neutral'].values.reshape(-1,1)
essay_com_cv=x_cv['compound'].values.reshape(-1,1)
essay_neg_train=x_train['negative'].values.reshape(-1,1)
essay_pos_train=x_train['positive'].values.reshape(-1,1)
essay_neu_train=x_train['neutral'].values.reshape(-1,1)
essay_com_train=x_train['compound'].values.reshape(-1,1)
```

In [72]:

```
cattrain_pos=x_train['clean_cat_pos'].values.reshape(-1,1)
cattrain_neg=x_train['clean_cat_neg'].values.reshape(-1,1)
subcattrain_pos=x_train['clean_subcat_pos'].values.reshape(-1,1)
subcattrain_neg=x_train['clean_subcat_neg'].values.reshape(-1,1)
ss_postrain=x_train['school_state_pos'].values.reshape(-1,1)
ss_negtrain=x_train['school_state_neg'].values.reshape(-1,1)
teachertrain_pos=x_train['teacher_prefix_pos'].values.reshape(-1,1)
teachertrain_neg=x_train['teacher_prefix_neg'].values.reshape(-1,1)
projgradetrain_pos=x_train['proj_grade_cat_pos'].values.reshape(-1,1)
projgradetrain_neg=x_train['proj_grade_cat_neg'].values.reshape(-1,1)
catcv_pos=x_cv['clean_cat_pos'].values.reshape(-1,1)
catcv_neg=x_cv['clean_cat_neg'].values.reshape(-1,1)
subcatcv_pos=x_cv['clean_subcat_pos'].values.reshape(-1,1)
subcatcv_neg=x_cv['clean_subcat_neg'].values.reshape(-1,1)
ss_poscv=x_cv['school_state_pos'].values.reshape(-1,1)
ss_negcv=x_cv['school_state_neg'].values.reshape(-1,1)
teachercv_pos=x_cv['teacher_prefix_pos'].values.reshape(-1,1)
teachercv_neg=x_cv['teacher_prefix_neg'].values.reshape(-1,1)
projgradecv_pos=x_cv['proj_grade_cat_pos'].values.reshape(-1,1)
projgradecv_neg=x_cv['proj_grade_cat_neg'].values.reshape(-1,1)
```

In [73]:

```
cattest_pos=x_test['clean_cat_pos'].values.reshape(-1,1)
cattest_neg=x_test['clean_cat_neg'].values.reshape(-1,1)
subcattest_pos=x_test['clean_subcat_pos'].values.reshape(-1,1)
subcattest_neg=x_test['clean_subcat_neg'].values.reshape(-1,1)
ss_postest=x_test['school_state_pos'].values.reshape(-1,1)
ss_negtest=x_test['school_state_neg'].values.reshape(-1,1)
teachertest_pos=x_test['teacher_prefix_pos'].values.reshape(-1,1)
teachertest_neg=x_test['teacher_prefix_neg'].values.reshape(-1,1)
projgradetest_pos=x_test['proj_grade_cat_pos'].values.reshape(-1,1)
projgradetest_neg=x_test['proj_grade_cat_neg'].values.reshape(-1,1)
```

In [74]:

```
type(train_text_bow)
```

Out[74]:

```
scipy.sparse.csr.csr_matrix
```

In [75]:

```
from scipy.sparse import csr_matrix
train_avg_w2v_vectors=csr_matrix(train_avg_w2v_vectors)
cv_avg_w2v_vectors=csr_matrix(cv_avg_w2v_vectors)
test_avg_w2v_vectors=csr_matrix(test_avg_w2v_vectors)
train_title_avg_w2v_vectors=csr_matrix(train_title_avg_w2v_vectors)
cv_title_avg_w2v_vectors=csr_matrix(cv_title_avg_w2v_vectors)
test_title_avg_w2v_vectors=csr_matrix(test_title_avg_w2v_vectors)
train_essay_tfidf_w2v_vectors=csr_matrix(train_essay_tfidf_w2v_vectors)
cv_essay_tfidf_w2v_vectors=csr_matrix(cv_essay_tfidf_w2v_vectors)
test_essay_tfidf_w2v_vectors=csr_matrix(test_essay_tfidf_w2v_vectors)
train_title_tfidf_w2v_vectors=csr_matrix(train_title_tfidf_w2v_vectors)
cv_title_tfidf_w2v_vectors=csr_matrix(cv_title_tfidf_w2v_vectors)
test_title_tfidf_w2v_vectors=csr_matrix(test_title_tfidf_w2v_vectors)
```

In [76]:

```
type(train_avg_w2v_vectors)
```

Out[76]:

```
scipy.sparse.csr.csr_matrix
```

SET 1

In [77]:

```
from scipy.sparse import hstack
X_tr =
hstack((train_text_bow,train_title_bow,ss_postrain,ss_negtrain,projgradetrain_pos,projgradetrain_ne
g,teachertrain_pos,teachertrain_neg,cattrain_pos,cattrain_neg,subcattrain_pos,subcattrain_neg,prev_
projects_train,price_train,quantity_train,essay_neg_train,essay_pos_train,essay_neu_train,essay_com
_train)).tocsr()
X_te =
hstack((test_text_bow,test_title_bow,ss_postest,ss_negtest,projgradetest_pos,projgradetest_neg,tea
chertest_pos,teachertest_neg,cattest_pos,cattest_neg,subcattest_pos,subcattest_neg,prev_projects_te
st,price_test,quantity_test,essay_neg_test,essay_pos_test,essay_neu_test,essay_com_test)).tocsr()
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49041, 14280) (49041,)
(36052, 14280) (36052,)
```

In [78]:

```
X_cv =
hstack((cv_text_bow,cv_title_bow,ss_poscv,ss_negcv,projgradecv_pos,projgradecv_neg,teachercv_pos,t
eachercv_neg,catcv_pos,catcv_neg,subcatcv_pos,subcatcv_neg,prev_projects_cv,price_cv,quantity_cv,e
ssay_neg_cv,essay_pos_cv,essay_neu_cv,essay_com_cv)).tocsr()
print(X_cv.shape, y_cv.shape)
```

```
(24155, 14280) (24155,)
```

SET 2

In [77]:

```
from scipy.sparse import hstack
X_tr2 =
hstack((train_text_tfidf,train_title_tfidf,ss_postrain,ss_negtrain,projgradetrain_pos,projgradetrai
n_neg,teachertrain_pos,teachertrain_neg,cattrain_pos,cattrain_neg,subcattrain_pos,subcattrain_neg,
prev_projects_train,price_train,quantity_train,essay_neg_train,essay_pos_train,essay_neu_train,essa
y_com_train)).tocsr()
X_cv2 =
hstack((cv_text_tfidf,cv_title_tfidf,ss_poscv,ss_negcv,projgradecv_pos,projgradecv_neg,teachercv_po
s,teachercv_neg,catcv_pos,catcv_neg,subcatcv_pos,subcatcv_neg,prev_projects_cv,price_cv,quantity_cv
,essay_neg_cv,essay_pos_cv,essay_neu_cv,essay_com_cv)).tocsr()
X_te2 =
hstack((test_text_tfidf,test_title_tfidf,ss_postest,ss_negtest,projgradetest_pos,projgradetest_neg
,teachertest_pos,teachertest_neg,cattest_pos,cattest_neg,subcattest_pos,subcattest_neg,prev_project
s_test,price_test,quantity_test,essay_neg_test,essay_pos_test,essay_neu_test,essay_com_test)).tocsr
()
print("Final Data matrix")
print(X_tr2.shape, y_train.shape)
print(X_cv2.shape, y_train.shape)
print(X_te2.shape, y_test.shape)
```

```
Final Data matrix
(49041, 14240) (49041,)
(24155, 14240) (49041,)
(36052, 14240) (36052,)
```

SET 3

In [77]:

```
from scipy.sparse import hstack
X_tr3 =
hstack((train_avg_w2v_vectors,train_title_avg_w2v_vectors,ss_postrain,ss_negtrain,projgradetrain_po
s,projgradetrain_neg,teachertrain_pos,teachertrain_neg,cattrain_pos,cattrain_neg,subcattrain_pos,s
ubcattrain_neg,prev_projects_train,price_train,quantity_train,essay_neg_train,essay_pos_train,essay
_neu_train,essay_com_train)).tocsr()
X_cv3 =
hstack((cv_avg_w2v_vectors,cv_title_avg_w2v_vectors,ss_poscv,ss_negcv,projgradecv_pos,projgradecv_n
eg,teachercv_pos,teachercv_neg,catcv_pos,catcv_neg,subcatcv_pos,subcatcv_neg,prev_projects_cv,pric
e_cv,quantity_cv,essay_neg_cv,essay_pos_cv,essay_neu_cv,essay_com_cv)).tocsr()
X_te3 =
hstack((test_avg_w2v_vectors,test_title_avg_w2v_vectors,ss_postest,ss_negtest,projgradetest_pos,pr
ojgradetest_neg,teachertest_pos,teachertest_neg,cattest_pos,cattest_neg,subcattest_pos,subcattest_n
eg,prev_projects_test,price_test,quantity_test,essay_neg_test,essay_pos_test,essay_neu_test,essay_c
om_test)).tocsr()
print("Final Data matrix")
print(X_tr3.shape, y_train.shape)
print(X_cv3.shape, y_cv.shape)
print(X_te3.shape, y_test.shape)
```

```
Final Data matrix
(49041, 617) (49041,)
(24155, 617) (24155,)
(36052, 617) (36052,)
```

SET 4

In [78]:

```
from scipy.sparse import hstack
X_tr4 =
hstack((train_essay_tfidf_w2v_vectors,train_title_tfidf_w2v_vectors,ss_postrain,ss_negtrain,projgra
detrain_pos,projgradetrain_neg,teachertrain_pos,teachertrain_neg,cattrain_pos,cattrain_neg,subcattr
ain_pos,subcattrain_neg,prev_projects_train,price_train,quantity_train,essay_neg_train,essay_pos_tr
ain,essay_neu_train,essay_com_train)).tocsr()
X_cv4 =
hstack((cv_essay_tfidf_w2v_vectors,cv_title_tfidf_w2v_vectors,ss_poscv,ss_negcv,projgradecv_pos,pr
ojgradecv_neg,teachercv_pos,teachercv_neg,catcv_pos,catcv_neg,subcatcv_pos,subcatcv_neg,prev_projec
ts_cv,price_cv,quantity_cv,essay_neg_cv,essay_pos_cv,essay_neu_cv,essay_com_cv)).tocsr()
X_te4 = hstack((test_essay_tfidf_w2v_vectors,test_title_tfidf_w2v_vectors,ss_postest,ss_negtest,pr
ojgradetest_pos,projgradetest_neg,teachertest_pos,teachertest_neg,cattest_pos,cattest_neg,subcattes
t_pos,subcattest_neg,prev_projects_test,price_test,quantity_test,essay_neg_test,essay_pos_test,essa
y_neu_test,essay_com_test)).tocsr()
print("Final Data matrix")
print(X_tr4.shape, y_train.shape)
print(X_cv4.shape, y_cv.shape)
print(X_te4.shape, y_test.shape)
```

```
Final Data matrix
(49041, 617) (49041,)
(24155, 617) (24155,)
(36052, 617) (36052,)
```

Assignment 9: RF and GBDT

Response Coding: Example

> The response tabel is built only on train dataset. For a category which is not there in train data and present in test data, we will encode them with default values Ex: in our test data if have State: D then we encode it as [0.5, 0.5]

1. **Apply both Random Forrest and GBDT on these feature sets**
   - Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(BOW) + preprocessed_eassay (BOW)
   - Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
   - Set 3: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V). Here for this set take **20K** datapoints only.
   - Set 4: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V). Here for this set take **20K** datapoints only.
2. **The hyper paramter tuning (Consider any two hyper parameters preferably n_estimators, max_depth)**
   - Consider the following range for hyperparameters **n_estimators** = [10, 50, 100, 150, 200, 300, 500, 1000], **max_depth** = [2, 3, 4, 5, 6, 7, 8, 9, 10]
   - Find the best hyper parameter which will give the maximum AUC value
   - Find the best hyper paramter using simple cross validation data
   - You can write your own for loops to do this task
3. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure

     with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

     or
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown

in the figure

seaborn heat maps with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**

- You can choose either of the plotting techniques: 3d plot or heat map
- Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
- Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

4. **Conclusion**

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

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

Random Forest and GBDT

Applying Random Forest

Applying Random Forests on BOW

In [80]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
import seaborn as sns
```

In [94]:

```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
from sklearn.ensemble import RandomForestClassifier
main_score_trdata = []
main_score_cvdata = []
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = RandomForestClassifier(n_estimators=i,criterion='gini',max_depth=j,max_features='auto'
,bootstrap=True,n_jobs=-1,class_weight='balanced')
        rf.fit(X_tr, y_train)
        y_train_pred=rf.predict_proba(X_tr)[:, 1]
        y_cv_pred=rf.predict_proba(X_cv)[:, 1]
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    main_score_trdata.append(train_auc)
    main_score_cvdata.append(cv_auc)
```

```
100%|██████████| 8/8 [08:05<00:00, 60.64s/it]
```

In [95]:

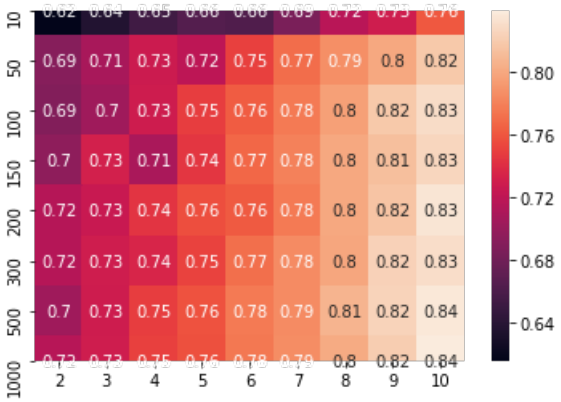
```
train_auc_df = pd.DataFrame(data=main_score_trdata, index=n_estimators, columns=max_depth)
cv_auc_df = pd.DataFrame(data=main_score_cvdata, index=n_estimators, columns=max_depth)
```

In [96]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[96]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x19c952bed88>
```

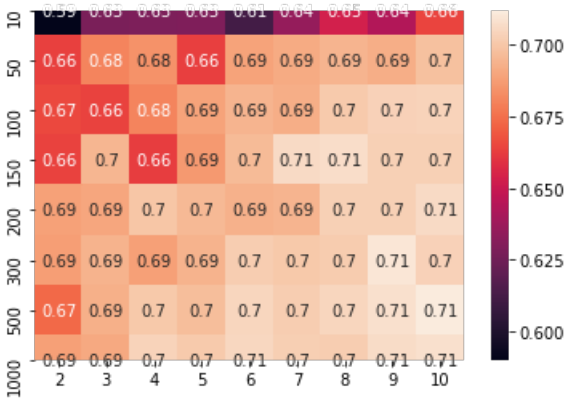


In [97]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[97]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x19c95213bc8>
```



In [98]:

```
best_n_estimators = 150
best_max_depth = 7
```

In [99]:

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

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

    return y_data_pred
```

In [104]:

```
from sklearn.metrics import roc_curve, auc
rf =
RandomForestClassifier(n_estimators=best_n_estimators,criterion='gini',max_depth=best_max_depth,ma
x_features='auto',bootstrap=True,n_jobs=-1,class_weight='balanced')
rf.fit(X_tr,y_train)
y_train_pred = batch_predict(rf,X_tr)
y_test_pred = batch_predict(rf,X_te)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```

==========

Confusion Matrix :

In [105]:

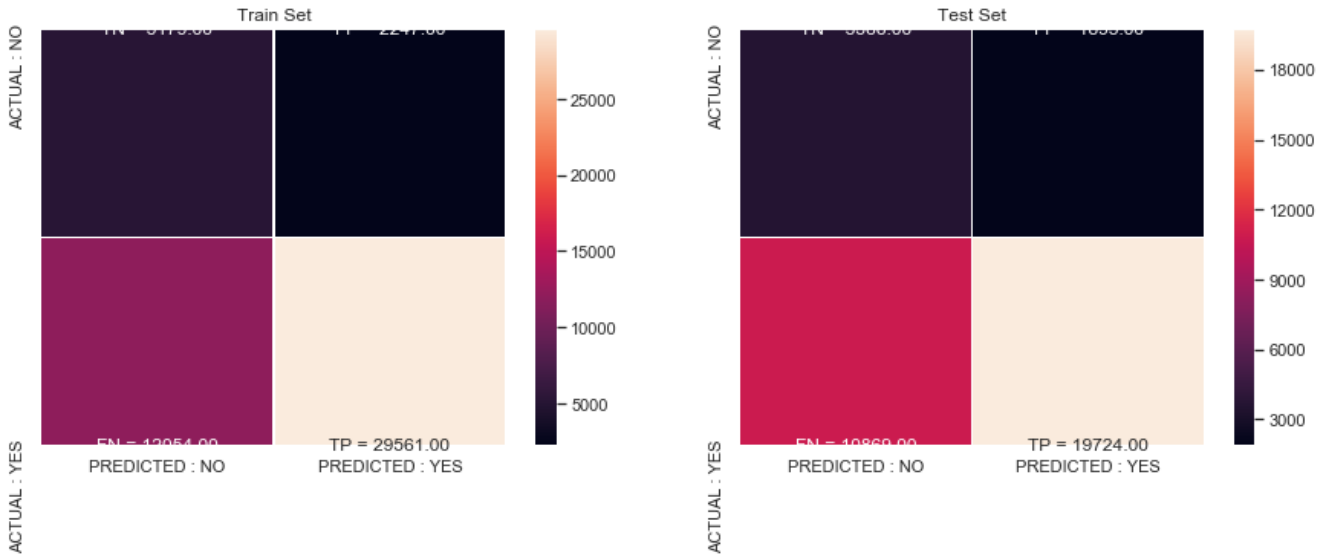
```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [108]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))
```

```
labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.49788237818881403 for threshold 0.499
the maximum value of tpr*(1-fpr) 0.4228364734985926 for threshold 0.503
```



2.4.2 Applying Random Forests on TFIDF, SET 2

In [109]:

```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
from sklearn.ensemble import RandomForestClassifier
main_score_trdata = []
main_score_cvdata = []
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = RandomForestClassifier(n_estimators=i,criterion='gini',max_depth=j,max_features='auto'
,bootstrap=True,n_jobs=-1,class_weight='balanced')
        rf.fit(X_tr2, y_train)
        y_train_pred=rf.predict_proba(X_tr2)[:, 1]
        y_cv_pred=rf.predict_proba(X_cv2)[:, 1]
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    main_score_trdata.append(train_auc)
    main_score_cvdata.append(cv_auc)
```

```
100%|██████████| 8/8 [09:55<00:00, 74.47s/it]
```

In [110]:

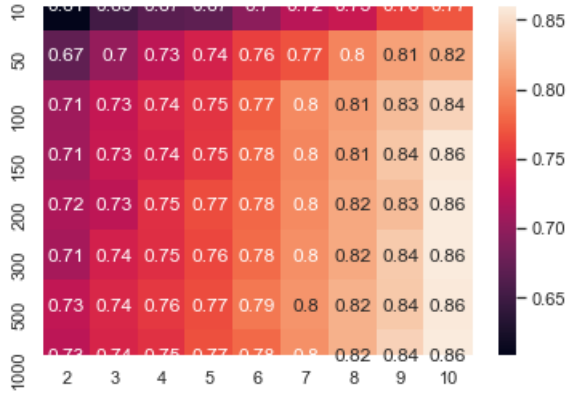
```
train_auc_df = pd.DataFrame(data=main_score_trdata, index=n_estimators, columns=max_depth)
cv_auc_df = pd.DataFrame(data=main_score_cvdata, index=n_estimators, columns=max_depth)
```

In [111]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[111]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x19c95643f48>
```

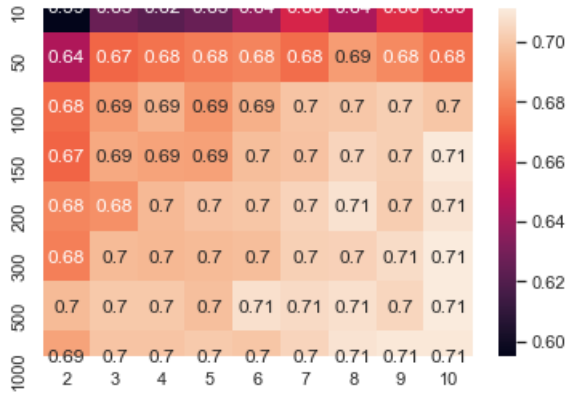


In [112]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[112]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x19c95719908>
```



In [113]:

```
best_n_estimators = 200
best_max_depth = 8
```

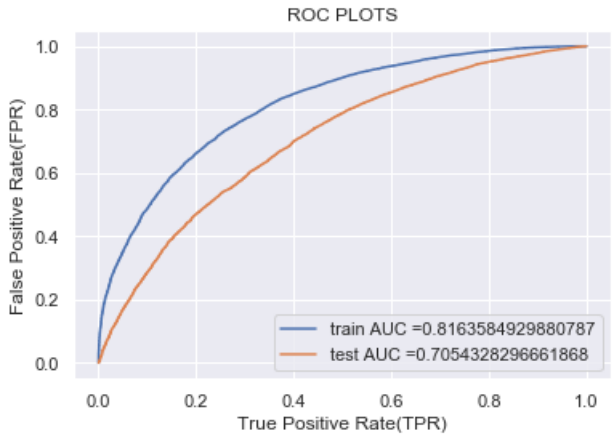
In [114]:

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

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

```
    return y_data_pred
```

In [115]:

```
from sklearn.metrics import roc_curve, auc
rf =
RandomForestClassifier(n_estimators=best_n_estimators,criterion='gini',max_depth=best_max_depth,ma
x_features='auto',bootstrap=True,n_jobs=-1,class_weight='balanced')
rf.fit(X_tr2,y_train)
y_train_pred = batch_predict(rf,X_tr2)
y_test_pred = batch_predict(rf,X_te2)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```



==========

Confusion Matrix :

In [116]:

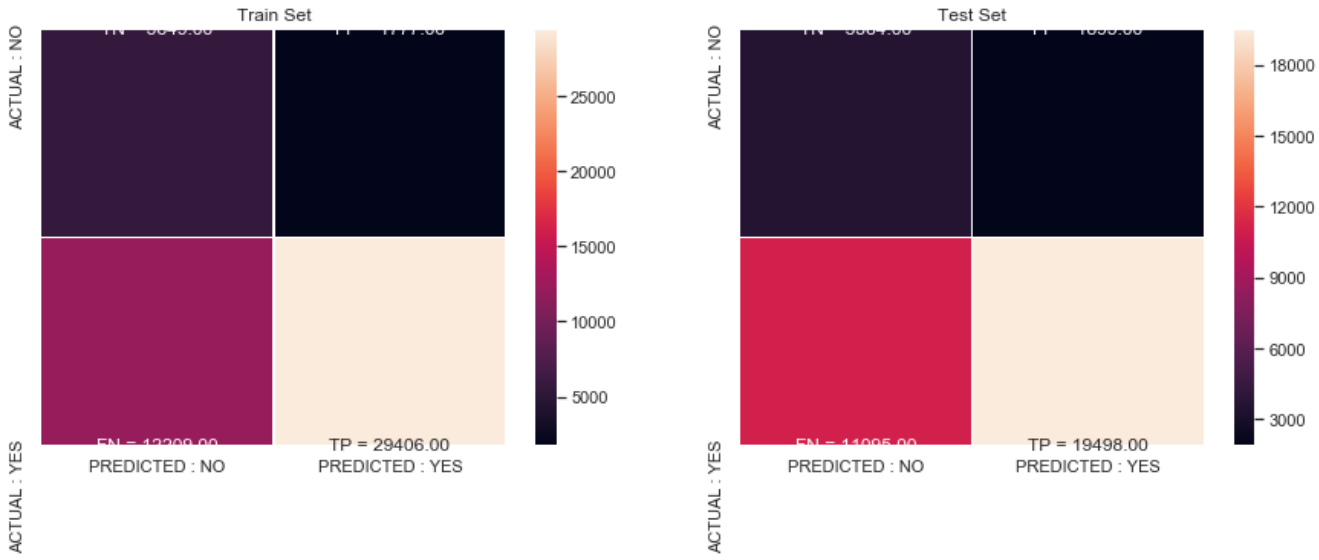
```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [117]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
```

```
fig, ax = plt.subplots(1,2, figsize=(15,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.5434473840478973 for threshold 0.506
the maximum value of tpr*(1-fpr) 0.4204988495495108 for threshold 0.509
```



Applying Random Forests on AVG W2V

In [83]:

```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
from sklearn.ensemble import RandomForestClassifier
main_score_trdata = []
main_score_cvdata = []
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = RandomForestClassifier(n_estimators=i,criterion='gini',max_depth=j,max_features='auto'
,bootstrap=True,n_jobs=-1,class_weight='balanced')
        rf.fit(X_tr3, y_train)
        y_train_pred=rf.predict_proba(X_tr3)[:, 1]
        y_cv_pred=rf.predict_proba(X_cv3)[:, 1]
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    main_score_trdata.append(train_auc)
    main_score_cvdata.append(cv_auc)
```

```
100%|██████████| 8/8 [1:56:22<00:00, 872.86s/it]
```

In [84]:

```
train_auc_df = pd.DataFrame(data=main_score_trdata, index=n_estimators, columns=max_depth)
```

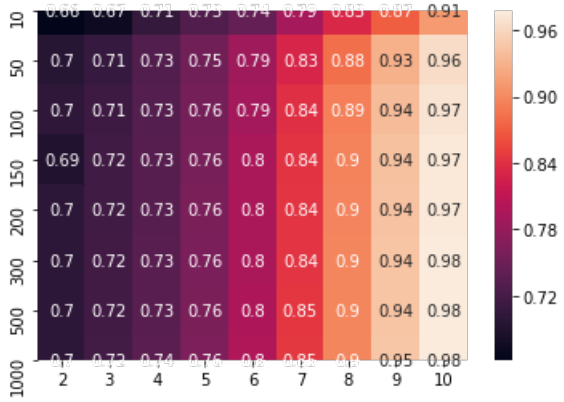
```
cv_auc_df = pd.DataFrame(data=main_score_cvdata, index=n_estimators, columns=max_depth)
```

In [85]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[85]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x27394ca7e48>
```

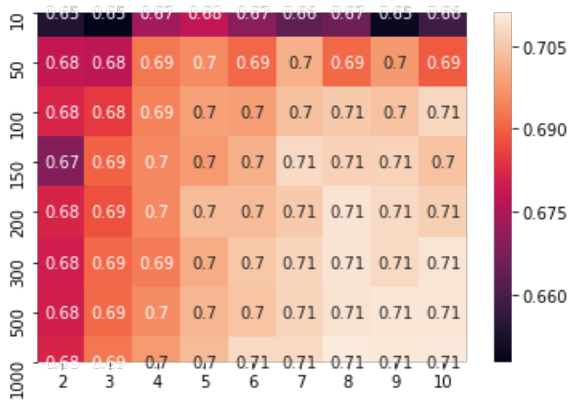


In [86]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[86]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x273952a1948>
```



In [91]:

```
best_n_estimators = 150
best_max_depth = 7
```

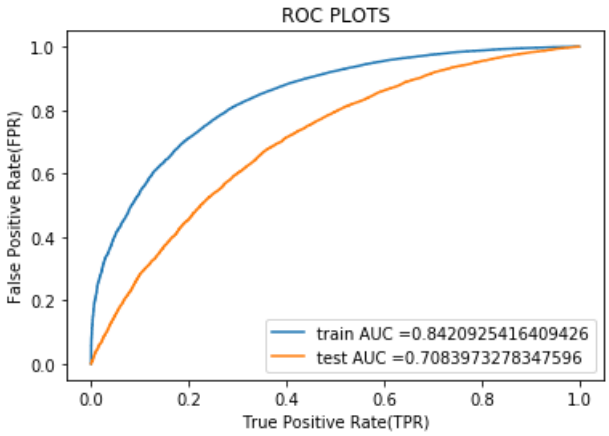
In [92]:

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

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

```
    return y_data_pred
```

In [93]:

```
from sklearn.metrics import roc_curve, auc
rf =
RandomForestClassifier(n_estimators=best_n_estimators,criterion='gini',max_depth=best_max_depth,ma
x_features='auto',bootstrap=True,n_jobs=-1,class_weight='balanced')
rf.fit(X_tr3,y_train)
y_train_pred = batch_predict(rf,X_tr3)
y_test_pred = batch_predict(rf,X_te3)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```



==========

Confusion Matrix :

In [94]:

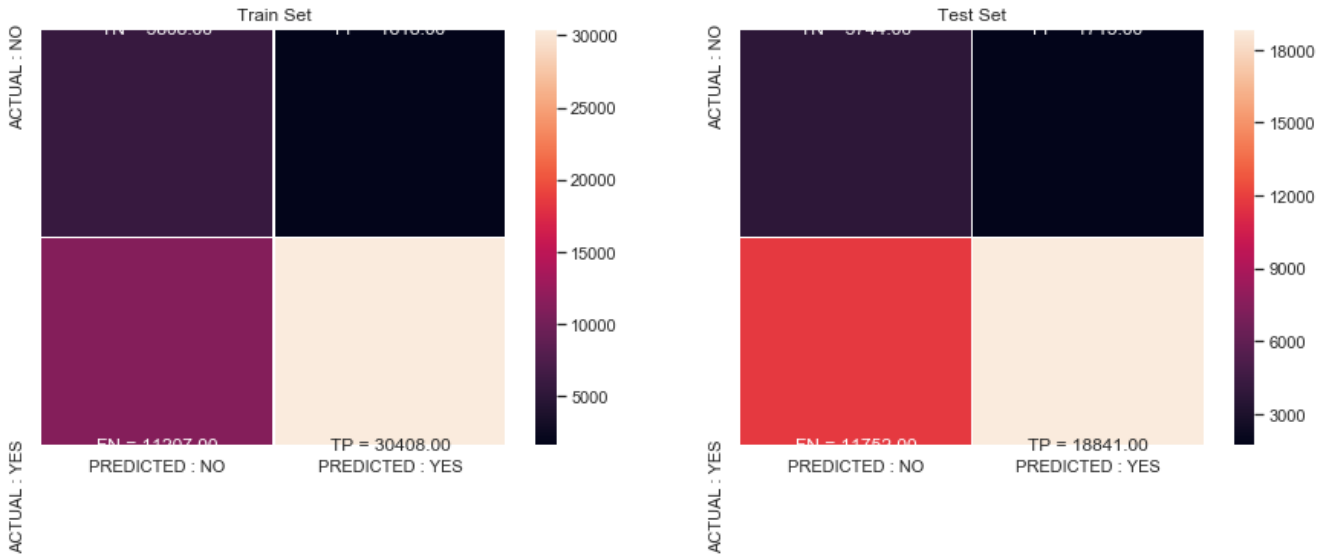
```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [95]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))
```

```
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.5774650531647123 for threshold 0.52
the maximum value of tpr*(1-fpr) 0.432958948048146 for threshold 0.535
```



2.4.4 Applying Random Forests on TFIDF W2V, SET 4

In [87]:

```
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
from sklearn.ensemble import RandomForestClassifier
main_score_trdata4 = []
main_score_cvdata4 = []
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = RandomForestClassifier(n_estimators=i,criterion='gini',max_depth=j,max_features='auto'
,bootstrap=True,n_jobs=-1,class_weight='balanced')
        rf.fit(X_tr4, y_train)
        y_train_pred=rf.predict_proba(X_tr4)[:, 1]
        y_cv_pred=rf.predict_proba(X_cv4)[:, 1]
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    main_score_trdata4.append(train_auc)
    main_score_cvdata4.append(cv_auc)
```

```
100%|██████████| 8/8 [1:58:22<00:00, 887.84s/it]
```

In [88]:

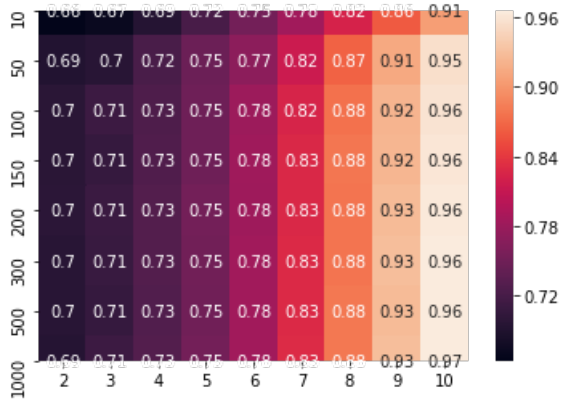
```
train_auc_df = pd.DataFrame(data=main_score_trdata4, index=n_estimators, columns=max_depth)
cv_auc_df = pd.DataFrame(data=main_score_cvdata4, index=n_estimators, columns=max_depth)
```

In [89]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[89]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x27394d8f048>
```

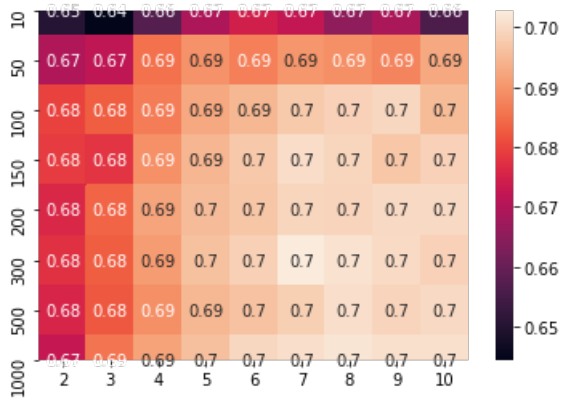


In [90]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[90]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x27394d20688>
```



In [96]:

```
best_n_estimators = 200
best_max_depth = 5
```

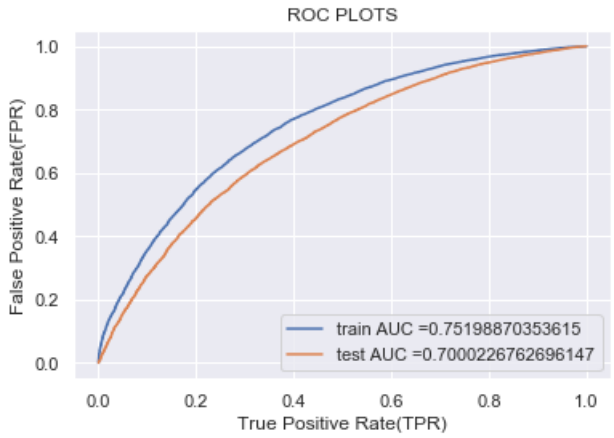
In [97]:

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

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

```
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [98]:

```
from sklearn.metrics import roc_curve, auc
rf =
RandomForestClassifier(n_estimators=best_n_estimators,criterion='gini',max_depth=best_max_depth,ma
x_features='auto',bootstrap=True,n_jobs=-1,class_weight='balanced')
rf.fit(X_tr4,y_train)
y_train_pred = batch_predict(rf,X_tr4)
y_test_pred = batch_predict(rf,X_te4)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```



==========

Confusion Matrix :

In [99]:

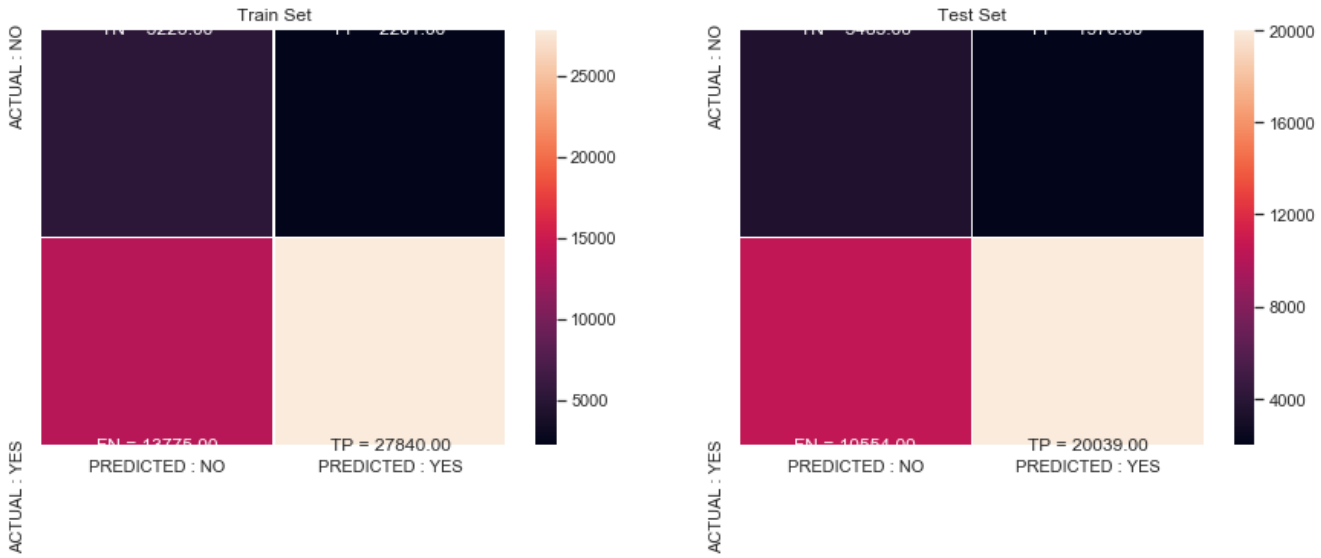
```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [100]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))
```

```
key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.4731860181011743 for threshold 0.503
the maximum value of tpr*(1-fpr) 0.4202548600498253 for threshold 0.503
```



2.5 Applying GBDT

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

2.5.1 Applying XGBOOST on BOW, SET 1

In [103]:

```
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
main_score_trdata = []
main_score_cvdata = []
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = XGBClassifier(n_estimators=i,max_depth=j,booster='gbtree',n_jobs=-1,class_weight='bala
nced')
        rf.fit(X_tr, y_train)
        y_train_pred=rf.predict_proba(X_tr)[:, 1]
        y_cv_pred=rf.predict_proba(X_cv)[:, 1]
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
```

```
    main_score_trdata.append(train_auc)
    main_score_cvdata.append(cv_auc)
```

```
100%|██████████| 8/8 [1:04:30<00:00, 483.86s/it]
```

In [104]:

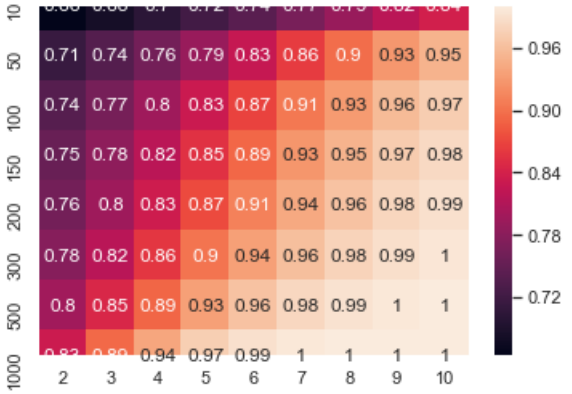
```
train_auc_df = pd.DataFrame(data=main_score_trdata, index=n_estimators, columns=max_depth)
cv_auc_df = pd.DataFrame(data=main_score_cvdata, index=n_estimators, columns=max_depth)
```

In [105]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[105]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x27394e92248>
```

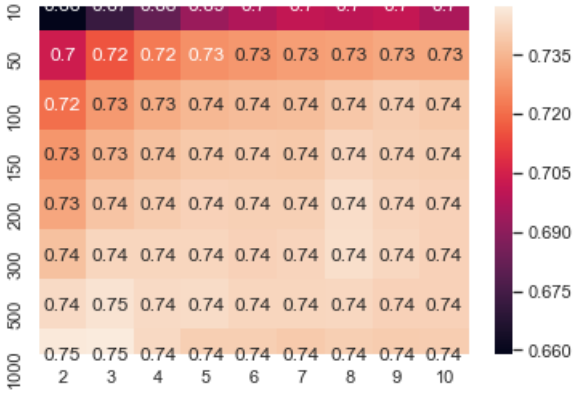


In [106]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[106]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x273954421c8>
```



In [107]:

```
best_n_estimators = 150
best_max_depth = 5
```

In [108]:

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

```
    # not the predicted outputs

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

    return y_data_pred
```

In [109]:

```
from sklearn.metrics import roc_curve, auc
rf = XGBClassifier(n_estimators=best_n_estimators,max_depth=best_max_depth,booster='gbtree',n_jobs
=-1,class_weight='balanced')
rf.fit(X_tr, y_train)
y_train_pred = batch_predict(rf,X_tr)
y_test_pred = batch_predict(rf,X_te)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```

==========

Confusion Matrix :

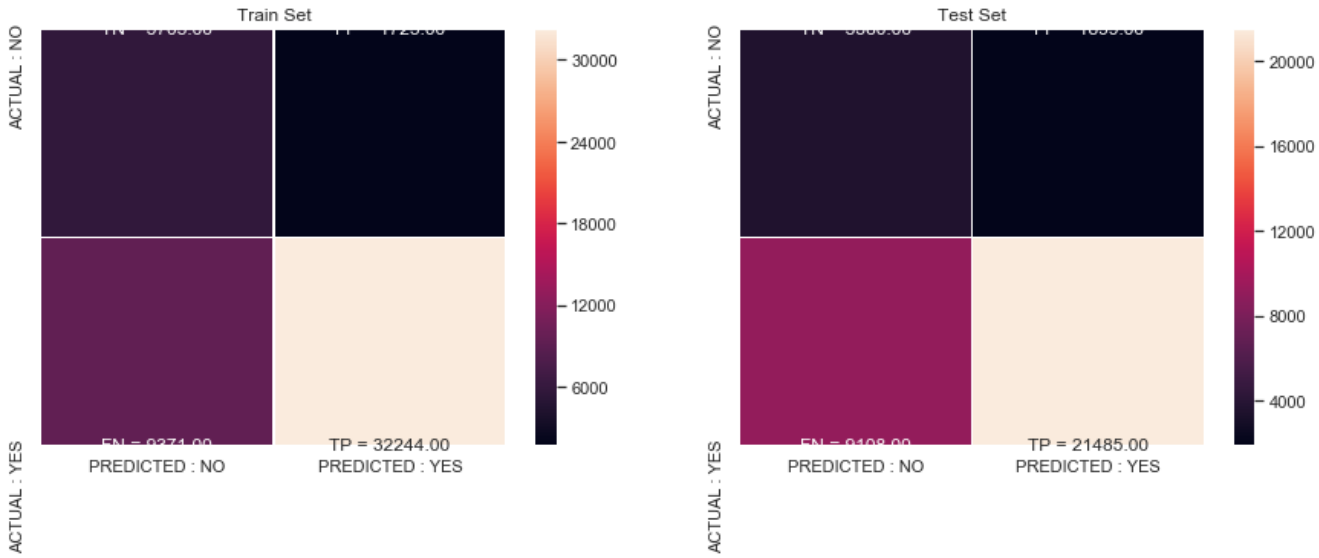
In [110]:

```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [111]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.5967965556039825 for threshold 0.828
the maximum value of tpr*(1-fpr) 0.46248596475072656 for threshold 0.846
```



2.5.2 Applying XGBOOST on TFIDF, SET 2

In [112]:

```
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
main_score_trdata = []
main_score_cvdata = []
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = XGBClassifier(n_estimators=i,max_depth=j,booster='gbtree',n_jobs=-1,class_weight='bala
nced')
        rf.fit(X_tr2, y_train)
        y_train_pred=rf.predict_proba(X_tr2)[:, 1]
        y_cv_pred=rf.predict_proba(X_cv2)[:, 1]
        train_auc.append(roc_auc_score(y_train,y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
```

```
    main_score_trdata.append(train_auc)
    main_score_cvdata.append(cv_auc)
```

```
100%|██████████| 8/8 [2:37:22<00:00, 1180.35s/it]
```

In [113]:

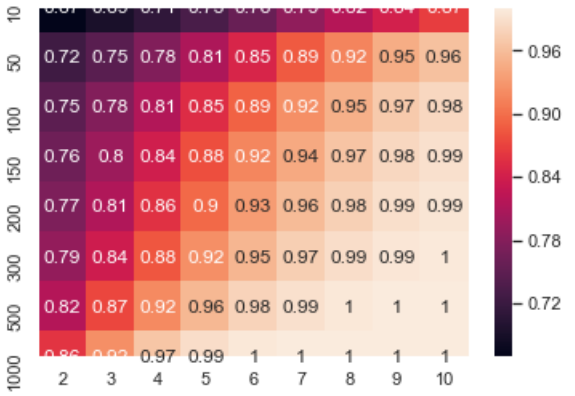
```
train_auc_df = pd.DataFrame(data=main_score_trdata, index=n_estimators, columns=max_depth)
cv_auc_df = pd.DataFrame(data=main_score_cvdata, index=n_estimators, columns=max_depth)
```

In [114]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[114]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2739558b288>
```

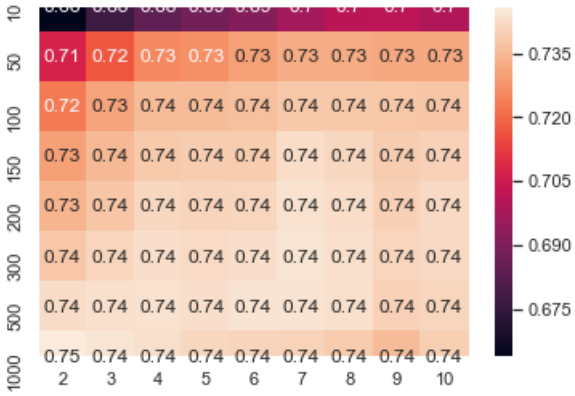


In [115]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[115]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2739561d788>
```



In [81]:

```
best_n_estimators = 100
best_max_depth = 4
```

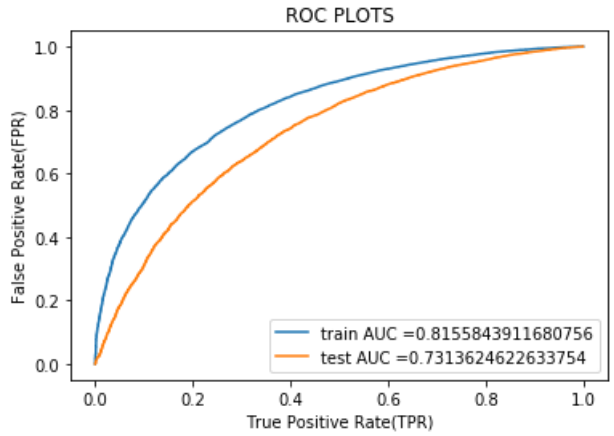
In [82]:

```
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
```

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

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

    return y_data_pred
```

In [83]:

```
from sklearn.metrics import roc_curve, auc
rf = XGBClassifier(n_estimators=best_n_estimators,max_depth=best_max_depth,booster='gbtree',n_jobs
=-1,class_weight='balanced')
rf.fit(X_tr2, y_train)
y_train_pred = batch_predict(rf,X_tr2)
y_test_pred = batch_predict(rf,X_te2)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```



==========

Confusion Matrix :

In [84]:

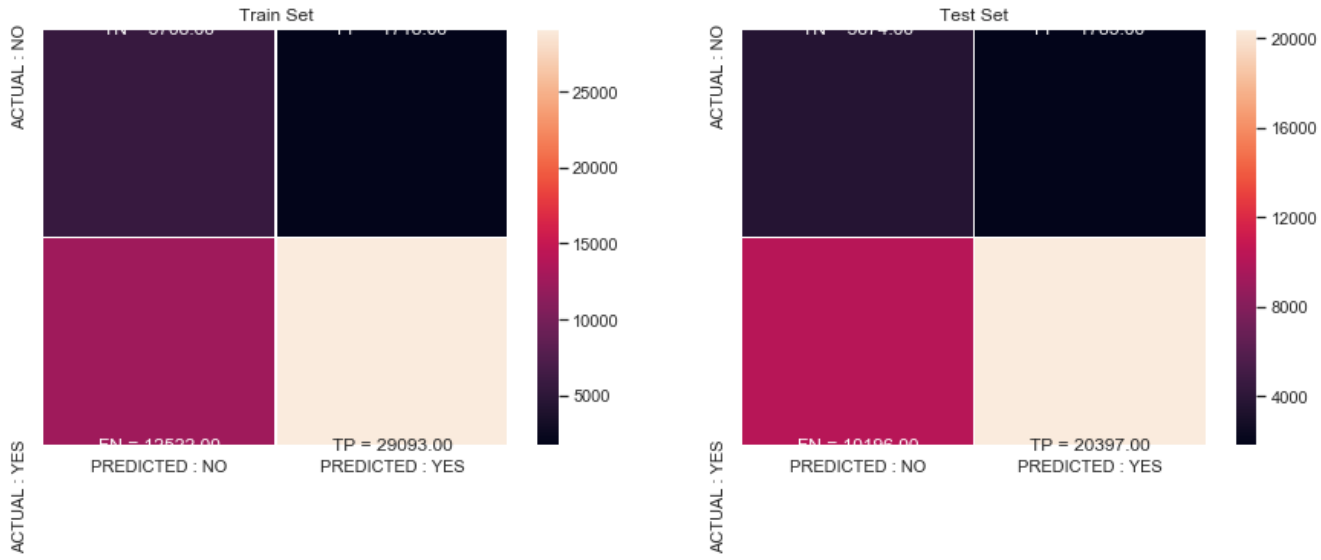
```
def predict(proba, threshould, fpr, tpr):

    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
```

```
    return predictions
```

In [85]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.5440248887343709 for threshold 0.85
the maximum value of tpr*(1-fpr) 0.45156989561173794 for threshold 0.853
```



2.5.3 Applying XGBOOST on AVG W2V, SET 3

In [81]:

```
X_tr3
```

Out[81]:

```
<49041x617 sparse matrix of type '<class 'numpy.float64'>'
 with 30237687 stored elements in Compressed Sparse Row format>
```

In [82]:

```
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
main_score_trdata3 = []
main_score_cvdata3 = []
```

```
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = XGBClassifier(n_estimators=i,max_depth=j,booster='gbtree',n_jobs=-1,class_weight='balanced')
        rf.fit(X_tr3[:20000], y_train[:20000])
        y_train_pred=rf.predict_proba(X_tr3[:20000])[:, 1]
        y_cv_pred=rf.predict_proba(X_cv3)[:, 1]
        train_auc.append(roc_auc_score(y_train[:20000],y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    main_score_trdata3.append(train_auc)
    main_score_cvdata3.append(cv_auc)
```

```
100%|██████████| 8/8 [7:24:07<00:00, 3330.93s/it]
```

In [83]:

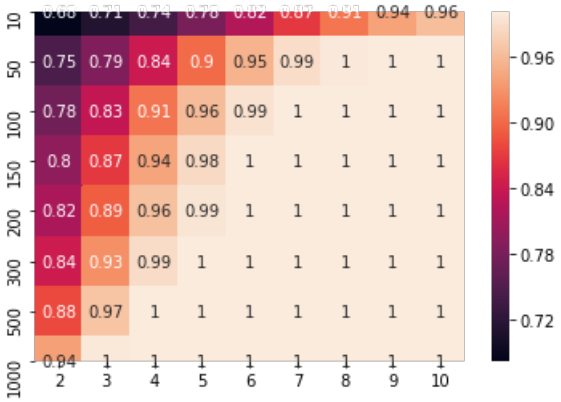
```
train_auc_df = pd.DataFrame(data=main_score_trdata3, index=n_estimators, columns=max_depth)
cv_auc_df = pd.DataFrame(data=main_score_cvdata3, index=n_estimators, columns=max_depth)
```

In [84]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[84]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25a32ddf448>
```

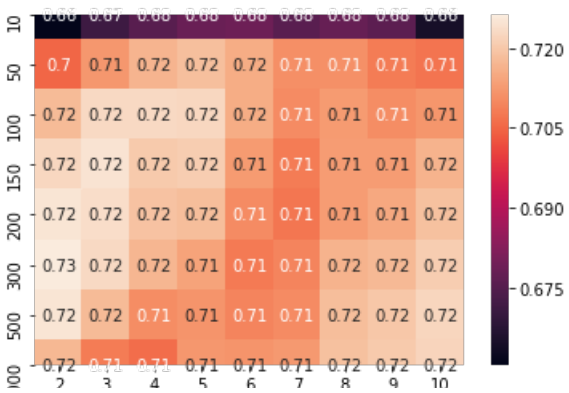


In [85]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[85]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25b94886e08>
```



In [90]:

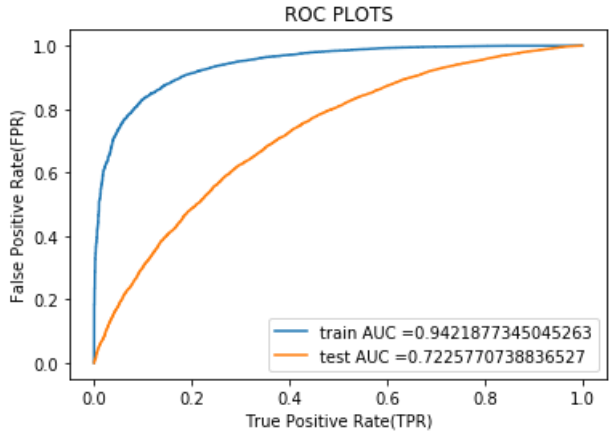
```
best_n_estimators = 150
best_max_depth = 4
```

In [91]:

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

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

    return y_data_pred
```

In [92]:

```
from sklearn.metrics import roc_curve, auc
rf = XGBClassifier(n_estimators=best_n_estimators,max_depth=best_max_depth,booster='gbtree',n_jobs
=-1,class_weight='balanced')
rf.fit(X_tr3[:20000], y_train[:20000])
y_train_pred = batch_predict(rf,X_tr3[:20000])
y_test_pred = batch_predict(rf,X_te3)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train[:20000], y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```



==========

Confusion Matrix :

In [93]:

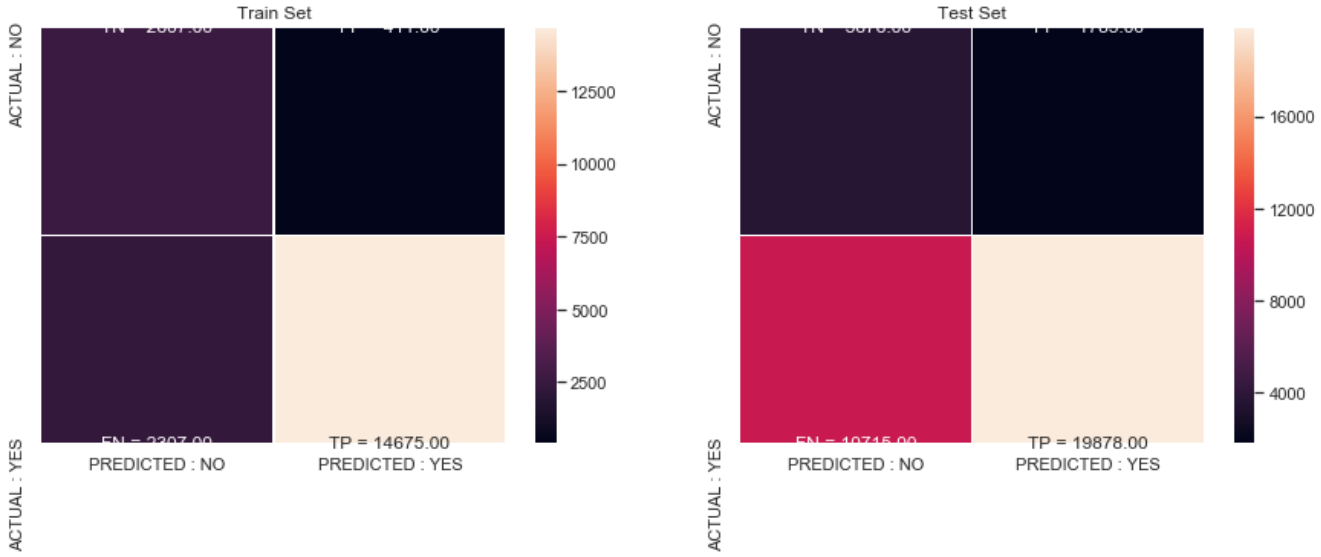
```
def predict(proba, threshould, fpr, tpr):
```

```
    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [95]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train[:20000], predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.7506904164460885 for threshold 0.811
the maximum value of tpr*(1-fpr) 0.4413126963212667 for threshold 0.867
```



2.5.4 Applying XGBOOST on TFIDF W2V, SET 4

In [86]:

```
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score
from sklearn.metrics import accuracy_score
main_score_trdata4 = []
main_score_cvdata4 = []
```

```
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
for i in tqdm(n_estimators):
    train_auc = []
    cv_auc = []
    for j in max_depth:
        rf = XGBClassifier(n_estimators=i,max_depth=j,booster='gbtree',n_jobs=-1,class_weight='balanced')
        rf.fit(X_tr4[:20000], y_train[:20000])
        y_train_pred=rf.predict_proba(X_tr4[:20000])[:, 1]
        y_cv_pred=rf.predict_proba(X_cv4)[:, 1]
        train_auc.append(roc_auc_score(y_train[:20000],y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    main_score_trdata4.append(train_auc)
    main_score_cvdata4.append(cv_auc)
```

```
100%|██████████| 8/8 [7:13:47<00:00, 3253.38s/it]
```

In [87]:

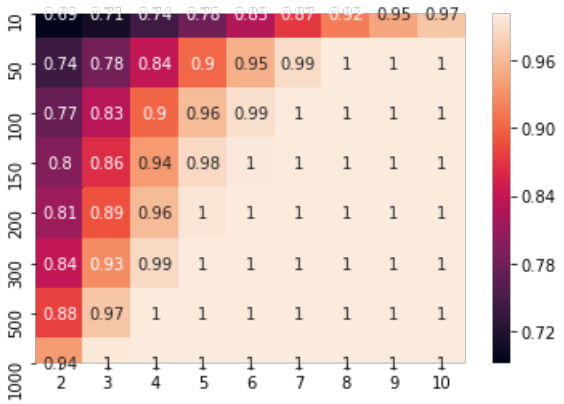
```
train_auc_df = pd.DataFrame(data=main_score_trdata4, index=n_estimators, columns=max_depth)
cv_auc_df = pd.DataFrame(data=main_score_cvdata4, index=n_estimators, columns=max_depth)
```

In [88]:

```
heat_train=sns.heatmap(data=train_auc_df,annot=True)
heat_train
```

Out[88]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25b944c4dc8>
```

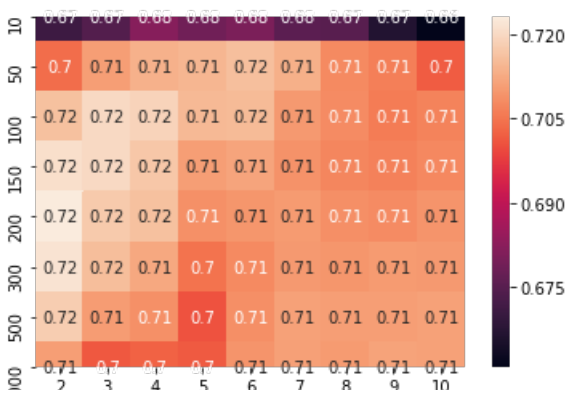


In [89]:

```
heat_cv=sns.heatmap(data=cv_auc_df,annot=True)
heat_cv
```

Out[89]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x25b93be68c8>
```



In [96]:

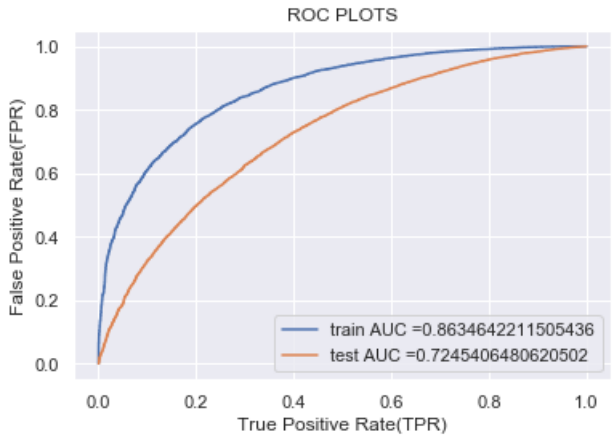
```
best_n_estimators = 150
best_max_depth = 3
```

In [97]:

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

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

    return y_data_pred
```

In [98]:

```
from sklearn.metrics import roc_curve, auc
rf = XGBClassifier(n_estimators=best_n_estimators,max_depth=best_max_depth,booster='gbtree',n_jobs
=-1,class_weight='balanced')
rf.fit(X_tr4[:20000], y_train[:20000])
y_train_pred = batch_predict(rf,X_tr4[:20000])
y_test_pred = batch_predict(rf,X_te4)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train[:20000], y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.show()
print("="*100)
```



==========

Confusion Matrix :

In [99]:

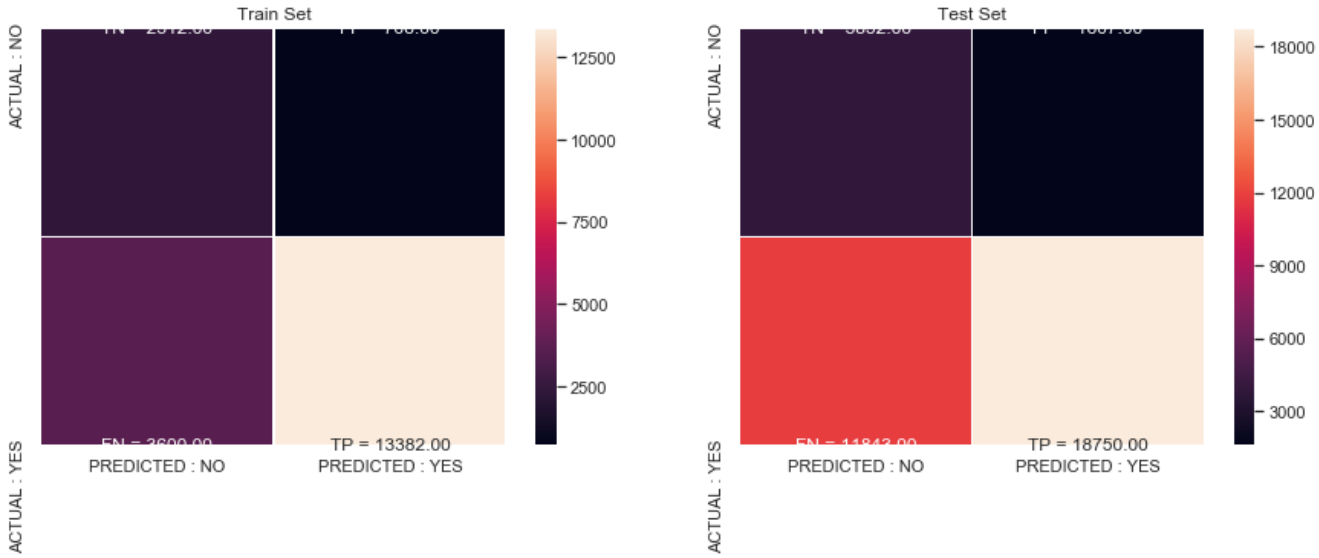
```
def predict(proba, threshould, fpr, tpr):
```

```
    t = threshould[np.argmax(fpr*(1-tpr))]
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
    predictions = []
    global predictions1
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    predictions1 = predictions
    return predictions
```

In [100]:

```
#https://www.quantinsti.com/blog/creating-heatmap-using-python-seaborn
import seaborn as sns; sns.set()

con_m_train = confusion_matrix(y_train[:20000], predict(y_train_pred, tr_thresholds, train_fpr,
train_tpr))
con_m_test = confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr))

key = (np.asarray([['TN','FP'], ['FN', 'TP']]))
fig, ax = plt.subplots(1,2, figsize=(15,5))

labels_train = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten()
, con_m_train.flatten())])).reshape(2,2)
labels_test = (np.asarray(["{0} = {1:.2f}" .format(key, value) for key, value in zip(key.flatten(),
con_m_test.flatten())])).reshape(2,2)

sns.heatmap(con_m_train, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_train, fmt = '', ax=ax[0])
sns.heatmap(con_m_test, linewidths=.5, xticklabels=['PREDICTED : NO', 'PREDICTED : YES'],
yticklabels=['ACTUAL : NO', 'ACTUAL : YES'], annot = labels_test, fmt = '', ax=ax[1])

ax[0].set_title('Train Set')
ax[1].set_title('Test Set')

plt.show()
```

```
the maximum value of tpr*(1-fpr) 0.6071837338548695 for threshold 0.824
the maximum value of tpr*(1-fpr) 0.44193496894238443 for threshold 0.865
```



3. Conclusion

In [102]:

```
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x=PrettyTable()
x.field_names=["Vectorizer","Model","AUC"]
```

```
x.add_row(["BOW","RF",0.702])
x.add_row(["TFIDF","RF",0.705])
x.add_row(["AVG W2V","RF",0.708])
x.add_row(["TFIDF W2V","RF",0.700])
x.add_row(["BOW","XGBOOST",0.737])
x.add_row(["TFIDF","XGBOOST",0.731])
x.add_row(["AVG W2V","XGBOOST",0.722])
x.add_row(["TFIDF W2V","XGBOOST",0.724])
print(x)
```

```
+------------+---------+-------+
| Vectorizer |  Model  |  AUC  |
+------------+---------+-------+
|    BOW     |    RF   | 0.702 |
|   TFIDF    |    RF   | 0.705 |
|  AVG W2V   |    RF   | 0.708 |
| TFIDF W2V  |    RF   |  0.7  |
|    BOW     | XGBOOST | 0.737 |
|   TFIDF    | XGBOOST | 0.731 |
|  AVG W2V   | XGBOOST | 0.722 |
| TFIDF W2V  | XGBOOST | 0.724 |
+------------+---------+-------+
```