DonorsChoose

In [1]:

```
'''import os
os.environ["PATH"] += os.pathsep + "C:/Users/Raftaar Singh/Anaconda3/release/bin"'''
```

Out[1]:

```
'import os\nos.environ["PATH"] += os.pathsep + "C:/Users/Raftaar Singh/Ana
conda3/release/bin"'
```

In [ ]:

```
system("jupyter" "notebook" "list")
```

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	De
project_id	A unique identifier for the proposed project. **Example:**
project_title	Title of the project. **E** • Art Will Make You • First Gr
project_grade_category	Grade level of students for which the project is targeted. One of the enumerate • Grades • Gra • Gra • Grad
project_subject_categories	One or more (comma-separated) subject categories for the projec following enumerated list • Applied L • Care & • Health & • History & • Literacy & L • Math & • Music & T • Specia • **E** • Music & T • Literacy & Language, Math &
school_state	State where school is located (Two-letter U.S. p (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Posta **Exar**
project_subject_subcategories	One or more (comma-separated) subject subcategories for th **E** • L • Literature & Writing, Social S
project_resource_summary	An explanation of the resources needed for the project. **E** • My students need hands on literacy materials to sensory
project_essay_1	First applicat
project_essay_2	Second applicat
project_essay_3	Third applicat
project_essay_4	Fourth applicat
project_submitted_datetime	Datetime when project application was submitted. **Example:** 201 12:43
teacher_id	A unique identifier for the teacher of the proposed project. bdf8baa8fedef6bfeec7ae4ff

Feature	De
`teacher_prefix`	Teacher's title. One of the following enumerate • • • • • • T
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the sam **Exa**

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

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

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [2]:

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

In [3]:

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

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

In [4]:

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

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

Out[4]:

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

1.1 Sorted by time

In [5]:

```
#https://stats.stackexchange.com/questions/341312/train-test-split-with-time-and-person
-indexed-data
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.col
umns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/40840
39
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)


# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
project_data = project_data[cols]


project_data.head(2)
```

Out[5]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT

1.2 Adding resource data in dataframe

In [6]:

```
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[6]:

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

In [7]:

```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_i
ndex()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [8]:

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

Out[8]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	D
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	20 04 00:27
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	20 04 00:3

In [9]:

```
print(project_data["project_is_approved"].value_counts(normalize = True))
```

```
1    0.848583
0    0.151417
Name: project_is_approved, dtype: float64
```

Very high imbalance dataset so require to be balanced.

In [10]:

```
#project_data = project_data.sample(n=50000)
#project_data=project_data.tail(10000)
project_data.shape
```

Out[10]:

```
(109248, 19)
```

In [11]:

```
project_data.shape
```

Out[11]:

```
(109248, 19)
```

1.3 preprocessing of project_subject_categories

In [12]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47
301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-stri
ng
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-pyth
on
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", "Warmt
h", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "M
ath & Science"=> "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:"M
ath & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spa
ces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

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

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

1.4 preprocessing of `project_subject_subcategories`

In [13]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47
301924/4084039

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

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", "Warmt
h", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "M
ath & Science"=> "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:"M
ath & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spa
ces
        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]))
```

In [14]:

```
project_data.columns
```

Out[14]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories'],
      dtype='object')
```

In [ ]:

1.3 Text preprocessing

In [15]:

```
# 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 [16]:

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

Out[16]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	D
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	20 04 00:27
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	20 04 00:3

In [17]:

```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [18]:

```
'''# 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)'''
```

Out[18]:

```
'# printing some random reviews\nprint(project_data[\'essay\'].values[0])
\nprint("="*50)\nprint(project_data[\'essay\'].values[150])\nprint("="*50)
\nprint(project_data[\'essay\'].values[1000])\nprint("="*50)\nprint(projec
t_data[\'essay\'].values[20000])\nprint("="*50)\nprint(project_data[\'essa
y\'].values[99999])\nprint("="*50)'
```

In [19]:

```
# 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 [20]:

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

Out[20]:

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

In [21]:

```
'''# \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)'''
```

Out[21]:

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

In [22]:

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

Out[22]:

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

In [23]:

```
# 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', 'each', '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', "doesn'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"]
```

1.3.1Preprocess of Preprocessing of essay

In [24]:

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

```
100%|████████████████████████████████| 109248/109248 [01:06<00:00, 1649.26
it/s]
```

In [25]:

```
# after preprocesing
#preprocessed_essays[10:]
```

In [26]:

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

1.3.2Preprocessing of `project_title`

In [27]:

```
# similarly you can preprocess the titles also
```

In [28]:

```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_project_title = []
# 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_project_title.append(sent.lower().strip())
```

```
100%|██████████████████████████████| 109248/109248 [00:02<00:00, 37475.73
it/s]
```

In [29]:

```
# after preprocesing
#preprocessed_project_title[1000]
```

In [30]:

```
#https://stackoverflow.com/questions/26666919/add-column-in-dataframe-from-list/38490727
project_data['preprocessed_project_title'] = preprocessed_project_title
project_data.drop(['project_title'], axis=1, inplace=True)
```

In [31]:

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

Out[31]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	D
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	20 04 00:27
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	20 04 00:3

In [32]:

```
project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 109248 entries, 0 to 109247
Data columns (total 20 columns):
Unnamed: 0                                      109248 non-null int64
id                                              109248 non-null object
teacher_id                                      109248 non-null object
teacher_prefix                                  109245 non-null object
school_state                                    109248 non-null object
Date                                            109248 non-null datetime64
[ns]
project_grade_category                          109248 non-null object
project_essay_1                                 109248 non-null object
project_essay_2                                 109248 non-null object
project_essay_3                                 3758 non-null object
project_essay_4                                 3758 non-null object
project_resource_summary                        109248 non-null object
teacher_number_of_previously_posted_projects    109248 non-null int64
project_is_approved                             109248 non-null int64
price                                           109248 non-null float64
quantity                                        109248 non-null int64
clean_categories                                109248 non-null object
clean_subcategories                             109248 non-null object
preprocessed_essays                             109248 non-null object
preprocessed_project_title                      109248 non-null object
dtypes: datetime64[ns](1), float64(1), int64(4), object(14)
memory usage: 17.5+ MB
```

In [ ]:

```

```

total number of word in each title and essay,

In [33]:

```
#https://stackoverflow.com/questions/49984905/count-number-of-words-per-row
project_data['totalwords_title'] = project_data['preprocessed_project_title'].str.split
().str.len()

project_data['totalwords_essay'] = project_data['preprocessed_essays'].str.split().str.
len()
project_data['totalwords_essay']
```

Out[33]:

```
0         175
1         179
2         116
3         127
4         114
5         159
6         173
7         280
8         198
9         170
10        163
11        250
12         97
13        150
14        240
15        200
16        164
17        260
18        208
19        154
20        125
21        183
22        160
23        151
24        173
25        127
26        230
27        172
28        158
29        187
          ...
109218    104
109219    180
109220    153
109221    190
109222    212
109223    120
109224    162
109225    138
109226    203
109227    143
109228    141
109229    130
109230    155
109231    207
109232    149
109233    177
109234    184
109235    111
109236    133
109237    134
109238    138
109239    165
109240    178
109241    148
109242    151
109243    186
109244    115
109245    169
```

```
109246    124
109247    120
Name: totalwords_essay, Length: 109248, dtype: int64
```

No need of normilization or standarization in case of decision tree method

In [ ]:

```
```

Sentiment feature of title and essay

In [34]:

```
#!pip install vaderSentiment
```

In [35]:

```
'''#sentiment analysis of project_title
#_____________________________________________
#https://medium.com/analytics-vidhya/simplifying-social-media-sentiment-analysis-using-vader-in-python-f9e6ec6fc52f

from nltk.sentiment.vader import SentimentIntensityAnalyzer

import nltk
#nltk.download('vader_lexicon')
catogories = list(project_data['preprocessed_project_title'].values)
sentiment_positive=[]
sentiment_negative=[]
sentiment_neutral=[]
sentiment_compound=[]
#cat_list = []
for i in catogories:
  sid = SentimentIntensityAnalyzer()
  sentiment_val=sid.polarity_scores(i)
  #cat_list.append(sentiment_val)
  sentiment_positive.append(sentiment_val['pos'])
  sentiment_negative.append(sentiment_val['neg'])
  sentiment_neutral.append(sentiment_val['neu'])
  sentiment_compound.append(sentiment_val['compound'])

#project_data['sentiment_pos_value'] = cat_list
project_data['sentiment_pos_title']=sentiment_positive
project_data['sentiment_neg_title']=sentiment_negative
project_data['sentiment_neu_title']=sentiment_neutral
project_data['sentiment_compound_title']=sentiment_compound'''
```

Out[35]:

```
"#sentiment analysis of project_title\n#_____________________________________
___________\n#https://medium.com/analytics-vidhya/simplifying-social-media
-sentiment-analysis-using-vader-in-python-f9e6ec6fc52f\n\nfrom nltk.sentim
ent.vader import SentimentIntensityAnalyzer\n\nimport nltk\n#nltk.download
('vader_lexicon')\ncatogories = list(project_data['preprocessed_project_ti
tle'].values)\nsentiment_positive=[]\nsentiment_negative=[]\nsentiment_neu
tral=[]\nsentiment_compound=[]\n#cat_list = []\nfor i in catogories:\n  si
d = SentimentIntensityAnalyzer()\n  sentiment_val=sid.polarity_scores(i)\n
#cat_list.append(sentiment_val)\n  sentiment_positive.append(sentiment_val
['pos'])\n  sentiment_negative.append(sentiment_val['neg'])\n  sentiment_n
eutral.append(sentiment_val['neu'])\n  sentiment_compound.append(sentiment
_val['compound'])\n    \n#project_data['sentiment_pos_value'] = cat_list\n
project_data['sentiment_pos_title']=sentiment_positive\nproject_data['sent
iment_neg_title']=sentiment_negative\nproject_data['sentiment_neu_title']=
sentiment_neutral\nproject_data['sentiment_compound_title']=sentiment_comp
ound"
```

Sentiment feature of title

In [36]:

```
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to C:\Users\IDM
[nltk_data]     LAB-09\AppData\Roaming\nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
```

Out[36]:

```
True
```

In [37]:

```
#sentiment analysis of title
#_____________________________________________
#https://medium.com/analytics-vidhya/simplifying-social-media-sentiment-analysis-using-vader-in-python-f9e6ec6fc52f

from nltk.sentiment.vader import SentimentIntensityAnalyzer

import nltk
#nltk.download('vader_lexicon')
catogories = list(project_data['preprocessed_project_title'].values)
sentiment_positive=[]
sentiment_negative=[]
sentiment_neutral=[]
sentiment_compound=[]
#cat_list = []
for i in catogories:
  sid = SentimentIntensityAnalyzer()
  sentiment_val=sid.polarity_scores(i)
  #cat_list.append(sentiment_val)
  sentiment_positive.append(sentiment_val['pos'])
  sentiment_negative.append(sentiment_val['neg'])
  sentiment_neutral.append(sentiment_val['neu'])
  sentiment_compound.append(sentiment_val['compound'])

#project_data['sentiment_pos_value'] = cat_list
project_data['sentiment_pos_title']=sentiment_positive
project_data['sentiment_neg_title']=sentiment_negative
project_data['sentiment_neu_title']=sentiment_neutral
project_data['sentiment_compound_title']=sentiment_compound
```

In [38]:

```
'''sentiment_pos_title=project_data['sentiment_pos_title'].values.reshape(-1,1)
sentiment_neg_title=project_data['sentiment_neg_title'].values.reshape(-1,1)
sentiment_neu_title=project_data['sentiment_neu_title'].values.reshape(-1,1)
sentiment_compound_title=project_data['sentiment_compound_title'].values.reshape(-1,1)
type(sentiment_pos_title)'''
```

Out[38]:

```
"sentiment_pos_title=project_data['sentiment_pos_title'].values.reshape(-
1,1)\nsentiment_neg_title=project_data['sentiment_neg_title'].values.resha
pe(-1,1)\nsentiment_neu_title=project_data['sentiment_neu_title'].values.r
eshape(-1,1)\nsentiment_compound_title=project_data['sentiment_compound_ti
tle'].values.reshape(-1,1)\ntype(sentiment_pos_title)"
```

Sentiment feature of essay

In [38]:

```
#sentiment analysis of essay
#_____________________________________________
#https://medium.com/analytics-vidhya/simplifying-social-media-sentiment-analysis-using-vader-in-python-f9e6ec6fc52f

from nltk.sentiment.vader import SentimentIntensityAnalyzer

import nltk
#nltk.download('vader_lexicon')
catogories = list(project_data['preprocessed_essays'].values)
sentiment_positive=[]
sentiment_negative=[]
sentiment_neutral=[]
sentiment_compound=[]
#cat_list = []
for i in catogories:
  sid = SentimentIntensityAnalyzer()
  sentiment_val=sid.polarity_scores(i)
  #cat_list.append(sentiment_val)
  sentiment_positive.append(sentiment_val['pos'])
  sentiment_negative.append(sentiment_val['neg'])
  sentiment_neutral.append(sentiment_val['neu'])
  sentiment_compound.append(sentiment_val['compound'])

#project_data['sentiment_pos_value'] = cat_list
project_data['sentiment_pos_essay']=sentiment_positive
project_data['sentiment_neg_essay']=sentiment_negative
project_data['sentiment_neu_essay']=sentiment_neutral
project_data['sentiment_compound_essay']=sentiment_compound
```

In [40]:

```
'''sentiment_pos_essay=project_data['sentiment_pos_essay'].values.reshape(-1,1)
sentiment_neg_essay=project_data['sentiment_neg_essay'].values.reshape(-1,1)
sentiment_neu_essay=project_data['sentiment_neu_essay'].values.reshape(-1,1)
sentiment_compound_essay=project_data['sentiment_compound_essay'].values.reshape(-1,1)
sentiment_pos_essay.shape'''
```

Out[40]:

```
"sentiment_pos_essay=project_data['sentiment_pos_essay'].values.reshape(-
1,1)\nsentiment_neg_essay=project_data['sentiment_neg_essay'].values.resha
pe(-1,1)\nsentiment_neu_essay=project_data['sentiment_neu_essay'].values.r
eshape(-1,1)\nsentiment_compound_essay=project_data['sentiment_compound_es
say'].values.reshape(-1,1)\nsentiment_pos_essay.shape"
```

In [ ]:

spliting data into train test and cv(to avoid data leak, spliting done before probability base encoding of categorical variable)

In [39]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn import model_selection
from sklearn.model_selection import train_test_split

from sklearn.metrics import accuracy_score

from collections import Counter
from sklearn.metrics import accuracy_score

from sklearn.model_selection import cross_val_score
from sklearn.model_selection import cross_validate
```

In [40]:

```
project_data1=project_data
```

In [41]:

```
#to check null column
#_____________________________________
print("is there any null value in teacher prefix dataset?", project_data['teacher_prefi
x'].isnull().any())
print("_"*50)
count_nan = len(project_data['teacher_prefix']) - project_data['teacher_prefix'].count
()
print("number of row have null value", count_nan)

print("_"*50)

print("total number of row have null value", project_data['teacher_prefix'].isnull().su
m())
```

```
is there any null value in teacher prefix dataset? True
__________________________________________________
number of row have null value 3
__________________________________________________
total number of row have null value 3
```

In [42]:

```
#https://stackoverflow.com/questions/54557423/series-object-has-no-attribute-values-counts
#https://stackoverflow.com/questions/26047209/what-is-the-difference-between-a-pandas-series-and-a-single-column-dataframe

y_project_data=project_data[project_data['teacher_prefix'].notnull()]
y_project_data.shape
```

Out[42]:

```
(109245, 30)
```

In [43]:

```
y=y_project_data['project_is_approved']
y.shape
```

Out[43]:

```
(109245,)
```

In [44]:

```
#https://stackoverflow.com/questions/42224700/attributeerror-float-object-has-no-attribute-split

#removing null row from teacher prefix column dataset
project_data = project_data[project_data['teacher_prefix'].notnull()]
project_data.shape
```

Out[44]:

```
(109245, 30)
```

In [45]:

```
#https://stackoverflow.com/questions/26266362/how-to-count-the-nan-values-in-a-column-in-pandas-dataframe/55608360

print("is there any null value in teacher prefix dataset?", project_data['teacher_prefix'].isnull().any())
print("_"*50)
count_nan = len(project_data['teacher_prefix']) - project_data['teacher_prefix'].count()
print("number of row have null value", count_nan)

print("_"*50)

print("total number of row have null value", project_data['teacher_prefix'].isnull().sum())
```

```
is there any null value in teacher prefix dataset? False
__________________________________________________
number of row have null value 0
__________________________________________________
total number of row have null value 0
```

Observation: very few row have hull value of large dataset so better remove the null row

In [46]:

```
#series value count
project_data['teacher_prefix'].value_counts()
```

Out[46]:

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

In [47]:

```
'''#removing null row from teacher prefix column dataset
df_new['teacher_prefix'] = df_new['teacher_prefix'][df_new['teacher_prefix'].notnull
()]'''
```

Out[47]:

```
"#removing null row from teacher prefix column dataset\ndf_new['teacher_pr
efix'] = df_new['teacher_prefix'][df_new['teacher_prefix'].notnull()]"
```

In [48]:

```
'''#replace NAN to space https ://stackoverflow.com/questions/49259305/raise-valueerror
np-nan-is-an-invalid-document-expected-byte-or?rq=1
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna(' ')'''
```

Out[48]:

```
"#replace NAN to space https ://stackoverflow.com/questions/49259305/raise
-valueerrornp-nan-is-an-invalid-document-expected-byte-or?rq=1\nproject_da
ta['teacher_prefix'] = project_data['teacher_prefix'].fillna(' ')"
```

In [49]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_s
plit.html
#split the data into train and test fo bag of words

x_train,x_test,y_train,y_test=model_selection.train_test_split(project_data,y,test_size
=0.3,random_state=0)
#split train into cross val train and cross val test
#x_train,x_cv,y_train,y_cv=model_selection.train_test_split(x_t,y_t,test_size=0.3,rando
m_state=0)
```

In [50]:

```
project_data.shape
```

Out[50]:

```
(109245, 30)
```

In [ ]:

```

```

In [51]:

```
x_train.columns
```

Out[51]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'preprocessed_essays', 'preprocessed_project_title', 'totalwords_ti
tle',
       'totalwords_essay', 'sentiment_pos_title', 'sentiment_neg_title',
       'sentiment_neu_title', 'sentiment_compound_title',
       'sentiment_pos_essay', 'sentiment_neg_essay', 'sentiment_neu_essa
y',
       'sentiment_compound_essay'],
      dtype='object')
```

encoding categorical features(probability ratio)

In [52]:

```
project_data.columns
```

Out[52]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'preprocessed_essays', 'preprocessed_project_title', 'totalwords_ti
tle',
       'totalwords_essay', 'sentiment_pos_title', 'sentiment_neg_title',
       'sentiment_neu_title', 'sentiment_compound_title',
       'sentiment_pos_essay', 'sentiment_neg_essay', 'sentiment_neu_essa
y',
       'sentiment_compound_essay'],
      dtype='object')
```

In [53]:

```
x_train.columns
```

Out[53]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'preprocessed_essays', 'preprocessed_project_title', 'totalwords_ti
tle',
       'totalwords_essay', 'sentiment_pos_title', 'sentiment_neg_title',
       'sentiment_neu_title', 'sentiment_compound_title',
       'sentiment_pos_essay', 'sentiment_neg_essay', 'sentiment_neu_essa
y',
       'sentiment_compound_essay'],
      dtype='object')
```

In [55]:

```
x_train_approved = x_train.loc[x_train['project_is_approved'] == 1]
x_train_reject = x_train.loc[x_train['project_is_approved'] == 0]

x_test_approved = x_test.loc[x_test['project_is_approved'] == 1]
x_test_reject = x_test.loc[x_test['project_is_approved'] == 0]
```

In [56]:

```
x_train_approved.drop(['project_is_approved'], axis=1, inplace=True)
x_train_reject.drop(['project_is_approved'], axis=1, inplace=True)
x_test_approved.drop(['project_is_approved'], axis=1, inplace=True)
x_test_reject.drop(['project_is_approved'], axis=1, inplace=True)
#X_cv.drop(['project_is_approved'], axis=1, inplace=True)
```

clean category

clean category x_train

In [57]:

```
#step1: Find counts of each
#_____________________________________________
x_train_clean_category_approved = {}
x_train_clean_category_reject = {}
x_train_clean_category_total = {}

for a in x_train_approved['clean_categories'] :
    for b in a.split():
        if b not in x_train_clean_category_approved :
            x_train_clean_category_approved[b] = 1
        else :
            x_train_clean_category_approved[b] += 1


for a in x_train_reject['clean_categories'] :
    for b in a.split():
        if b not in x_train_clean_category_reject :
            x_train_clean_category_reject[b] = 1
        else :
            x_train_clean_category_reject[b] += 1

for a in x_train['clean_categories'] :
    for b in a.split():
        if b not in x_train_clean_category_total :
            x_train_clean_category_total[b] = 1
        else :
            x_train_clean_category_total[b] += 1


print(x_train_clean_category_approved)
print(x_train_clean_category_reject)
print(x_train_clean_category_total)
```

```
{'AppliedLearning': 7030, 'Music_Arts': 6097, 'Literacy_Language': 31722,
'Math_Science': 24383, 'Warmth': 867, 'Care_Hunger': 867, 'SpecialNeeds':
8035, 'History_Civics': 3503, 'Health_Sports': 8436}
{'Math_Science': 4545, 'Literacy_Language': 4863, 'Health_Sports': 1557,
'SpecialNeeds': 1591, 'AppliedLearning': 1444, 'History_Civics': 579, 'Mus
ic_Arts': 1111, 'Warmth': 80, 'Care_Hunger': 80}
{'AppliedLearning': 8474, 'Music_Arts': 7208, 'Math_Science': 28928, 'Lite
racy_Language': 36585, 'Health_Sports': 9993, 'Warmth': 947, 'Care_Hunge
r': 947, 'SpecialNeeds': 9626, 'History_Civics': 4082}
```

In [58]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_train_approved_prob_clean_category = {}
x_train_reject_prob_clean_category = {}

for st in x_train_clean_category_total.keys():
  x_train_approved_prob_clean_category[st] = (x_train_clean_category_approved[st])/floa
t(x_train_clean_category_total[st])


for stt in x_train_clean_category_total.keys():
  x_train_reject_prob_clean_category[stt] = (x_train_clean_category_reject[stt])/float(
x_train_clean_category_total[stt])
```

In [59]:

```
#Step 3 : Apply probabilities to x_train_clean_category
#_____________________________________________
x_train_reject_clean_category = []
x_train_approved_clean_category = []

for a in x_train["clean_categories"] :
    b = a.split()
    if len(b) == 1 :
        x_train_reject_clean_category.append(x_train_reject_prob_clean_category[a])
        x_train_approved_clean_category.append(x_train_approved_prob_clean_category[a])
    else :
        c = x_train_reject_prob_clean_category[b[0]]
        d = x_train_reject_prob_clean_category[b[1]]
        e = x_train_approved_prob_clean_category[b[0]]
        f = x_train_approved_prob_clean_category[b[1]]

        x_train_reject_clean_category.append(c*d)
        x_train_approved_clean_category.append(e*f)
```

In [60]:

```
x_train['x_train_reject_clean_category']=x_train_reject_clean_category
x_train['x_train_approved_clean_category']=x_train_approved_clean_category
```

In [61]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_reject_clean_category"].values.reshape(-1,1))
x_train_reject_clean_category_nor = normalizer.transform(x_train["x_train_reject_clean_
category"].values.reshape(-1,1))
```

In [62]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_approved_clean_category"].values.reshape(-1,1))
x_train_approved_clean_category_nor = normalizer.transform(x_train["x_train_approved_cl
ean_category"].values.reshape(-1,1))
```

clean category x_test

In [63]:

```
#step1: Find counts of each
#_____________________________________________
x_test_clean_category_approved = {}
x_test_clean_category_reject = {}
x_test_clean_category_total = {}

for a in x_test_approved['clean_categories'] :
    for b in a.split():
        if b not in x_test_clean_category_approved :
            x_test_clean_category_approved[b] = 1
        else :
            x_test_clean_category_approved[b] += 1


for a in x_test_reject['clean_categories'] :
    for b in a.split():
        if b not in x_test_clean_category_reject :
            x_test_clean_category_reject[b] = 1
        else :
            x_test_clean_category_reject[b] += 1

for a in x_test['clean_categories'] :
    for b in a.split():
        if b not in x_test_clean_category_total :
            x_test_clean_category_total[b] = 1
        else :
            x_test_clean_category_total[b] += 1


print(x_test_clean_category_approved)
print(x_test_clean_category_reject)
print(x_test_clean_category_total)
```

```
{'Literacy_Language': 13508, 'Math_Science': 10459, 'Music_Arts': 2577, 'H
ealth_Sports': 3612, 'AppliedLearning': 3012, 'History_Civics': 1564, 'Spe
cialNeeds': 3355, 'Warmth': 407, 'Care_Hunger': 407}
{'AppliedLearning': 649, 'Math_Science': 2032, 'SpecialNeeds': 661, 'Healt
h_Sports': 618, 'Literacy_Language': 2143, 'Music_Arts': 508, 'History_Civ
ics': 268, 'Warmth': 34, 'Care_Hunger': 34}
{'Literacy_Language': 15651, 'Math_Science': 12491, 'Music_Arts': 3085, 'H
ealth_Sports': 4230, 'AppliedLearning': 3661, 'SpecialNeeds': 4016, 'Histo
ry_Civics': 1832, 'Warmth': 441, 'Care_Hunger': 441}
```

In [64]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_test_approved_prob_clean_category = {}
x_test_reject_prob_clean_category = {}

for st in x_test_clean_category_total.keys():
  x_test_approved_prob_clean_category[st] = (x_test_clean_category_approved[st])/float(
x_test_clean_category_total[st])


for stt in x_test_clean_category_total.keys():
  x_test_reject_prob_clean_category[stt] = (x_test_clean_category_reject[stt])/float(x_
test_clean_category_total[stt])
```

In [65]:

```
#Step 3 : Apply probabilities to x_test_clean_category
#_____________________________________________
x_test_reject_clean_category = []
x_test_approved_clean_category = []

for a in x_test["clean_categories"] :
    b = a.split()
    if len(b) == 1 :
        x_test_reject_clean_category.append(x_test_reject_prob_clean_category[a])
        x_test_approved_clean_category.append(x_test_approved_prob_clean_category[a])
    else :
        c = x_test_reject_prob_clean_category[b[0]]
        d = x_test_reject_prob_clean_category[b[1]]
        e = x_test_approved_prob_clean_category[b[0]]
        f = x_test_approved_prob_clean_category[b[1]]

        x_test_reject_clean_category.append(c*d)
        x_test_approved_clean_category.append(e*f)
```

In [66]:

```
x_test['x_test_reject_clean_category']=x_test_reject_clean_category
x_test['x_test_approved_clean_category']=x_test_approved_clean_category
```

In [67]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_reject_clean_category"].values.reshape(-1,1))
x_test_reject_clean_category_nor = normalizer.transform(x_test["x_test_reject_clean_cat
egory"].values.reshape(-1,1))
```

In [68]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_approved_clean_category"].values.reshape(-1,1))
x_test_approved_clean_category_nor = normalizer.transform(x_test["x_test_approved_clean
_category"].values.reshape(-1,1))
```

clean_subcategories

clean subcategory x_train

In [69]:

```
#step1: Find counts of each
#_____________________________________________
x_train_clean_subcategory_approved = {}
x_train_clean_subcategory_reject = {}
x_train_clean_subcategory_total = {}

for a in x_train_approved['clean_subcategories'] :
    for b in a.split():
        if b not in x_train_clean_subcategory_approved :
            x_train_clean_subcategory_approved[b] = 1
        else :
            x_train_clean_subcategory_approved[b] += 1


for a in x_train_reject['clean_subcategories'] :
    for b in a.split():
        if b not in x_train_clean_subcategory_reject :
            x_train_clean_subcategory_reject[b] = 1
        else :
            x_train_clean_subcategory_reject[b] += 1

for a in x_train['clean_subcategories'] :
    for b in a.split():
        if b not in x_train_clean_subcategory_total :
            x_train_clean_subcategory_total[b] = 1
        else :
            x_train_clean_subcategory_total[b] += 1


print(x_train_clean_subcategory_approved)
print(x_train_clean_subcategory_reject)
print(x_train_clean_subcategory_total)
```

```
{'EarlyDevelopment': 2459, 'PerformingArts': 1211, 'VisualArts': 3610, 'Li
terature_Writing': 13322, 'Mathematics': 16617, 'College_CareerPrep': 148
7, 'Warmth': 867, 'Care_Hunger': 867, 'SpecialNeeds': 8035, 'AppliedScienc
es': 6312, 'Other': 1368, 'History_Geography': 1873, 'Literacy': 20647, 'E
SL': 2644, 'CommunityService': 236, 'EnvironmentalScience': 3191, 'TeamSpo
rts': 1190, 'CharacterEducation': 1169, 'Health_Wellness': 6179, 'Gym_Fitn
ess': 2677, 'Health_LifeScience': 2447, 'ForeignLanguages': 502, 'Civics_G
overnment': 450, 'Extracurricular': 456, 'ParentInvolvement': 443, 'Musi
c': 1949, 'SocialSciences': 1165, 'NutritionEducation': 760, 'FinancialLit
eracy': 349, 'Economics': 153}
{'AppliedSciences': 1308, 'Literacy': 3012, 'Health_Wellness': 1000, 'Math
ematics': 2936, 'Literature_Writing': 2166, 'SpecialNeeds': 1591, 'Nutriti
onEducation': 186, 'Other': 285, 'EarlyDevelopment': 516, 'Health_LifeScie
nce': 512, 'TeamSports': 332, 'FinancialLiteracy': 61, 'ForeignLanguages':
117, 'Gym_Fitness': 518, 'VisualArts': 760, 'History_Geography': 326, 'Env
ironmentalScience': 704, 'PerformingArts': 188, 'SocialSciences': 172, 'Ch
aracterEducation': 271, 'College_CareerPrep': 303, 'ESL': 428, 'Economic
s': 26, 'Extracurricular': 94, 'CommunityService': 65, 'ParentInvolvemen
t': 58, 'Music': 265, 'Civics_Government': 81, 'Warmth': 80, 'Care_Hunge
r': 80}
{'EarlyDevelopment': 2975, 'PerformingArts': 1399, 'AppliedSciences': 762
0, 'Literacy': 23659, 'VisualArts': 4370, 'Health_Wellness': 7179, 'Mathem
atics': 19553, 'Literature_Writing': 15488, 'College_CareerPrep': 1790, 'W
armth': 947, 'Care_Hunger': 947, 'SpecialNeeds': 9626, 'Other': 1653, 'His
tory_Geography': 2199, 'ESL': 3072, 'NutritionEducation': 946, 'CommunityS
ervice': 301, 'EnvironmentalScience': 3895, 'TeamSports': 1522, 'Character
Education': 1440, 'Gym_Fitness': 3195, 'Health_LifeScience': 2959, 'Financ
ialLiteracy': 410, 'ForeignLanguages': 619, 'Civics_Government': 531, 'Ext
racurricular': 550, 'ParentInvolvement': 501, 'Music': 2214, 'SocialScienc
es': 1337, 'Economics': 179}
```

In [70]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_train_approved_prob_clean_subcategory = {}
x_train_reject_prob_clean_subcategory = {}

for st in x_train_clean_subcategory_total.keys():
  x_train_approved_prob_clean_subcategory[st] = (x_train_clean_subcategory_approved[st
])/float(x_train_clean_subcategory_total[st])


for stt in x_train_clean_subcategory_total.keys():
  x_train_reject_prob_clean_subcategory[stt] = (x_train_clean_subcategory_reject[stt])/
float(x_train_clean_subcategory_total[stt])
```

In [71]:

```
#Step 3 : Apply probabilities to x_train_clean_subcategory
#_____________________________________________
x_train_reject_clean_subcategory = []
x_train_approved_clean_subcategory = []

for a in x_train["clean_subcategories"] :
    b = a.split()
    if len(b) == 1 :
        x_train_reject_clean_subcategory.append(x_train_reject_prob_clean_subcategory[a
])
        x_train_approved_clean_subcategory.append(x_train_approved_prob_clean_subcatego
ry[a])
    else :
        c = x_train_reject_prob_clean_subcategory[b[0]]
        d = x_train_reject_prob_clean_subcategory[b[1]]
        e = x_train_approved_prob_clean_subcategory[b[0]]
        f = x_train_approved_prob_clean_subcategory[b[1]]

        x_train_reject_clean_subcategory.append(c*d)
        x_train_approved_clean_subcategory.append(e*f)
```

In [72]:

```
x_train['x_train_reject_clean_subcategory']=x_train_reject_clean_subcategory
x_train['x_train_approved_clean_subcategory']=x_train_approved_clean_subcategory
```

In [73]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_reject_clean_subcategory"].values.reshape(-1,1))
x_train_reject_clean_subcategory_nor = normalizer.transform(x_train["x_train_reject_cle
an_subcategory"].values.reshape(-1,1))
```

In [74]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_approved_clean_subcategory"].values.reshape(-1,1))
x_train_approved_clean_subcategory_nor = normalizer.transform(x_train["x_train_approved
_clean_subcategory"].values.reshape(-1,1))
```

clean subsubcategory x_test

In [75]:

```
#step1: Find counts of each
#_____________________________________________
x_test_clean_subcategory_approved = {}
x_test_clean_subcategory_reject = {}
x_test_clean_subcategory_total = {}

for a in x_test_approved['clean_subcategories'] :
    for b in a.split():
        if b not in x_test_clean_subcategory_approved :
            x_test_clean_subcategory_approved[b] = 1
        else :
            x_test_clean_subcategory_approved[b] += 1


for a in x_test_reject['clean_subcategories'] :
    for b in a.split():
        if b not in x_test_clean_subcategory_reject :
            x_test_clean_subcategory_reject[b] = 1
        else :
            x_test_clean_subcategory_reject[b] += 1

for a in x_test['clean_subcategories'] :
    for b in a.split():
        if b not in x_test_clean_subcategory_total :
            x_test_clean_subcategory_total[b] = 1
        else :
            x_test_clean_subcategory_total[b] += 1


print(x_test_clean_subcategory_approved)
print(x_test_clean_subcategory_reject)
print(x_test_clean_subcategory_total)
```

```
{'ForeignLanguages': 218, 'Mathematics': 7160, 'Music': 824, 'Gym_Fitnes
s': 1133, 'Health_Wellness': 2650, 'AppliedSciences': 2635, 'Literature_Wr
iting': 5723, 'Literacy': 8774, 'College_CareerPrep': 660, 'History_Geogra
phy': 843, 'VisualArts': 1547, 'CharacterEducation': 496, 'SpecialNeeds':
3355, 'SocialSciences': 492, 'Extracurricular': 217, 'ESL': 1077, 'Warmt
h': 407, 'Care_Hunger': 407, 'CommunityService': 107, 'Health_LifeScienc
e': 1054, 'EnvironmentalScience': 1399, 'Civics_Government': 241, 'TeamSpo
rts': 545, 'Other': 591, 'NutritionEducation': 341, 'ParentInvolvement': 1
37, 'EarlyDevelopment': 1053, 'Economics': 73, 'PerformingArts': 481, 'Fin
ancialLiteracy': 131}
{'EarlyDevelopment': 226, 'Mathematics': 1359, 'SpecialNeeds': 661, 'Healt
h_Wellness': 405, 'Literacy': 1266, 'Health_LifeScience': 222, 'NutritionE
ducation': 68, 'VisualArts': 361, 'History_Geography': 129, 'AppliedScienc
es': 561, 'EnvironmentalScience': 297, 'Literature_Writing': 966, 'College
_CareerPrep': 118, 'PerformingArts': 81, 'ForeignLanguages': 53, 'ESL': 21
8, 'Music': 107, 'ParentInvolvement': 39, 'CharacterEducation': 129, 'Comm
unityService': 33, 'Gym_Fitness': 181, 'SocialSciences': 91, 'Other': 128,
'Warmth': 34, 'Care_Hunger': 34, 'Civics_Government': 43, 'Economics': 17,
'FinancialLiteracy': 27, 'TeamSports': 125, 'Extracurricular': 43}
{'ForeignLanguages': 271, 'Mathematics': 8519, 'Music': 931, 'Gym_Fitnes
s': 1314, 'Health_Wellness': 3055, 'AppliedSciences': 3196, 'Literature_Wr
iting': 6689, 'Literacy': 10040, 'EarlyDevelopment': 1279, 'SpecialNeeds':
4016, 'College_CareerPrep': 778, 'History_Geography': 972, 'VisualArts': 1
908, 'CharacterEducation': 625, 'SocialSciences': 583, 'Extracurricular':
260, 'ESL': 1295, 'Health_LifeScience': 1276, 'NutritionEducation': 409,
'Warmth': 441, 'Care_Hunger': 441, 'CommunityService': 140, 'Environmental
Science': 1696, 'Civics_Government': 284, 'TeamSports': 670, 'Other': 719,
'ParentInvolvement': 176, 'PerformingArts': 562, 'Economics': 90, 'Financi
alLiteracy': 158}
```

In [76]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_test_approved_prob_clean_subcategory = {}
x_test_reject_prob_clean_subcategory = {}

for st in x_test_clean_subcategory_total.keys():
  x_test_approved_prob_clean_subcategory[st] = (x_test_clean_subcategory_approved[st])/
float(x_test_clean_subcategory_total[st])


for stt in x_test_clean_subcategory_total.keys():
  x_test_reject_prob_clean_subcategory[stt] = (x_test_clean_subcategory_reject[stt])/fl
oat(x_test_clean_subcategory_total[stt])
```

In [77]:

```
#Step 3 : Apply probabilities to x_test_clean_subcategory
#_____________________________________________
x_test_reject_clean_subcategory = []
x_test_approved_clean_subcategory = []

for a in x_test["clean_subcategories"] :
    b = a.split()
    if len(b) == 1 :
        x_test_reject_clean_subcategory.append(x_test_reject_prob_clean_subcategory[a])
        x_test_approved_clean_subcategory.append(x_test_approved_prob_clean_subcategory
[a])
    else :
        c = x_test_reject_prob_clean_subcategory[b[0]]
        d = x_test_reject_prob_clean_subcategory[b[1]]
        e = x_test_approved_prob_clean_subcategory[b[0]]
        f = x_test_approved_prob_clean_subcategory[b[1]]

        x_test_reject_clean_subcategory.append(c*d)
        x_test_approved_clean_subcategory.append(e*f)
```

In [78]:

```
x_test['x_test_reject_clean_subcategory']=x_test_reject_clean_subcategory
x_test['x_test_approved_clean_subcategory']=x_test_approved_clean_subcategory
```

In [79]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_reject_clean_subcategory"].values.reshape(-1,1))
x_test_reject_clean_subcategory_nor = normalizer.transform(x_test["x_test_reject_clean_
subcategory"].values.reshape(-1,1))
```

In [80]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_approved_clean_subcategory"].values.reshape(-1,1))
x_test_approved_clean_subcategory_nor = normalizer.transform(x_test["x_test_approved_cl
ean_subcategory"].values.reshape(-1,1))
```

Project Grade Category

Project Grade Category x_train

In [81]:

```
#step1: Find counts of each
#_____________________________________________
x_train_grade_approved = {}
x_train_grade_reject = {}
x_train_grade_total = {}

for a in x_train_approved['project_grade_category'] :
    for b in a.split():
        if b not in x_train_grade_approved :
            x_train_grade_approved[b] = 1
        else :
            x_train_grade_approved[b] += 1


for a in x_train_reject['project_grade_category'] :
    for b in a.split():
        if b not in x_train_grade_reject :
            x_train_grade_reject[b] = 1
        else :
            x_train_grade_reject[b] += 1

for a in x_train['project_grade_category'] :
    for b in a.split():
        if b not in x_train_grade_total :
            x_train_grade_total[b] = 1
        else :
            x_train_grade_total[b] += 1


print(x_train_grade_approved)
print(x_train_grade_reject)
print(x_train_grade_total)
```

```
{'Grades': 64926, 'PreK-2': 26316, '9-12': 6407, '3-5': 22193, '6-8': 1001
0}
{'Grades': 11545, 'PreK-2': 4692, '3-5': 3712, '6-8': 1868, '9-12': 1273}
{'Grades': 76471, 'PreK-2': 31008, '9-12': 7680, '3-5': 25905, '6-8': 1187
8}
```

In [82]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_train_approved_prob_grade = {}
x_train_reject_prob_grade = {}

for st in x_train_grade_total.keys():
  x_train_approved_prob_grade[st] = (x_train_grade_approved[st])/float(x_train_grade_to
tal[st])


for stt in x_train_grade_total.keys():
  x_train_reject_prob_grade[stt] = (x_train_grade_reject[stt])/float(x_train_grade_tota
l[stt])
```

In [83]:

```
#Step 3 : Apply probabilities to clean_category
#_____________________________________________
x_train_reject_grade = []
x_train_approved_grade = []

for a in x_train["project_grade_category"] :
    b = a.split()
    if len(b) == 1 :
        x_train_reject_grade.append(x_train_reject_prob_grade[a])
        x_train_approved_grade.append(x_train_approved_prob_grade[a])
    else :
        c = x_train_reject_prob_grade[b[0]]
        d = x_train_reject_prob_grade[b[1]]
        e = x_train_approved_prob_grade[b[0]]
        f = x_train_approved_prob_grade[b[1]]

        x_train_reject_grade.append(c*d)
        x_train_approved_grade.append(e*f)
```

In [84]:

```
x_train['x_train_reject_grade']=x_train_reject_grade
x_train['x_train_approved_grade']=x_train_approved_grade
```

In [85]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_reject_grade"].values.reshape(-1,1))
x_train_reject_grade_nor = normalizer.transform(x_train["x_train_reject_grade"].values.
reshape(-1,1))
```

In [86]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_approved_grade"].values.reshape(-1,1))
x_train_approved_grade_nor = normalizer.transform(x_train["x_train_approved_grade"].val
ues.reshape(-1,1))
```

Project Grade Category x_test

In [87]:

```
#step1: Find counts of each
#_____________________________________________
x_test_grade_approved = {}
x_test_grade_reject = {}
x_test_grade_total = {}

for a in x_test_approved['project_grade_category'] :
    for b in a.split():
        if b not in x_test_grade_approved :
            x_test_grade_approved[b] = 1
        else :
            x_test_grade_approved[b] += 1


for a in x_test_reject['project_grade_category'] :
    for b in a.split():
        if b not in x_test_grade_reject :
            x_test_grade_reject[b] = 1
        else :
            x_test_grade_reject[b] += 1

for a in x_test['project_grade_category'] :
    for b in a.split():
        if b not in x_test_grade_total :
            x_test_grade_total[b] = 1
        else :
            x_test_grade_total[b] += 1


print(x_test_grade_approved)
print(x_test_grade_reject)
print(x_test_grade_total)
```

```
{'Grades': 27777, '9-12': 2775, 'PreK-2': 11220, '6-8': 4248, '3-5': 9534}
{'Grades': 4997, 'PreK-2': 1997, '6-8': 797, '9-12': 507, '3-5': 1696}
{'Grades': 32774, '9-12': 3282, 'PreK-2': 13217, '6-8': 5045, '3-5': 1123
0}
```

In [88]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_test_approved_prob_grade = {}
x_test_reject_prob_grade = {}

for st in x_test_grade_total.keys():
  x_test_approved_prob_grade[st] = (x_test_grade_approved[st])/float(x_test_grade_total
[st])


for stt in x_test_grade_total.keys():
  x_test_reject_prob_grade[stt] = (x_test_grade_reject[stt])/float(x_test_grade_total[s
tt])
```

In [89]:

```
#Step 3 : Apply probabilities to clean_category
#_____________________________________________
x_test_reject_grade = []
x_test_approved_grade = []

for a in x_test["project_grade_category"] :
    b = a.split()
    if len(b) == 1 :
        x_test_reject_grade.append(x_test_reject_prob_grade[a])
        x_test_approved_grade.append(x_test_approved_prob_grade[a])
    else :
        c = x_test_reject_prob_grade[b[0]]
        d = x_test_reject_prob_grade[b[1]]
        e = x_test_approved_prob_grade[b[0]]
        f = x_test_approved_prob_grade[b[1]]

        x_test_reject_grade.append(c*d)
        x_test_approved_grade.append(e*f)
```

In [90]:

```
x_test['x_test_reject_grade']=x_test_reject_grade
x_test['x_test_approved_grade']=x_test_approved_grade
```

In [91]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_reject_grade"].values.reshape(-1,1))
x_test_reject_grade_nor = normalizer.transform(x_test["x_test_reject_grade"].values.res
hape(-1,1))
```

In [92]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_approved_grade"].values.reshape(-1,1))
x_test_approved_grade_nor = normalizer.transform(x_test["x_test_approved_grade"].values
.reshape(-1,1))
```

Teacher Prefix

Teacher Prefix train

In [93]:

```
count_nan = len(project_data['teacher_prefix']) - project_data['teacher_prefix'].count
()
count_nan
```

Out[93]:

```
0
```

In [94]:

```
project_data['teacher_prefix'].isnull().any()
```

Out[94]:

```
False
```

In [95]:

```
project_data['teacher_prefix'].isnull().sum()
```

Out[95]:

```
0
```

In [96]:

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

Out[96]:

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

In [97]:

```
#step1: Find counts of each
#_____________________________________________
x_train_teacher_prefix_approved = {}
x_train_teacher_prefix_reject = {}
x_train_teacher_prefix_total = {}

for a in x_train_approved['teacher_prefix'] :
    for b in a.split():
        if b not in x_train_teacher_prefix_approved :
            x_train_teacher_prefix_approved[b] = 1
        else :
            x_train_teacher_prefix_approved[b] += 1


for a in x_train_reject['teacher_prefix'] :
    for b in a.split():
        if b not in x_train_teacher_prefix_reject :
            x_train_teacher_prefix_reject[b] = 1
        else :
            x_train_teacher_prefix_reject[b] += 1

for a in x_train['teacher_prefix'] :
    for b in a.split():
        if b not in x_train_teacher_prefix_total :
            x_train_teacher_prefix_total[b] = 1
        else :
            x_train_teacher_prefix_total[b] += 1


print(x_train_teacher_prefix_approved)
print(x_train_teacher_prefix_reject)
print(x_train_teacher_prefix_total)
```

```
{'Mrs.': 34306, 'Ms.': 22995, 'Mr.': 6295, 'Teacher': 1324, 'Dr.': 6}
{'Ms.': 4266, 'Mrs.': 5733, 'Teacher': 338, 'Mr.': 1205, 'Dr.': 3}
{'Mrs.': 40039, 'Ms.': 27261, 'Mr.': 7500, 'Teacher': 1662, 'Dr.': 9}
```

In [98]:

```
a
```

Out[98]:

```
'Mrs.'
```

In [99]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_train_approved_prob_teacher_prefix = {}
x_train_reject_prob_teacher_prefix = {}

for st in x_train_teacher_prefix_total.keys():
  x_train_approved_prob_teacher_prefix[st] = (x_train_teacher_prefix_approved[st])/floa
t(x_train_teacher_prefix_total[st])


for stt in x_train_teacher_prefix_total.keys():
  x_train_reject_prob_teacher_prefix[stt] = (x_train_teacher_prefix_reject[stt])/float(
x_train_teacher_prefix_total[stt])
```

In [100]:

```
#Step 3 : Apply probabilities to
x_train_reject_teacher_prefix = []
x_train_approved_teacher_prefix = []

for a in x_train["teacher_prefix"] :
    b = a.split()
    if len(b) == 1 :
        x_train_reject_teacher_prefix.append(x_train_reject_prob_teacher_prefix[a])
        x_train_approved_teacher_prefix.append(x_train_approved_prob_teacher_prefix[a])
    else :
        c = x_train_reject_prob_teacher_prefix[b[0]]
        d = x_train_reject_prob_teacher_prefix[b[1]]
        e = x_train_approved_prob_teacher_prefix[b[0]]
        f = x_train_approved_prob_teacher_prefix[b[1]]

        x_train_reject_teacher_prefix.append(c*d)
        x_train_approved_teacher_prefix.append(e*f)
```

In [101]:

```
x_train['x_train_reject_teacher_prefix']=x_train_reject_teacher_prefix
x_train['x_train_approved_teacher_prefix']=x_train_approved_teacher_prefix
```

In [102]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_reject_teacher_prefix"].values.reshape(-1,1))
x_train_reject_teacher_prefix_nor = normalizer.transform(x_train["x_train_reject_teache
r_prefix"].values.reshape(-1,1))
```

In [103]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_approved_teacher_prefix"].values.reshape(-1,1))
x_train_approved_teacher_prefix_nor = normalizer.transform(x_train["x_train_approved_te
acher_prefix"].values.reshape(-1,1))
```

Teacher Prefix test

In [104]:

```
#step1: Find counts of each
#_____________________________________________
x_test_teacher_prefix_approved = {}
x_test_teacher_prefix_reject = {}
x_test_teacher_prefix_total = {}

for a in x_test_approved['teacher_prefix'] :
    for b in a.split():
        if b not in x_test_teacher_prefix_approved :
            x_test_teacher_prefix_approved[b] = 1
        else :
            x_test_teacher_prefix_approved[b] += 1


for a in x_test_reject['teacher_prefix'] :
    for b in a.split():
        if b not in x_test_teacher_prefix_reject :
            x_test_teacher_prefix_reject[b] = 1
        else :
            x_test_teacher_prefix_reject[b] += 1

for a in x_test['teacher_prefix'] :
    for b in a.split():
        if b not in x_test_teacher_prefix_total :
            x_test_teacher_prefix_total[b] = 1
        else :
            x_test_teacher_prefix_total[b] += 1


print(x_test_teacher_prefix_approved)
print(x_test_teacher_prefix_reject)
print(x_test_teacher_prefix_total)
```

```
{'Mrs.': 14691, 'Ms.': 9865, 'Mr.': 2665, 'Teacher': 553, 'Dr.': 3}
{'Mrs.': 2539, 'Ms.': 1829, 'Mr.': 483, 'Teacher': 145, 'Dr.': 1}
{'Mrs.': 17230, 'Ms.': 11694, 'Mr.': 3148, 'Teacher': 698, 'Dr.': 4}
```

In [105]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_test_approved_prob_teacher_prefix = {}
x_test_reject_prob_teacher_prefix = {}

for st in x_test_teacher_prefix_total.keys():
  x_test_approved_prob_teacher_prefix[st] = (x_test_teacher_prefix_approved[st])/float(
x_test_teacher_prefix_total[st])


for stt in x_test_teacher_prefix_total.keys():
  x_test_reject_prob_teacher_prefix[stt] = (x_test_teacher_prefix_reject[stt])/float(x_
test_teacher_prefix_total[stt])
```

In [106]:

```
#Step 3 : Apply probabilities to clean_category
#_____________________________________________
x_test_reject_teacher_prefix = []
x_test_approved_teacher_prefix = []

for a in x_test["teacher_prefix"] :
    b = a.split()
    if len(b) == 1 :
        x_test_reject_teacher_prefix.append(x_test_reject_prob_teacher_prefix[a])
        x_test_approved_teacher_prefix.append(x_test_approved_prob_teacher_prefix[a])
    else :
        c = x_test_reject_prob_teacher_prefix[b[0]]
        d = x_test_reject_prob_teacher_prefix[b[1]]
        e = x_test_approved_prob_teacher_prefix[b[0]]
        f = x_test_approved_prob_teacher_prefix[b[1]]

        x_test_reject_teacher_prefix.append(c*d)
        x_test_approved_teacher_prefix.append(e*f)
```

In [107]:

```
x_test['x_test_reject_teacher_prefix']=x_test_reject_teacher_prefix
x_test['x_test_approved_teacher_prefix']=x_test_approved_teacher_prefix
```

In [108]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_reject_teacher_prefix"].values.reshape(-1,1))
x_test_reject_teacher_prefix_nor = normalizer.transform(x_test["x_test_reject_teacher_p
refix"].values.reshape(-1,1))
```

In [109]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_approved_teacher_prefix"].values.reshape(-1,1))
x_test_approved_teacher_prefix_nor = normalizer.transform(x_test["x_test_approved_teach
er_prefix"].values.reshape(-1,1))
```

School State

School State train

In [110]:

```
#step1: Find counts of each
#_____________________________________________
x_train_school_state_approved = {}
x_train_school_state_reject = {}
x_train_school_state_total = {}

for a in x_train_approved['school_state'] :
    for b in a.split():
        if b not in x_train_school_state_approved :
            x_train_school_state_approved[b] = 1
        else :
            x_train_school_state_approved[b] += 1


for a in x_train_reject['school_state'] :
    for b in a.split():
        if b not in x_train_school_state_reject :
            x_train_school_state_reject[b] = 1
        else :
            x_train_school_state_reject[b] += 1

for a in x_train['school_state'] :
    for b in a.split():
        if b not in x_train_school_state_total :
            x_train_school_state_total[b] = 1
        else :
            x_train_school_state_total[b] += 1


print(x_train_school_state_approved)
print(x_train_school_state_reject)
print(x_train_school_state_total)
```

```
{'AK': 203, 'LA': 1370, 'OH': 1493, 'NY': 4419, 'CA': 9219, 'NC': 3053, 'G
A': 2344, 'MO': 1532, 'OK': 1327, 'WA': 1426, 'VA': 1247, 'NH': 217, 'MI':
1877, 'FL': 3603, 'IL': 2626, 'UT': 992, 'IN': 1564, 'MA': 1439, 'PA': 188
0, 'TX': 4184, 'SD': 175, 'MN': 766, 'TN': 1015, 'AZ': 1282, 'KS': 386, 'N
J': 1338, 'SC': 2334, 'KY': 799, 'CO': 652, 'MD': 867, 'OR': 741, 'WI': 10
47, 'MS': 798, 'NV': 787, 'IA': 381, 'WV': 320, 'HI': 314, 'CT': 1031, 'D
C': 286, 'AL': 1035, 'WY': 63, 'ME': 311, 'AR': 622, 'ND': 98, 'NM': 313,
'DE': 202, 'VT': 39, 'NE': 188, 'MT': 138, 'ID': 394, 'RI': 189}
{'NY': 741, 'CA': 1556, 'FL': 747, 'AL': 182, 'CT': 150, 'WI': 196, 'MI':
318, 'TX': 978, 'RI': 32, 'MA': 227, 'IL': 469, 'NC': 532, 'IN': 295, 'U
T': 203, 'MO': 253, 'NJ': 242, 'OK': 267, 'SC': 362, 'VA': 212, 'AZ': 232,
'OH': 208, 'CO': 123, 'HI': 50, 'PA': 310, 'WA': 191, 'GA': 442, 'MD': 17
3, 'TN': 171, 'AR': 119, 'ME': 56, 'LA': 280, 'OR': 131, 'MN': 122, 'WV':
46, 'KY': 123, 'MT': 33, 'MS': 134, 'AK': 36, 'NE': 38, 'NH': 23, 'ID': 8
0, 'DC': 65, 'NV': 136, 'SD': 33, 'KS': 65, 'NM': 56, 'ND': 8, 'IA': 63,
'VT': 12, 'WY': 8, 'DE': 16}
{'AK': 239, 'NY': 5160, 'LA': 1650, 'CA': 10775, 'OH': 1701, 'NC': 3585,
'GA': 2786, 'FL': 4350, 'MO': 1785, 'OK': 1594, 'WA': 1617, 'AL': 1217, 'C
T': 1181, 'VA': 1459, 'NH': 240, 'MI': 2195, 'IL': 3095, 'WI': 1243, 'UT':
1195, 'IN': 1859, 'MA': 1666, 'PA': 2190, 'TX': 5162, 'RI': 221, 'SD': 20
8, 'MN': 888, 'TN': 1186, 'AZ': 1514, 'KS': 451, 'NJ': 1580, 'SC': 2696,
'KY': 922, 'CO': 775, 'MD': 1040, 'OR': 872, 'MS': 932, 'NV': 923, 'IA': 4
44, 'WV': 366, 'HI': 364, 'DC': 351, 'WY': 71, 'ME': 367, 'AR': 741, 'ND':
106, 'NM': 369, 'DE': 218, 'VT': 51, 'NE': 226, 'MT': 171, 'ID': 474}
```

In [111]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_train_approved_prob_school_state = {}
x_train_reject_prob_school_state = {}

for st in x_train_school_state_total.keys():
  x_train_approved_prob_school_state[st] = (x_train_school_state_approved[st])/float(x_
train_school_state_total[st])


for stt in x_train_school_state_total.keys():
  x_train_reject_prob_school_state[stt] = (x_train_school_state_reject[stt])/float(x_tr
ain_school_state_total[stt])
```

In [112]:

```
#Step 3 : Apply probabilities to clean_category
#_____________________________________________
x_train_reject_school_state = []
x_train_approved_school_state = []

for a in x_train["school_state"] :
    b = a.split()
    if len(b) == 1 :
        x_train_reject_school_state.append(x_train_reject_prob_school_state[a])
        x_train_approved_school_state.append(x_train_approved_prob_school_state[a])
    else :
        c = x_train_reject_prob_school_state[b[0]]
        d = x_train_reject_prob_school_state[b[1]]
        e = x_train_approved_prob_school_state[b[0]]
        f = x_train_approved_prob_school_state[b[1]]

        x_train_reject_school_state.append(c*d)
        x_train_approved_school_state.append(e*f)
```

In [113]:

```
x_train['x_train_reject_school_state']=x_train_reject_school_state
x_train['x_train_approved_school_state']=x_train_approved_school_state
```

In [114]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_reject_school_state"].values.reshape(-1,1))
x_train_reject_school_state_nor = normalizer.transform(x_train["x_train_reject_school_s
tate"].values.reshape(-1,1))
```

In [115]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_train["x_train_approved_school_state"].values.reshape(-1,1))
x_train_approved_school_state_nor = normalizer.transform(x_train["x_train_approved_scho
ol_state"].values.reshape(-1,1))
```

School State test

In [116]:

```
#step1: Find counts of each
#_____________________________________________
x_test_school_state_approved = {}
x_test_school_state_reject = {}
x_test_school_state_total = {}

for a in x_test_approved['school_state'] :
    for b in a.split():
        if b not in x_test_school_state_approved :
            x_test_school_state_approved[b] = 1
        else :
            x_test_school_state_approved[b] += 1


for a in x_test_reject['school_state'] :
    for b in a.split():
        if b not in x_test_school_state_reject :
            x_test_school_state_reject[b] = 1
        else :
            x_test_school_state_reject[b] += 1

for a in x_test['school_state'] :
    for b in a.split():
        if b not in x_test_school_state_total :
            x_test_school_state_total[b] = 1
        else :
            x_test_school_state_total[b] += 1


print(x_test_school_state_approved)
print(x_test_school_state_reject)
print(x_test_school_state_total)
```

```
{'TX': 1830, 'OK': 573, 'CA': 3985, 'MD': 403, 'MO': 670, 'AZ': 518, 'OR':
315, 'VA': 492, 'DE': 106, 'NC': 1300, 'NV': 380, 'MI': 795, 'NY': 1872,
'CO': 283, 'NJ': 550, 'PA': 777, 'AL': 471, 'LA': 620, 'FL': 1541, 'AR': 2
50, 'WI': 498, 'IN': 650, 'WA': 619, 'MN': 270, 'MA': 616, 'ID': 185, 'C
T': 414, 'NM': 166, 'SC': 1050, 'OH': 666, 'GA': 985, 'VT': 25, 'WV': 110,
'NE': 72, 'UT': 456, 'IL': 1084, 'IA': 187, 'SD': 77, 'TN': 420, 'NH': 87,
'HI': 120, 'DC': 128, 'KY': 327, 'ME': 117, 'KS': 146, 'AK': 87, 'RI': 54,
'MS': 320, 'MT': 62, 'ND': 29, 'WY': 19}
{'GA': 192, 'CA': 627, 'MA': 107, 'DC': 37, 'TX': 404, 'IA': 35, 'DE': 19,
'PA': 141, 'UT': 80, 'MO': 121, 'SC': 189, 'OK': 109, 'NC': 206, 'TN': 82,
'AL': 74, 'FL': 294, 'OH': 100, 'CT': 68, 'NV': 64, 'IN': 111, 'AK': 19,
'NY': 286, 'VA': 94, 'ID': 34, 'AZ': 115, 'LA': 124, 'WA': 98, 'OR': 55,
'MD': 71, 'CO': 53, 'IL': 171, 'WI': 86, 'MN': 50, 'VT': 4, 'MI': 171, 'A
R': 58, 'HI': 23, 'ME': 21, 'KS': 37, 'NJ': 107, 'NM': 22, 'MS': 71, 'NE':
11, 'KY': 55, 'RI': 10, 'WV': 27, 'WY': 8, 'ND': 8, 'SD': 15, 'NH': 21, 'M
T': 12}
{'TX': 2234, 'OK': 682, 'CA': 4612, 'MD': 474, 'MO': 791, 'AZ': 633, 'OR':
370, 'GA': 1177, 'VA': 586, 'DE': 125, 'NC': 1506, 'NV': 444, 'MI': 966,
'NY': 2158, 'CO': 336, 'MA': 723, 'DC': 165, 'NJ': 657, 'PA': 918, 'AL': 5
45, 'IA': 222, 'LA': 744, 'FL': 1835, 'AR': 308, 'WI': 584, 'IN': 761, 'W
A': 717, 'MN': 320, 'ID': 219, 'CT': 482, 'NM': 188, 'SC': 1239, 'OH': 76
6, 'UT': 536, 'VT': 29, 'WV': 137, 'NE': 83, 'IL': 1255, 'TN': 502, 'SD':
92, 'NH': 108, 'AK': 106, 'HI': 143, 'KY': 382, 'ME': 138, 'KS': 183, 'R
I': 64, 'MS': 391, 'MT': 74, 'WY': 27, 'ND': 37}
```

In [117]:

```
#step2: Find Probabilities with respect to classes
#_____________________________________________________

x_test_approved_prob_school_state = {}
x_test_reject_prob_school_state = {}

for st in x_test_school_state_total.keys():
  x_test_approved_prob_school_state[st] = (x_test_school_state_approved[st])/float(x_te
st_school_state_total[st])


for stt in x_test_school_state_total.keys():
  x_test_reject_prob_school_state[stt] = (x_test_school_state_reject[stt])/float(x_test
_school_state_total[stt])
```

In [118]:

```
#Step 3 : Apply probabilities to clean_category
#_____________________________________________
x_test_reject_school_state = []
x_test_approved_school_state = []

for a in x_test["school_state"] :
    b = a.split()
    if len(b) == 1 :
        x_test_reject_school_state.append(x_test_reject_prob_school_state[a])
        x_test_approved_school_state.append(x_test_approved_prob_school_state[a])
    else :
        c = x_test_reject_prob_school_state[b[0]]
        d = x_test_reject_prob_school_state[b[1]]
        e = x_test_approved_prob_school_state[b[0]]
        f = x_test_approved_prob_school_state[b[1]]

        x_test_reject_school_state.append(c*d)
        x_test_approved_school_state.append(e*f)
```

In [119]:

```
x_test['x_test_reject_school_state']=x_test_reject_school_state
x_test['x_test_approved_school_state']=x_test_approved_school_state
```

In [120]:

```
#normalize
#-----------------------------------
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_reject_school_state"].values.reshape(-1,1))
x_test_reject_school_state_nor = normalizer.transform(x_test["x_test_reject_school_stat
e"].values.reshape(-1,1))
```

In [121]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(x_test["x_test_approved_school_state"].values.reshape(-1,1))
x_test_approved_school_state_nor = normalizer.transform(x_test["x_test_approved_school_
state"].values.reshape(-1,1))
```

In [ ]:

```

```

encoding numerical features AND NORMALIZATION

In [122]:

```
x_train.columns
```

Out[122]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'preprocessed_essays', 'preprocessed_project_title', 'totalwords_ti
tle',
       'totalwords_essay', 'sentiment_pos_title', 'sentiment_neg_title',
       'sentiment_neu_title', 'sentiment_compound_title',
       'sentiment_pos_essay', 'sentiment_neg_essay', 'sentiment_neu_essa
y',
       'sentiment_compound_essay', 'x_train_reject_clean_category',
       'x_train_approved_clean_category', 'x_train_reject_clean_subcategor
y',
       'x_train_approved_clean_subcategory', 'x_train_reject_grade',
       'x_train_approved_grade', 'x_train_reject_teacher_prefix',
       'x_train_approved_teacher_prefix', 'x_train_reject_school_state',
       'x_train_approved_school_state'],
      dtype='object')
```

price

In [123]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['price'].values.reshape(-1,1))

train_price_nor = normalizer.transform(x_train['price'].values.reshape(-1,1))

test_price_nor = normalizer.transform(x_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(train_price_nor.shape, y_train.shape)

print(test_price_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================================
==========
```

Quantity

In [124]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['quantity'].values.reshape(-1,1))

train_quantity_nor = normalizer.transform(x_train['quantity'].values.reshape(-1,1))

test_quantity_nor = normalizer.transform(x_test['quantity'].values.reshape(-1,1))

print("After vectorizations")
print(train_quantity_nor.shape, y_train.shape)

print(test_quantity_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================================
==========
```

Number of Projects previously proposed by Teacher

In [125]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

train_teacher_nor = normalizer.transform(x_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

test_teacher_nor = normalizer.transform(x_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

print("After vectorizations")
print(train_teacher_nor.shape, y_train.shape)

print(test_teacher_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================================
```

Title word Count

In [126]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['totalwords_title'].values.reshape(-1,1))

train_totalwords_title_nor = normalizer.transform(x_train['totalwords_title'].values.reshape(-1,1))

test_totalwords_title_nor = normalizer.transform(x_test['totalwords_title'].values.reshape(-1,1))

print("After vectorizations")
print(train_totalwords_title_nor.shape, y_train.shape)

print(test_totalwords_title_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================================
```

essay word Count

In [127]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['totalwords_essay'].values.reshape(-1,1))

train_totalwords_essay_nor = normalizer.transform(x_train['totalwords_essay'].values.re
shape(-1,1))

test_totalwords_essay_nor = normalizer.transform(x_test['totalwords_essay'].values.resh
ape(-1,1))

print("After vectorizations")
print(train_totalwords_essay_nor.shape, y_train.shape)

print(test_totalwords_essay_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================
==========================
```

Essay Sentiments - pos

In [128]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_pos_essay'].values.reshape(-1,1))

train_sentiment_pos_essay_nor = normalizer.transform(x_train['sentiment_pos_essay'].val
ues.reshape(-1,1))

test_sentiment_pos_essay_nor = normalizer.transform(x_test['sentiment_pos_essay'].value
s.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_pos_essay_nor.shape, y_train.shape)

print(test_sentiment_pos_essay_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================
==========================
```

Essay Sentiments - neg

In [129]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_neg_essay'].values.reshape(-1,1))

train_sentiment_neg_essay_nor = normalizer.transform(x_train['sentiment_neg_essay'].val
ues.reshape(-1,1))

test_sentiment_neg_essay_nor = normalizer.transform(x_test['sentiment_neg_essay'].value
s.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_neg_essay_nor.shape, y_train.shape)

print(test_sentiment_neg_essay_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================
==========================
```

Essay Sentiments -neu

In [130]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_neu_essay'].values.reshape(-1,1))

train_sentiment_neu_essay_nor = normalizer.transform(x_train['sentiment_neu_essay'].val
ues.reshape(-1,1))

test_sentiment_neu_essay_nor = normalizer.transform(x_test['sentiment_neu_essay'].value
s.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_neu_essay_nor.shape, y_train.shape)

print(test_sentiment_neu_essay_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================
==========================
```

Essay Sentiments - compound

In [131]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_compound_essay'].values.reshape(-1,1))

train_sentiment_compound_essay_nor = normalizer.transform(x_train['sentiment_compound_essay'].values.reshape(-1,1))

test_sentiment_compound_essay_nor = normalizer.transform(x_test['sentiment_compound_essay'].values.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_compound_essay_nor.shape, y_train.shape)

print(test_sentiment_compound_essay_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================================
```

title Sentiments - pos

In [132]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_pos_title'].values.reshape(-1,1))

train_sentiment_pos_title_nor = normalizer.transform(x_train['sentiment_pos_title'].values.reshape(-1,1))

test_sentiment_pos_title_nor = normalizer.transform(x_test['sentiment_pos_title'].values.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_pos_title_nor.shape, y_train.shape)

print(test_sentiment_pos_title_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================================
```

title Sentiments - neg

In [133]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_neg_title'].values.reshape(-1,1))

train_sentiment_neg_title_nor = normalizer.transform(x_train['sentiment_neg_title'].val
ues.reshape(-1,1))

test_sentiment_neg_title_nor = normalizer.transform(x_test['sentiment_neg_title'].value
s.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_neg_title_nor.shape, y_train.shape)

print(test_sentiment_neg_title_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================
==========================
```

title Sentiments - neu

In [134]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_neu_title'].values.reshape(-1,1))

train_sentiment_neu_title_nor = normalizer.transform(x_train['sentiment_neu_title'].val
ues.reshape(-1,1))

test_sentiment_neu_title_nor = normalizer.transform(x_test['sentiment_neu_title'].value
s.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_neu_title_nor.shape, y_train.shape)

print(test_sentiment_neu_title_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================
==========================
```

title Sentiments - compound

In [135]:

```
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()
normalizer.fit(x_train['sentiment_compound_title'].values.reshape(-1,1))

train_sentiment_compound_title_nor = normalizer.transform(x_train['sentiment_compound_t
itle'].values.reshape(-1,1))

test_sentiment_compound_title_nor = normalizer.transform(x_test['sentiment_compound_tit
le'].values.reshape(-1,1))

print("After vectorizations")
print(train_sentiment_compound_title_nor.shape, y_train.shape)

print(test_sentiment_compound_title_nor.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(76471, 1) (76471,)
(32774, 1) (32774,)
====================================================================================
==========================
```

In [136]:

```
#x_train_reject_school_state_nor,x_train_approved_school_state_nor,x_train_reject_clean
_subcategory_nor,x_train_approved_clean_subcategory_nor,x_train_reject_teacher_prefix_n
or,x_train_approved_teacher_prefix_nor,
#x_test_reject_clean_subcategory_nor,x_test_approved_clean_subcategory_nor,x_test_rejec
t_school_state_nor,x_test_approved_school_state_nor,x_test_reject_teacher_prefix_nor,x_
test_approved_teacher_prefix_nor,
```

In [137]:

```
#x_train_reject_school_state_nor,x_train_approved_school_state_nor,
#x_test_reject_school_state_nor,x_test_approved_school_state_nor,
```

merge all above variable(categorical and numerical)

In [137]:

```
#,x_train_reject_teacher_prefix_nor,x_train_approved_teacher_prefix_nor,x_train_reject_
school_state_nor,x_train_approved_school_state_nor
#x_test_reject_teacher_prefix_nor,x_test_approved_teacher_prefix_nor,x_test_reject_clea
n_subcategory_nor,x_test_approved_clean_subcategory_nor
```

In [138]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
x_train_ohe = np.hstack((x_train_reject_clean_category_nor,x_train_approved_clean_categ
ory_nor,x_train_reject_clean_subcategory_nor,x_train_approved_clean_subcategory_nor,x_t
rain_reject_teacher_prefix_nor,x_train_approved_teacher_prefix_nor,x_train_reject_grade
_nor,x_train_approved_grade_nor,x_train_reject_school_state_nor,x_train_approved_school
_state_nor,train_price_nor,train_quantity_nor,train_teacher_nor,train_totalwords_title_
nor,train_totalwords_essay_nor,train_sentiment_pos_essay_nor,train_sentiment_neg_essay_
nor,train_sentiment_neu_essay_nor,train_sentiment_compound_essay_nor,train_sentiment_po
s_title_nor,train_sentiment_neg_title_nor,train_sentiment_neu_title_nor,train_sentiment
_compound_title_nor))
x_test_ohe = np.hstack((x_test_reject_clean_category_nor,x_test_approved_clean_category
_nor,x_test_reject_clean_subcategory_nor,x_test_approved_clean_subcategory_nor,x_test_r
eject_teacher_prefix_nor,x_test_approved_teacher_prefix_nor,x_test_reject_grade_nor,x_t
est_approved_grade_nor,x_test_reject_school_state_nor,x_test_approved_school_state_nor,
test_price_nor,test_quantity_nor,test_teacher_nor,test_totalwords_title_nor,test_totalw
ords_essay_nor,test_sentiment_pos_essay_nor,test_sentiment_neg_essay_nor,test_sentiment
_neu_essay_nor,test_sentiment_compound_essay_nor,test_sentiment_pos_title_nor,test_sent
iment_neg_title_nor,test_sentiment_neu_title_nor,test_sentiment_compound_title_nor))

print(x_train_ohe.shape)

print(x_test_ohe.shape)
```

```
(76471, 23)
(32774, 23)
```

In [139]:

```
type(x_train_ohe)
```

Out[139]:

```
numpy.ndarray
```

In [ ]:

```

```

Steps in Decision Tree

1. **Apply Decision Tree Classifier(DecisionTreeClassifier) on these feature sets**

    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **Hyper paramter tuning (best `depth` in range [1, 5, 10, 50, 100, 500, 100], and the best `min_samples_split` in range [5, 10, 100, 500])**

    - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
    - Find the best hyper paramter using k-fold cross validation or simple cross validation data
    - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

3. **Graphviz**

    - Visualize your decision tree with Graphviz. It helps you to understand how a decision is being made, given a new vector.
    - Since feature names are not obtained from word2vec related models, visualize only BOW & TFIDF decision trees using Graphviz
    - Make sure to print the words in each node of the decision tree instead of printing its index.
    - Just for visualization purpose, limit max_depth to 2 or 3 and either embed the generated images of graphviz in your notebook, or directly upload them as .png files.

4. **Representation of results**

    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure 
    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test. 
    - Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points 
    - Once after you plot the confusion matrix with the test data, get all the `false positive data points`
        - Plot the WordCloud WordCloud (https://www.geeksforgeeks.org/generating-word-cloud-python/)
        - Plot the box plot with the `price` of these `false positive data points`
        - Plot the pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points`

5. **[Task-2]**

    - Select 5k best features from features of Set 2 using`feature_importances_` (https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html), discard all the other remaining features and then apply any of the model of you choice i.e. (Dession tree, Logistic

Regression, Linear SVM), you need to do hyperparameter tuning corresponding to the model you selected and procedure in step 2 and step 3

6. **Conclusion**

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

Note: Data Leakage

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

2. Decision Tree

2.3 Apply Decision Tree on different kind of featurization as mentioned in the instructions

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

2.4.1 Applying Decision Trees on BOW, SET 1

vectorize the essay and title data, SET 1

In [420]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

In [140]:

```
#vectorize the essay
#_____________________________
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.CountVectorizer.html

# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_essay_bow = CountVectorizer(min_df=10)
vectorizer_essay_bow.fit(x_train['preprocessed_essays'].values)# fit has to apply only on train data
#z_bow1=vectorizer.fit(x_train['preprocessed_essays'].values)# fit has to apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_bow_essays = vectorizer_essay_bow.transform(x_train['preprocessed_essays'].values)

x_test_bow_essays = vectorizer_essay_bow.transform(x_test['preprocessed_essays'].values)

print("Shape of matrix after one hot encodig ",x_train_bow_essays.shape, y_train.shape)

print("Shape of matrix after one hot encodig ",x_test_bow_essays.shape)
```

```
Shape of matrix after one hot encodig  (76471, 14504) (76471,)
Shape of matrix after one hot encodig  (32774, 14504)
```

In [141]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.CountVectorizer.html
#you can vectorize the title
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_title_bow = CountVectorizer(min_df=10)
vectorizer_title_bow.fit(x_train['preprocessed_project_title'].values)# fit has to apply only on train data
#z_bow2=vectorizer.fit(x_train['preprocessed_project_title'].values)# fit has to apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_bow_title = vectorizer_title_bow.transform(x_train['preprocessed_project_title'].values)

x_test_bow_title = vectorizer_title_bow.transform(x_test['preprocessed_project_title'].values)

print("Shape of matrix after one hot encodig ",x_train_bow_title.shape)

print("Shape of matrix after one hot encodig ",x_test_bow_title.shape)
```

```
Shape of matrix after one hot encodig  (76471, 2698)
Shape of matrix after one hot encodig  (32774, 2698)
```

merge final dataset, SET 1

In [142]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
x_train_bow = hstack((x_train_ohe, x_train_bow_essays, x_train_bow_title)).tocsr()

x_test_bow = hstack((x_test_ohe, x_test_bow_essays, x_test_bow_title)).tocsr()


print(x_train_bow.shape)

print(x_test_bow.shape)
```

```
(76471, 17225)
(32774, 17225)
```

In [146]:

```
type(x_train_bow)
```

Out[146]:

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

GridsearchCV, SET 1

In [248]:

```
#https://chrisalbon.com/machine_learning/model_selection/hyperparameter_tuning_using_grid_search/
#https://discuss.analyticsvidhya.com/t/extracting-the-best-fitted-decisiontreeclassifier-after-grid-search/10029
#https://www.kaggle.com/shotashimizu/09-decisiontree-gridsearchcv
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html

%time
from sklearn.model_selection import GridSearchCV,TimeSeriesSplit
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc

print("***************Grid search cv perform on train dataset******************")

DT = DecisionTreeClassifier(class_weight='balanced')
#params we need to try on classifier
param_grid = {'max_depth':[1, 5, 10, 50, 100, 500, 1000],
              'min_samples_split':[5, 10, 100, 500]}
ts_cv = TimeSeriesSplit(n_splits=10) #For time based splitting
grid_bow = GridSearchCV(DT,param_grid,cv=ts_cv,verbose=1,n_jobs=-1,scoring='roc_auc',return_train_score=True)
grid_bow.fit(x_train_bow,y_train)

split_hyperparameter_bow=grid_bow.best_params_['min_samples_split']
depth_hyperparameter_bow=grid_bow.best_params_['max_depth']

#savetofile(gsv,"Log Reg/gsv_uni")
print("Best HyperParameter: ",grid_bow.best_params_)



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

print("-----------------------------------------------------")
```

```
Wall time: 0 ns
***************Grid search cv perform on train dataset******************
Fitting 10 folds for each of 28 candidates, totalling 280 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed:   15.3s
[Parallel(n_jobs=-1)]: Done 192 tasks      | elapsed: 13.2min
[Parallel(n_jobs=-1)]: Done 280 out of 280 | elapsed: 35.5min finished

Best HyperParameter:  {'max_depth': 10, 'min_samples_split': 500}
-----------------------------------------------------
```

In [503]:

```
train_auc
```

Out[503]:

```
array([0.54761844, 0.54761844, 0.54761844, 0.54761844, 0.62792101,
       0.62775571, 0.62679988, 0.62215202, 0.71877171, 0.71589113,
       0.6987917 , 0.6751973 , 0.96991192, 0.95902218, 0.89234622,
       0.79746813, 0.99224831, 0.98629184, 0.93410732, 0.82568723,
       0.99991013, 0.99825546, 0.9583968 , 0.83435505, 0.99990441,
       0.99827552, 0.95805566, 0.8364779 ])
```

3D plot of AUC value with hyperparameter

In [504]:

```
import plotly
plotly.tools.set_credentials_file(username='Rana_Singh', api_key='jZjhDgnliBgNu6jqwfR7'
)
import plotly.plotly as py
import plotly.graph_objs as go

%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits import mplot3d
```

In [505]:

```
z1= list(train_auc)
x1 = pd.Series([1,1,1,1,5,5,5,5,10,10,10,10,50,50,50,50,100,100,100,100,500,500,500,500
])
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,1
00,500])
```

In [506]:

```
trace = go.Scatter3d(
    x=x1, y=y1, z=z1,
    marker=dict(
        size=4,
        color=z1,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)
```

In [507]:

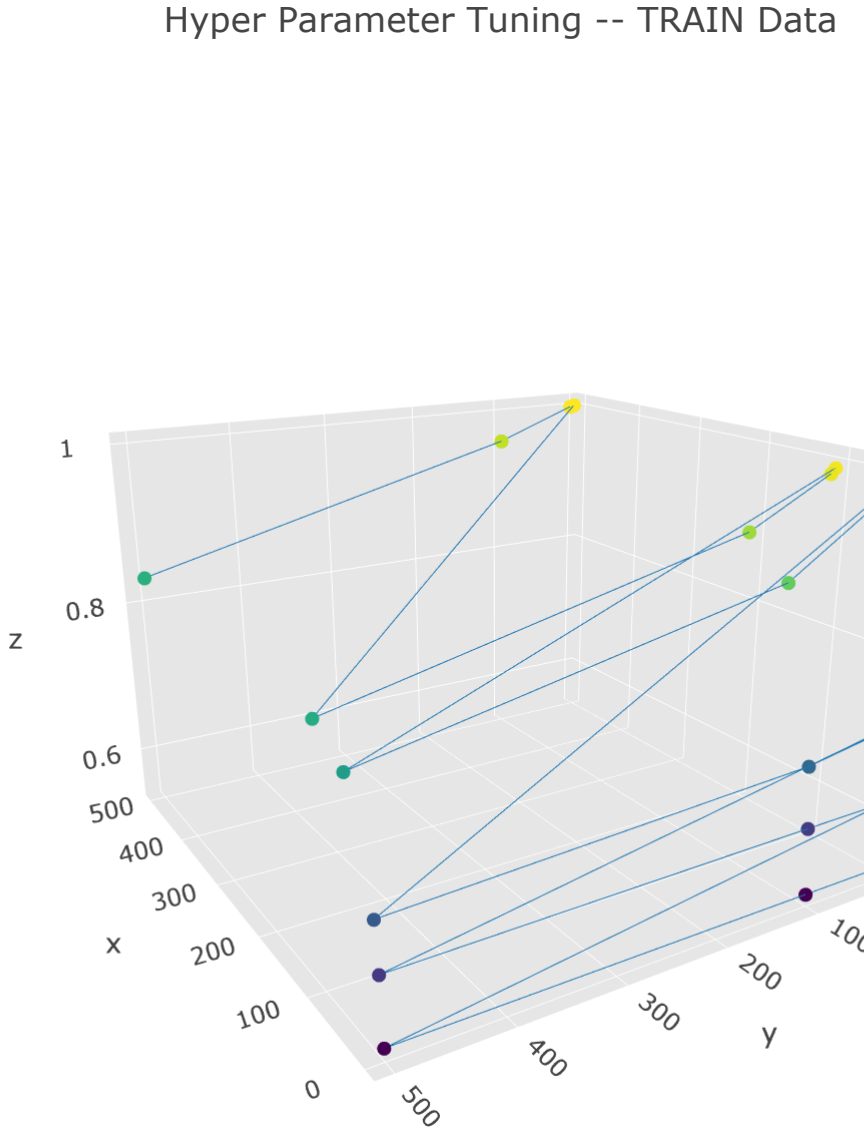
```
data = [trace]
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- TRAIN Data',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [512]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Decision-trees-bow', height=700)
#fig.write_image("Decision-trees-bow.png")
```

```
High five! You successfully sent some data to your account on plotly. View
your plot in your browser at https://plot.ly/~Rana_Singh/0 or inside your
plot.ly account where it is named 'Decision-trees-bow'

C:\Users\IDM LAB-09\Anaconda3\lib\site-packages\IPython\core\display.py:68
9: UserWarning:

Consider using IPython.display.IFrame instead
```

Out[512]:



AUC plot for test and train dataset

In [255]:

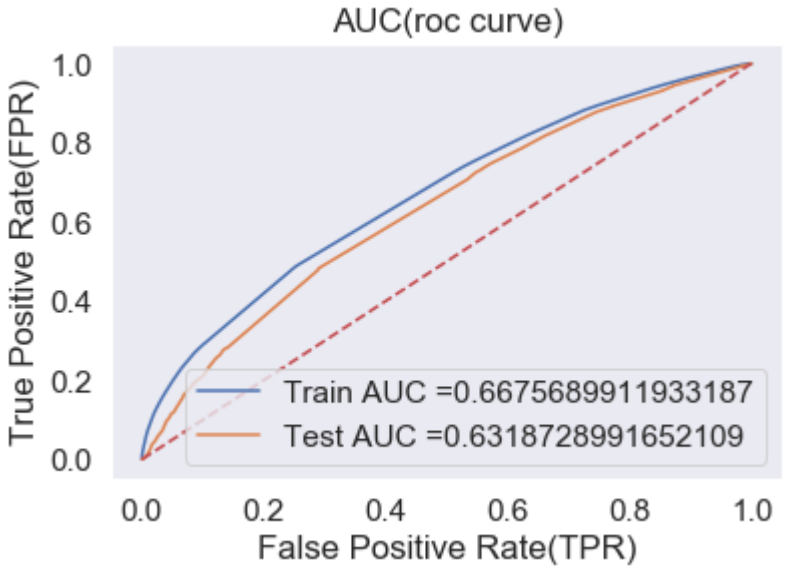
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates
 of the positive class
    # not the predicted outputs

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

    return y_data_pred
```

In [ ]:

```

```

In [317]:

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

DT = DecisionTreeClassifier(max_depth = depth_hyperparameter_bow, min_samples_split = split_hyperparameter_bow,class_weight='balanced')

DT.fit(x_train_bow, y_train)

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

y_train_pred = batch_predict(DT, x_train_bow)
y_test_pred = batch_predict(DT, x_test_bow)

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)

BOW_auc_train = auc(train_fpr, train_tpr)
BOW_auc_test = auc(test_fpr, test_tpr)

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.plot([0,1],[0,1],'r--')
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC(roc curve)")
plt.grid()
plt.show()
```



Confusion matrix, SET 1

In [318]:

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

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

In [319]:

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

```
====================================================================================
==========================
the maximum value of tpr*(1-fpr) 0.36527886023075046 for threshold 0.481
Train confusion matrix
[[ 8595  2950]
 [33070 31856]]
Test confusion matrix
[[ 3546  1451]
 [14361 13416]]
```

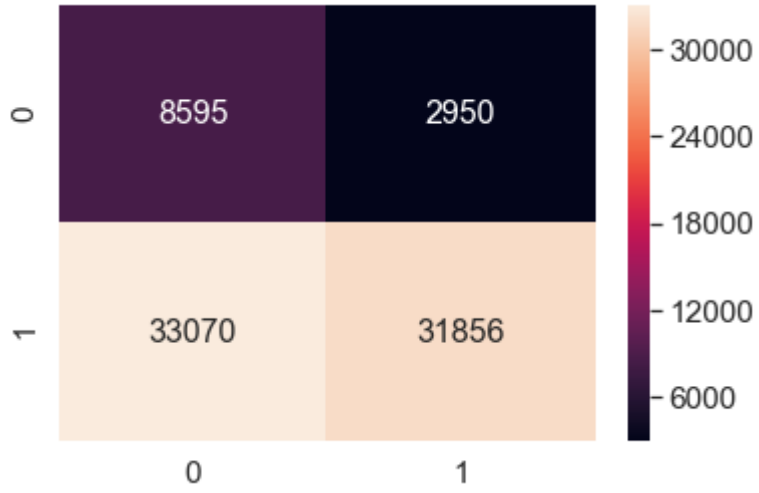
In [320]:

```
print("="*100)
print("TRAIN confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict_with_best_t(y_tra
in_pred, best_t)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
TRAIN confusion matrix
[[ 8595  2950]
 [33070 31856]]
```

Out[320]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x739ff438>
```



obtaining false positive data points SET 1

In [321]:

```
#conver sparse to dense
bow_test = x_test_bow.todense()
print(bow_test.shape)

#vectorize preprocessed_essays
vectorizer_bow_essay = CountVectorizer(min_df=10)
vectorizer_bow_essay.fit_transform(x_train["preprocessed_essays"])
bow_features = vectorizer_bow_essay.get_feature_names()
len(bow_features)
```

```
(32774, 17225)
```

Out[321]:

```
14504
```

In [322]:

```
#find index of fp
y_test_converted = list(y_test[::])

false_positives_index_a = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if ((y_test_converted[i] == 0) - (y_test_pred[i])).all() <= best_t:
        false_positives_index_a.append(i)
        fp_count = fp_count + 1
    else :
        continue

print(fp_count)
print(x_test.columns)
```

```
100%|██████████████████████████████| 32774/32774 [00:00<00:00, 137697.93
it/s]

30
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'preprocessed_essays', 'preprocessed_project_title', 'totalwords_ti
tle',
       'totalwords_essay', 'sentiment_pos_title', 'sentiment_neg_title',
       'sentiment_neu_title', 'sentiment_compound_title',
       'sentiment_pos_essay', 'sentiment_neg_essay', 'sentiment_neu_essa
y',
       'sentiment_compound_essay', 'x_test_reject_clean_category',
       'x_test_approved_clean_category', 'x_test_reject_clean_subcategor
y',
       'x_test_approved_clean_subcategory', 'x_test_reject_grade',
       'x_test_approved_grade', 'x_test_reject_teacher_prefix',
       'x_test_approved_teacher_prefix', 'x_test_reject_school_state',
       'x_test_approved_school_state'],
      dtype='object')
```

In [323]:

```
false_positives_index_a[0:10]
```

Out[323]:

```
[80, 1630, 3803, 3871, 5019, 6807, 7276, 8765, 9520, 10122]
```

In [324]:

```
df1 = pd.DataFrame(bow_test)
df1_final = df1.iloc[false_positives_index_a,:]
df1_final.shape
```

Out[324]:

```
(30, 17225)
```

In [325]:

```
#number of column
z=len(df1_final.columns)
print(z)
print("*"*30)
print(df1_final[0].sum())
```

```
17225
******************************
30.0
```

In [349]:

```
df1_final[12506].value_counts()
```

Out[349]:

```
7.0     7
8.0     6
9.0     4
10.0    4
4.0     2
2.0     2
3.0     1
1.0     1
6.0     1
5.0     1
13.0    1
Name: 12506, dtype: int64
```

In [344]:

```
df1_final[12506].shape
```

Out[344]:

```
(30,)
```

In [350]:

```
best_indices_bow = []

for j in range(z):

    s = df1_final[j].sum()

    if s >= 30 :
        best_indices_bow.append(j)
    else :
        continue


print(len(best_indices_bow))
print("*"*50)
print(best_indices_bow[:])
```

```
35
**************************************************
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 17, 18, 21, 286, 2436,
2449, 6152, 7483, 7487, 7929, 8505, 8529, 8730, 11348, 12506, 12661, 1300
6, 13044, 13806, 14142]
```

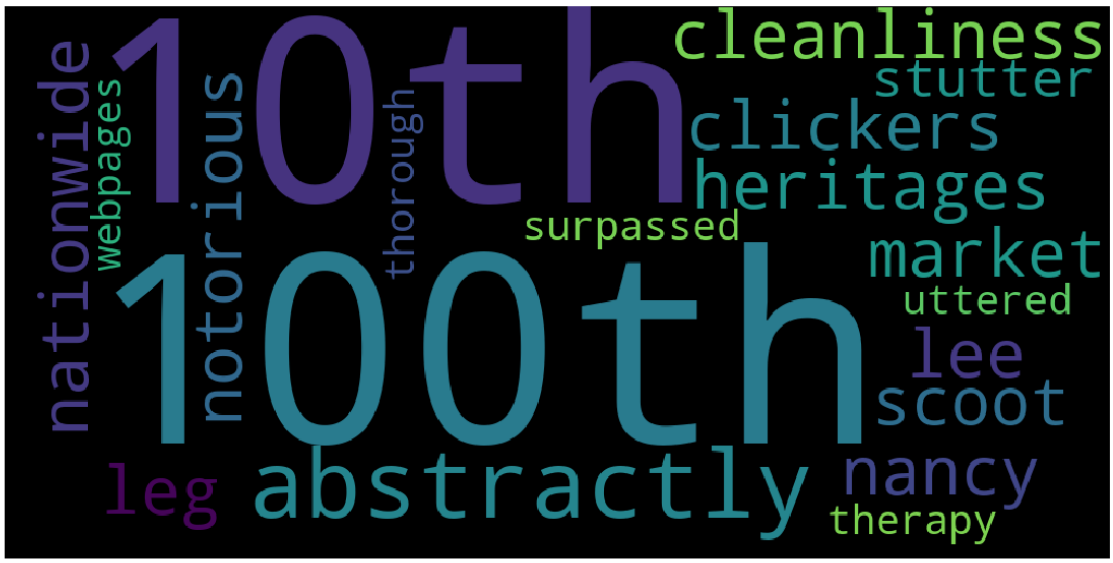
In [351]:

```
#https://stackoverflow.com/questions/37619848/python-loop-list-index-out-of-range
fp_words_bow = []

for a in best_indices_bow:
    fp_words_bow.append(str(bow_features[a]))
```

Word Cloud for False Positives words SET 1

In [352]:

```
#Word Cloud for False Positives words
#-----------------------------------------------
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words_bow)
wordcloud = WordCloud(width = 1000, height = 500).generate(unique_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("your_file_name"+".png", bbox_inches='tight')
plt.show()
plt.close()
```

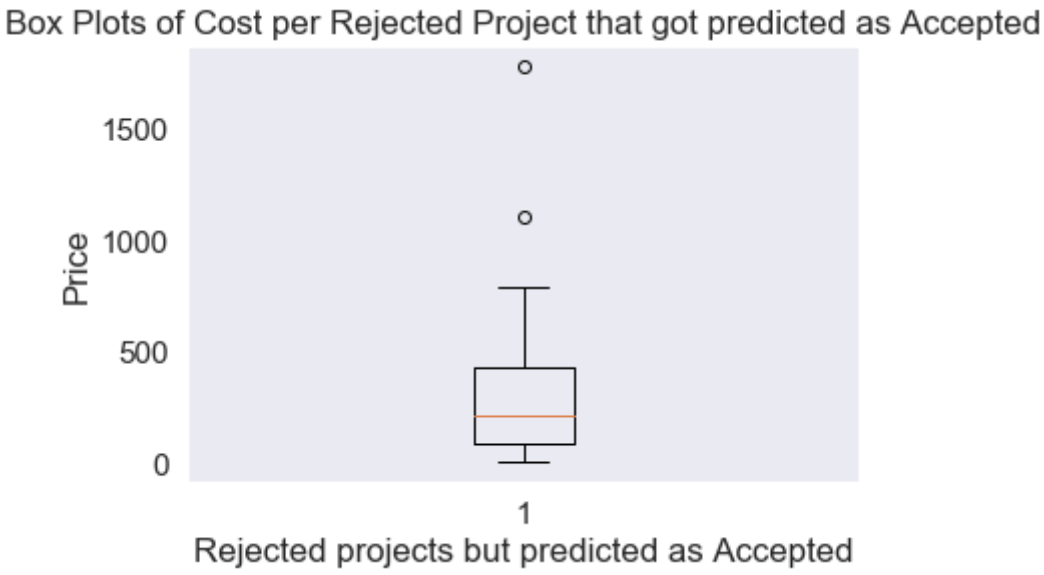


Box - Plot with the price of these False positive data points SET 1

In [354]:

```
print(len(false_positives_index_a))
print("*"*50)

#select all row of fp index
df2 = pd.DataFrame(x_test['price'])
df2_final = df2.iloc[false_positives_index_a,:]

plt.boxplot(df2_final.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```

```
30
**************************************************
```



Majority of the projects that were rejected but predicted as accepted Costs almost less than 400 Dollars.

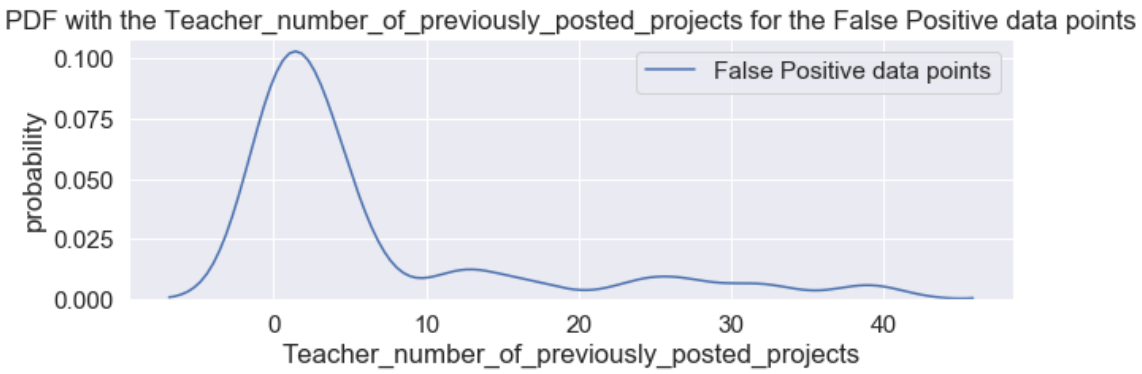
A Few of them are Extremely costs costing more than 500 Dollars.

pdf with the `teacher_number_of_previously_posted_projects` of these false positive data points SET 1

In [355]:

```
df3 = pd.DataFrame(x_test['teacher_number_of_previously_posted_projects'])
df3_final = df3.iloc[false_positives_index_a,:]
print(df3_final.shape)

plt.figure(figsize=(10,3))
sns.distplot(df3_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Posi
tive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```

```
(30, 1)
```



Majority of the cases have Teachers with previously posted projects as zero (which is nearly 10% of the total data)

2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

In [356]:

```
#!pip install graphviz
```

In [357]:

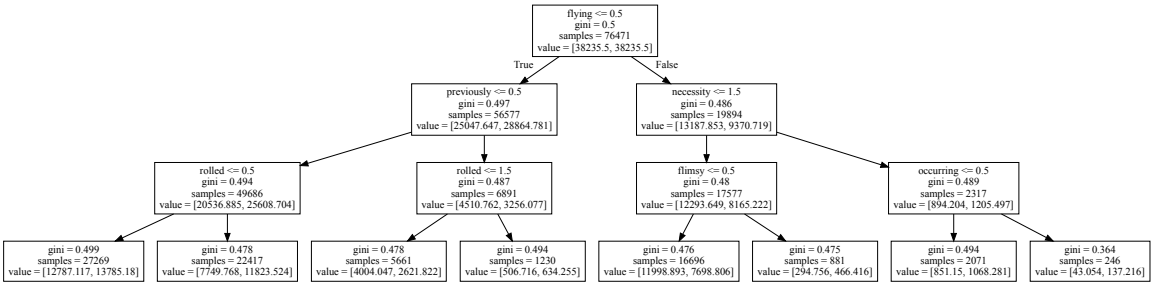
```
bow_features_names = []
## Obtain Feature names

bow_features_names.append("price")
bow_features_names.append("quantity")

bow_features_names.append("teacher_number_of_previously_posted_projects")
bow_features_names.append("totalwords_title")
bow_features_names.append("totalwords_essay")
bow_features_names.append("sentiment_pos_title")
bow_features_names.append("sentiment_neg_title")
bow_features_names.append("sentiment_neu_title")
bow_features_names.append("sentiment_compound_title")
bow_features_names.append("sentiment_pos_essay")
bow_features_names.append("sentiment_neg_essay")
bow_features_names.append("sentiment_neu_essay")
bow_features_names.append("sentiment_compound_essay")


bow_features_names.append("cat_reject_clean_category")
bow_features_names.append("cat_approved_clean_category")
bow_features_names.append("cat_reject_clean_subcategory")
bow_features_names.append("cat_approved_clean_subcategory")

bow_features_names.append("cat_reject_grade")
bow_features_names.append("cat_approved_grade")
bow_features_names.append("cat_reject_teacher_prefix")
bow_features_names.append("cat_approved_teacher_prefix")
bow_features_names.append("cat_reject_school_state")
bow_features_names.append("cat_approved_school_state")


for a in vectorizer_title_bow.get_feature_names() :
    bow_features_names.append(a)
for a in vectorizer_essay_bow.get_feature_names() :
    bow_features_names.append(a)

print(len(bow_features_names))
```

```
17225
```

In [358]:

```
#https://stackoverflow.com/questions/33381594/decisiontreeclassifier-object-has-no-attr
ibute-export-graphviz
#https://scikit-learn.org/stable/modules/tree.html
import graphviz
from sklearn import tree
from graphviz import Source
from sklearn.tree import DecisionTreeClassifier


DT = DecisionTreeClassifier(max_depth = 3, min_samples_split = split_hyperparameter_bow
,class_weight='balanced',random_state=0)
clf = DT.fit(x_train_bow, y_train)

# Visualize data
dot_data = tree.export_graphviz(DT, out_file=None, feature_names=bow_features_names)
graph = graphviz.Source(dot_data)
graph.render("Bow tree",view = True)
graph
```

Out[358]:



2.4.2 Applying Decision Trees on TFIDF, SET 2

vectorize the essay and title data, SET 2

In [178]:

```
#convert the essay text to vector
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_essay_tfidf = TfidfVectorizer()
vectorizer_essay_tfidf.fit(x_train['preprocessed_essays'].values)# fit has to apply onl
y on train data
z_tfidf1=vectorizer_essay_tfidf.fit(x_train['preprocessed_essays'].values)# fit has to
 apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_tfidf_essays = vectorizer_essay_tfidf.transform(x_train['preprocessed_essays'].
values)

x_test_tfidf_essays = vectorizer_essay_tfidf.transform(x_test['preprocessed_essays'].va
lues)

print("Shape of matrix after one hot encodig ",x_train_tfidf_essays.shape, y_train.shap
e)

print("Shape of matrix after one hot encodig ",x_test_tfidf_essays.shape)
```

```
Shape of matrix after one hot encodig  (76471, 48972) (76471,)
Shape of matrix after one hot encodig  (32774, 48972)
```

In [179]:

```
#convert the title text to vector
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_title_tfidf = TfidfVectorizer()
vectorizer_title_tfidf.fit(x_train['preprocessed_project_title'].values)# fit has to ap
ply only on train data
z_tfidf2=vectorizer_title_tfidf.fit(x_train['preprocessed_project_title'].values)# fit
 has to apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_tfidf_title = vectorizer_title_tfidf.transform(x_train['preprocessed_project_ti
tle'].values)

x_test_tfidf_title = vectorizer_title_tfidf.transform(x_test['preprocessed_project_titl
e'].values)

print("Shape of matrix after one hot encodig ",x_train_tfidf_title.shape)

print("Shape of matrix after one hot encodig ",x_test_tfidf_title.shape)
```

```
Shape of matrix after one hot encodig  (76471, 14337)
Shape of matrix after one hot encodig  (32774, 14337)
```

In [180]:

```
type(x_test_tfidf_title)
```

Out[180]:

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

merge all sparse data, SET 2

In [371]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
x_train_tfidf = hstack((x_train_ohe, x_train_tfidf_essays, x_train_tfidf_title)).tocsr
()

x_test_tfidf = hstack((x_test_ohe, x_test_tfidf_essays, x_test_tfidf_title)).tocsr()

print(x_train_tfidf.shape)

print(x_test_tfidf.shape)
print(type(x_train_tfidf))
```

```
(76471, 63332)
(32774, 63332)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [ ]:

```

```

GridsearchCV, SET 2

In [242]:

```
#https://chrisalbon.com/machine_learning/model_selection/hyperparameter_tuning_using_grid_search/
#https://discuss.analyticsvidhya.com/t/extracting-the-best-fitted-decisiontreeclassifier-after-grid-search/10029
#https://www.kaggle.com/shotashimizu/09-decisiontree-gridsearchcv
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html

%time
from sklearn.model_selection import GridSearchCV,TimeSeriesSplit
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc

print("***************Grid search cv perform on train dataset******************")

DT = DecisionTreeClassifier(class_weight='balanced')
#params we need to try on classifier
param_grid = {'max_depth':[1, 5, 10, 50, 100, 500, 100],
              'min_samples_split':[5, 10, 100, 500]}
ts_cv = TimeSeriesSplit(n_splits=10) #For time based splitting
grid_bow = GridSearchCV(DT,param_grid,cv=ts_cv,verbose=1,n_jobs=-1,scoring='roc_auc',return_train_score=True)
grid_bow.fit(x_train_tfidf,y_train)

split_hyperparameter_tfidf=grid_bow.best_params_['min_samples_split']
depth_hyperparameter_tfidf=grid_bow.best_params_['max_depth']

#savetofile(gsv,"Log Reg/gsv_uni")
print("Best HyperParameter: ",grid_bow.best_params_)

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

print("-----------------------------------------------------")
```

```
Wall time: 0 ns
***************Grid search cv perform on train dataset******************
Fitting 10 folds for each of 28 candidates, totalling 280 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed:   22.5s
[Parallel(n_jobs=-1)]: Done 192 tasks      | elapsed: 17.9min
[Parallel(n_jobs=-1)]: Done 280 out of 280 | elapsed: 39.4min finished

Best HyperParameter:  {'max_depth': 10, 'min_samples_split': 500}
-----------------------------------------------------
```

3D plot of AUC with hyperparameter

In [243]:

```
import plotly
plotly.tools.set_credentials_file(username='Rana_Singh', api_key='jZjhDgnliBgNu6jqwfR7'
)
import plotly.plotly as py
import plotly.graph_objs as go

%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits import mplot3d
```

In [244]:

```
z1= list(train_auc)
x1 = pd.Series([1,1,1,1,5,5,5,5,10,10,10,10,50,50,50,50,100,100,100,100,500,500,500,500
])
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,1
00,500])
```

In [245]:

```
trace = go.Scatter3d(
    x=x1, y=y1, z=z1,
    marker=dict(
        size=4,
        color=z1,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)
```

In [246]:

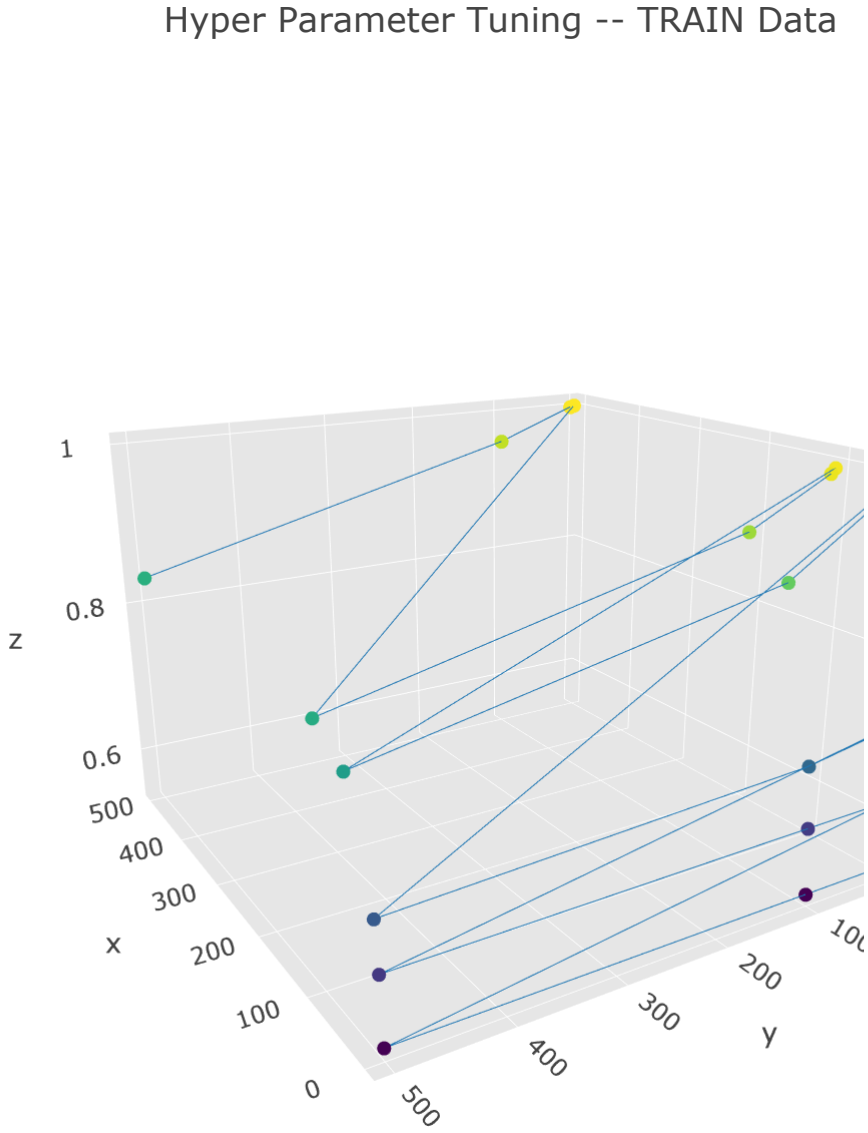
```
data = [trace]
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- TRAIN Data',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [513]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Decision-trees-tfidf', height=700)
```

```
C:\Users\IDM LAB-09\Anaconda3\lib\site-packages\IPython\core\display.py:68
9: UserWarning:

Consider using IPython.display.IFrame instead
```

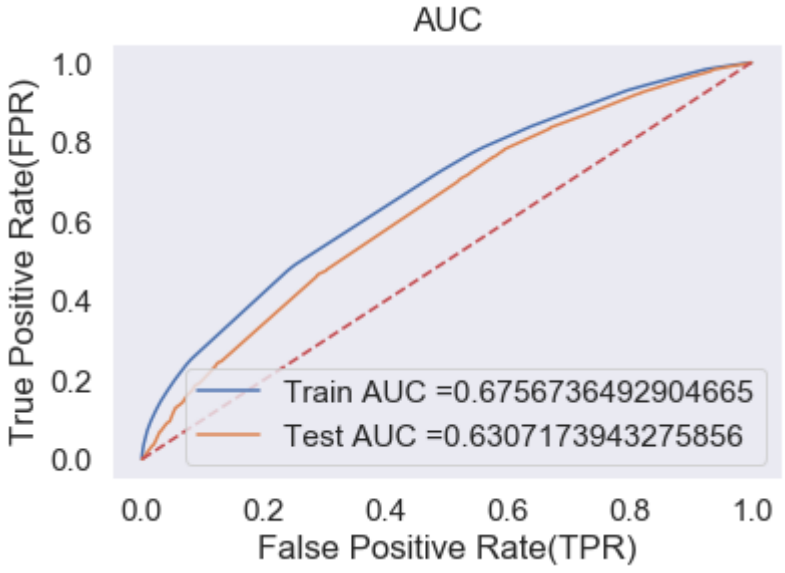
Out[513]:



ROC of tain , test and cv dataset, SET 2

In [390]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html

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

DT = DecisionTreeClassifier(max_depth = depth_hyperparameter_tfidf, min_samples_split = split_hyperparameter_tfidf,class_weight='balanced')

DT.fit(x_train_tfidf, y_train)

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

y_train_pred = batch_predict(DT, x_train_tfidf)
y_test_pred = batch_predict(DT, x_test_tfidf)

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)

TFIDF_auc_train = auc(train_fpr, train_tpr)
TFIDF_auc_test = auc(test_fpr, test_tpr)

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.plot([0,1],[0,1],'r--')
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



In [ ]:

```
```

Confusion matrix, SET 2

In [391]:

```
x_test_tfidf.shape
```

Out[391]:

```
(32774, 63332)
```

In [392]:

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

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

In [393]:

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

```
====================================================================================
==========================
the maximum value of tpr*(1-fpr) 0.3736430935858256 for threshold 0.497
Train confusion matrix
[[ 6064  5481]
 [18740 46186]]
Test confusion matrix
[[ 2410  2587]
 [ 8349 19428]]
```

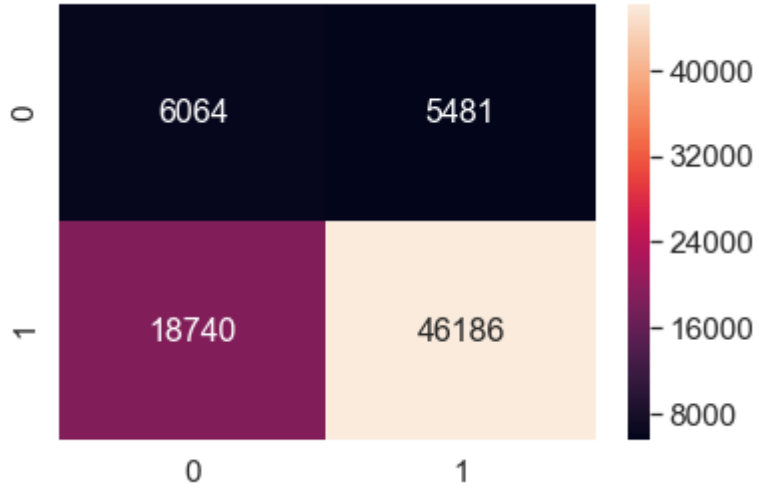
In [394]:

```
print("="*100)
print("TRAIN confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict_with_best_t(y_tra
in_pred, best_t)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
TRAIN confusion matrix
[[ 6064  5481]
 [18740 46186]]
```

Out[394]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7da49278>
```



obtaining false positive data points SET 2

In [395]:

```
x_test_tfidf.shape
```

Out[395]:

```
(32774, 63332)
```

In [500]:

```
#conver sparse to dense
tfidf_test = x_test_tfidf.todense()
tfidf_test.shape
```

In [397]:

```
#find index of fp
y_test_converted = list(y_test[::])


false_positives_index_b = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if y_test_converted[i] == 0 and y_test_pred[i] <= best_t:
        false_positives_index_b.append(i)
        fp_count = fp_count + 1
    else :
        continue

print(fp_count)
```

```
100%|████████████████████████████████| 32774/32774 [00:00<00:00, 2184813.87
it/s]

3477
```

In [398]:

```
#get feature name vectorize preprocessed_essays
vectorizer_tfidf_essay = TfidfVectorizer()
vectorizer_tfidf_essay.fit_transform(x_train["preprocessed_essays"])

tfidf_features = vectorizer_tfidf_essay.get_feature_names()
len(tfidf_features)
```

Out[398]:

```
48972
```

In [399]:

```
type(tfidf_test)
```

Out[399]:

```
numpy.matrix
```

In [400]:

```
import pandas as pd
df2 = pd.DataFrame(tfidf_test)
df2_final = df2.iloc[false_positives_index_b,:]
df2_final.shape
```

Out[400]:

```
(3477, 63332)
```

In [401]:

```
#number of column
z=len(df2_final.columns)
print(z)
print("*"*30)
print(df2_final[0].sum())
```

```
63332
******************************
3477.0
```

In [419]:

```
best_indices_tfidf = []

for j in range(z):

    s = df2_final[j].sum()

    if s >= 100 :
        best_indices_tfidf.append(j)
    else :
        continue


print(len(best_indices_tfidf))
print("*"*50)
print(best_indices_tfidf[0:10])
```

```
33
**************************************************
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

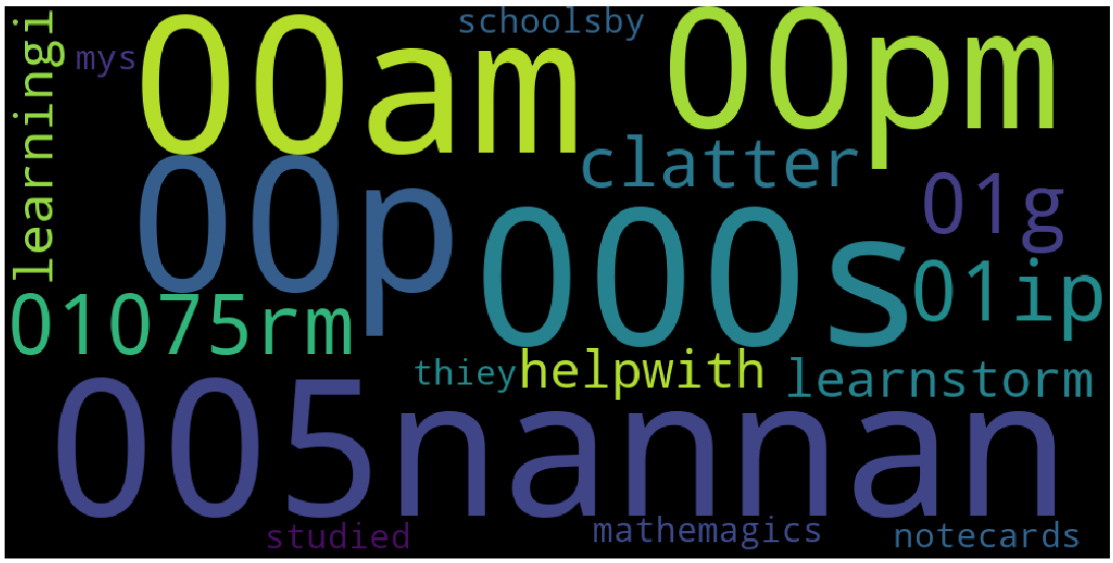
In [420]:

```
fp_words_tfidf = []

for a in best_indices_tfidf:
    fp_words_tfidf.append((tfidf_features[a]))
```

Word Cloud for False Positives words SET 2

In [423]:

```
#Word Cloud for False Positives words
#-------------------------------------------
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words_tfidf)
wordcloud = WordCloud(width = 1000, height = 500).generate(unique_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("your_file_name"+".png", bbox_inches='tight')
plt.show()
plt.close()
```

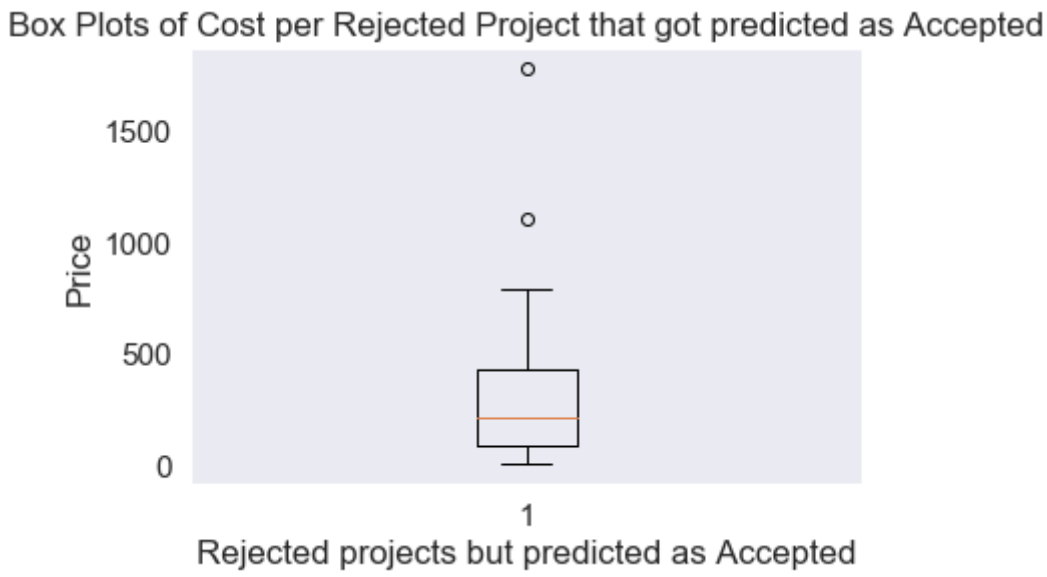


Box - Plot with the price of these False positive data points SET 2

In [424]:

```
print(len(false_positives_index_a))
print("*"*50)

#select all row of fp index
df2 = pd.DataFrame(x_test['price'])
df2_fina1 = df2.iloc[false_positives_index_a,:]

plt.boxplot(df2_fina1.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```

```
30
**************************************************
```



Majority of the projects that were rejected but predicted as accepted Costs almost less than 300 Dollars.

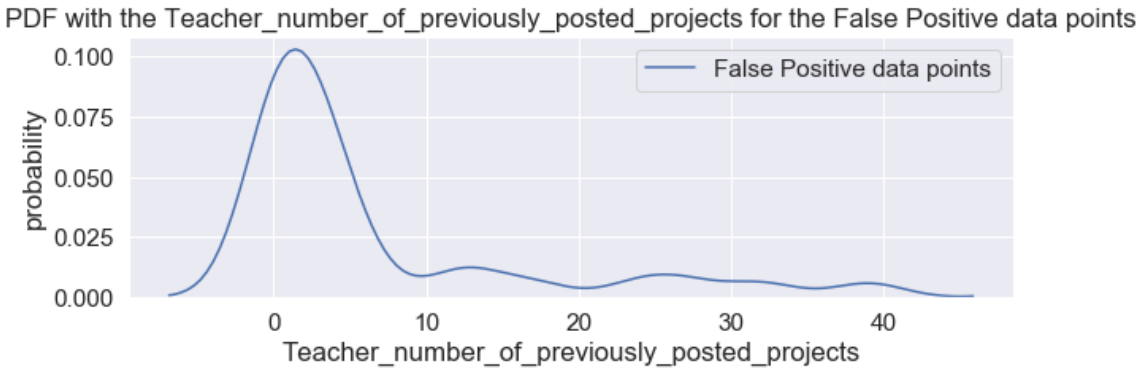
A Few of them are Extremely costs costing more than 500 Dollars.

pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points` SET 2

In [425]:

```
df3 = pd.DataFrame(x_test['teacher_number_of_previously_posted_projects'])
df3_final = df3.iloc[false_positives_index_a,:]
print(df3_final.shape)

plt.figure(figsize=(10,3))
sns.distplot(df3_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Posi
tive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```

```
(30, 1)
```



Majority of the cases have Teachers with previously posted projects as zero (which is nearly 10% of the total data)

Graphviz visualization of Decision Tree on TFIDF, SET 2

In [426]:

```
x_train.columns
```

Out[426]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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_approve
d',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'preprocessed_essays', 'preprocessed_project_title', 'totalwords_ti
tle',
       'totalwords_essay', 'sentiment_pos_title', 'sentiment_neg_title',
       'sentiment_neu_title', 'sentiment_compound_title',
       'sentiment_pos_essay', 'sentiment_neg_essay', 'sentiment_neu_essa
y',
       'sentiment_compound_essay', 'x_train_reject_clean_category',
       'x_train_approved_clean_category', 'x_train_reject_clean_subcategor
y',
       'x_train_approved_clean_subcategory', 'x_train_reject_grade',
       'x_train_approved_grade', 'x_train_reject_teacher_prefix',
       'x_train_approved_teacher_prefix', 'x_train_reject_school_state',
       'x_train_approved_school_state'],
      dtype='object')
```

In [427]:

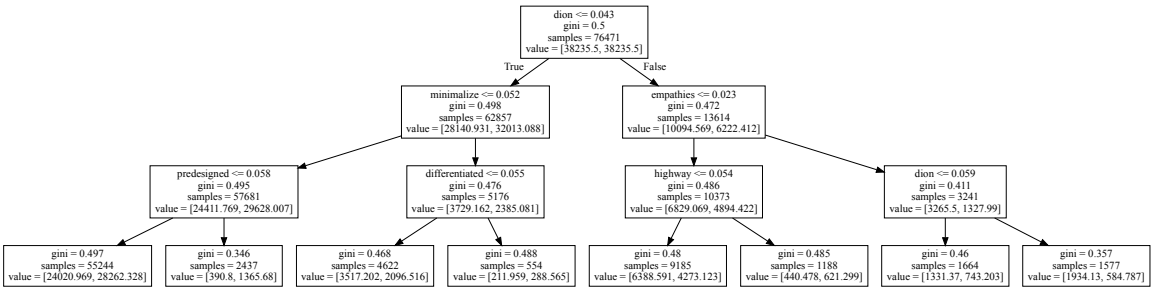
```
tfidf_features_names = []
## Obtain Feature names

tfidf_features_names.append("price")
tfidf_features_names.append("quantity")

tfidf_features_names.append("teacher_number_of_previously_posted_projects")
tfidf_features_names.append("totalwords_title")
tfidf_features_names.append("totalwords_essay")
tfidf_features_names.append("sentiment_pos_title")
tfidf_features_names.append("sentiment_neg_title")
tfidf_features_names.append("sentiment_neu_title")
tfidf_features_names.append("sentiment_compound_title")
tfidf_features_names.append("sentiment_pos_essay")
tfidf_features_names.append("sentiment_neg_essay")
tfidf_features_names.append("sentiment_neu_essay")
tfidf_features_names.append("sentiment_compound_essay")


tfidf_features_names.append("cat_reject_clean_category")
tfidf_features_names.append("cat_approved_clean_category")
tfidf_features_names.append("cat_reject_clean_subcategory")
tfidf_features_names.append("cat_approved_clean_subcategory")

tfidf_features_names.append("cat_reject_grade")
tfidf_features_names.append("cat_approved_grade")
tfidf_features_names.append("cat_reject_teacher_prefix")
tfidf_features_names.append("cat_approved_teacher_prefix")
tfidf_features_names.append("cat_reject_school_state")
tfidf_features_names.append("cat_approved_school_state")


for a in vectorizer_title_tfidf.get_feature_names() :
    tfidf_features_names.append(a)
for a in vectorizer_essay_tfidf.get_feature_names() :
    tfidf_features_names.append(a)

print(len(tfidf_features_names))
```

```
63332
```

In [428]:

```
#https://stackoverflow.com/questions/33381594/decisiontreeclassifier-object-has-no-attr
ibute-export-graphviz
#https://scikit-learn.org/stable/modules/tree.html
import graphviz
from sklearn import tree
from graphviz import Source
from sklearn.tree import DecisionTreeClassifier


DT = DecisionTreeClassifier(max_depth = 3, min_samples_split = split_hyperparameter_tfi
df,class_weight='balanced',random_state=0)
clf = DT.fit(x_train_tfidf, y_train)

# Visualize data
dot_data = tree.export_graphviz(DT, out_file=None, feature_names=tfidf_features_names)
graph = graphviz.Source(dot_data)
graph.render("TFIDF tree",view = True)
graph
```

Out[428]:



2.4.3 Applying Decision Trees on AVG W2V, SET 3

vectorize using AVG W2V, SET 3

In [0]:

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

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

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

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

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

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

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


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

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

Out[0]:

```
'# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4
084039\ndef loadGloveModel(gloveFile):\n    print ("Loading Glove Model")
\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}\n    for
line in tqdm(f):\n        splitLine = line.split()\n        word = splitLi
ne[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])
\n        model[word] = embedding\n    print ("Done.",len(model)," words l
oaded!")\n    return model\nmodel = loadGloveModel(\'glove.42B.300d.txt\')
\n\n# ============================\nOutput:\n    \nLoading Glove Model\n19
17495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n# ============
================\n\nwords = []\nfor i in preproced_texts:\n    words.exten
d(i.split(\' \'))\n\nfor i in preproced_titles:\n    words.extend(i.split
(\' \'))\nprint("all the words in the coupus", len(words))\nwords = set(wo
rds)\nprint("the unique words in the coupus", len(words))\n\ninter_words =
set(model.keys()).intersection(words)\nprint("The number of words that are
present in both glove vectors and our coupus",       len(inter_words),"(",
np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nw
ords_glove = set(model.keys())\nfor i in words:\n    if i in words_glov
e:\n        words_courpus[i] = model[i]\nprint("word 2 vec length", len(wo
rds_courpus))\n\n\n# stronging variables into pickle files python: http://
www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-pytho
n/\n\nimport pickle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickl
e.dump(words_courpus, f)'
```

In [188]:

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

In [189]:

```
#!pip install tqdm
```

In [190]:

```
# Using Pretrained Models: AVG W2V on `essay`
#_____________________________________________

# -----average Word2Vec on train
# compute average word2vec for each review.
avg_w2v_vectors_essays_train = []; # the avg-w2v for each sentence/review is stored in
 this list
for sentence in tqdm(x_train['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_train.append(vector)

print(len(avg_w2v_vectors_essays_train))
print(len(avg_w2v_vectors_essays_train[0]))
```

```
100%|████████████████████████████████| 76471/76471 [00:24<00:00, 3117.02
it/s]

76471
300
```

In [191]:

```
type(avg_w2v_vectors_essays_train)
```

Out[191]:

```
list
```

In [192]:

```
'''# -----average Word2Vec on CV
# compute average word2vec for each review.
avg_w2v_vectors_essays_cv = []; # the avg-w2v for each sentence/review is stored in thi
s list
for sentence in tqdm(x_cv['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_cv.append(vector)

print(len(avg_w2v_vectors_essays_cv))
print(len(avg_w2v_vectors_essays_cv[0]))'''
```

Out[192]:

```
"# -----average Word2Vec on CV\n# compute average word2vec for each revie
w.\navg_w2v_vectors_essays_cv = []; # the avg-w2v for each sentence/review
is stored in this list\nfor sentence in tqdm(x_cv['preprocessed_essays']):
# for each review/sentence\n    vector = np.zeros(300) # as word vectors a
re of zero length\n    cnt_words =0; # num of words with a valid vector in
the sentence/review\n    for word in sentence.split(): # for each word in
a review/sentence\n        if word in glove_words:\n            vector +=
model[word]\n            cnt_words += 1\n    if cnt_words != 0:\n        v
ector /= cnt_words\n    avg_w2v_vectors_essays_cv.append(vector)\n\nprint
(len(avg_w2v_vectors_essays_cv))\nprint(len(avg_w2v_vectors_essays_cv
[0]))"
```

In [193]:

```
# -----average Word2Vec on test
# compute average word2vec for each review.
avg_w2v_vectors_essays_test = []; # the avg-w2v for each sentence/review is stored in t
his list
for sentence in tqdm(x_test['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_essays_test.append(vector)

print(len(avg_w2v_vectors_essays_test))
print(len(avg_w2v_vectors_essays_test[0]))
```

```
100%|████████████████████████████████████| 32774/32774 [00:09<00:00, 3415.54
it/s]

32774
300
```

In [194]:

```
# Using Pretrained Models: AVG W2V on `project_title`
#_____________________________________________________

# ------average Word2Vec on train
# compute average word2vec for each review.
avg_w2v_vectors_project_title_train = []; # the avg-w2v for each sentence/review is sto
red in this list
for sentence in tqdm(x_train['preprocessed_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_project_title_train.append(vector)

print(len(avg_w2v_vectors_project_title_train))
print(len(avg_w2v_vectors_project_title_train[0]))
```

```
100%|████████████████████████████████| 76471/76471 [00:01<00:00, 42694.94
it/s]

76471
300
```

In [195]:

```
'''# ------average Word2Vec on cv
# compute average word2vec for each review.
avg_w2v_vectors_project_title_cv = []; # the avg-w2v for each sentence/review is stored
in this list
for sentence in tqdm(x_cv['preprocessed_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_project_title_cv.append(vector)

print(len(avg_w2v_vectors_project_title_cv))
print(len(avg_w2v_vectors_project_title_cv[0]))'''
```

Out[195]:

```
"# ------average Word2Vec on cv\n# compute average word2vec for each revie
w.\navg_w2v_vectors_project_title_cv = []; # the avg-w2v for each sentenc
e/review is stored in this list\nfor sentence in tqdm(x_cv['preprocessed_p
roject_title']): # for each review/sentence\n    vector = np.zeros(300) #
as word vectors are of zero length\n    cnt_words =0; # num of words with
a valid vector in the sentence/review\n    for word in sentence.split(): #
for each word in a review/sentence\n        if word in glove_words:\n
vector += model[word]\n            cnt_words += 1\n    if cnt_words !=
0:\n        vector /= cnt_words\n    avg_w2v_vectors_project_title_cv.appe
nd(vector)\n\nprint(len(avg_w2v_vectors_project_title_cv))\nprint(len(avg_
w2v_vectors_project_title_cv[0]))"
```

In [196]:

```
# ------average Word2Vec on test
# compute average word2vec for each review.
avg_w2v_vectors_project_title_test = []; # the avg-w2v for each sentence/review is stor
ed in this list
for sentence in tqdm(x_test['preprocessed_project_title']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_project_title_test.append(vector)

print(len(avg_w2v_vectors_project_title_test))
print(len(avg_w2v_vectors_project_title_test[0]))
```

```
100%|██████████████████████████████████| 32774/32774 [00:00<00:00, 45707.29
it/s]

32774
300
```

merge all sparse data, SET 3

In [197]:

```
'''#converting list to array
from numpy  import array
avg_w2v_vectors_essays_train=array(avg_w2v_vectors_essays_train)
avg_w2v_vectors_project_title_train=array(avg_w2v_vectors_project_title_train)
avg_w2v_vectors_essays_cv=array(avg_w2v_vectors_essays_cv)
avg_w2v_vectors_project_title_cv=array(avg_w2v_vectors_project_title_cv)
avg_w2v_vectors_essays_test=array(avg_w2v_vectors_essays_test)
avg_w2v_vectors_project_title_test=array(avg_w2v_vectors_project_title_test)

print(avg_w2v_vectors_essays_train.shape)
print(avg_w2v_vectors_project_title_train.shape)
print(avg_w2v_vectors_essays_cv.shape)
print(avg_w2v_vectors_project_title_cv.shape)
print(avg_w2v_vectors_essays_test.shape)
print(avg_w2v_vectors_project_title_test.shape)
print(x_train_ohe.shape)
print(x_cv_ohe.shape)
print(x_test_ohe.shape)'''
```

Out[197]:

```
'#converting list to array\nfrom numpy  import array\navg_w2v_vectors_essa
ys_train=array(avg_w2v_vectors_essays_train)\navg_w2v_vectors_project_titl
e_train=array(avg_w2v_vectors_project_title_train)\navg_w2v_vectors_essays
_cv=array(avg_w2v_vectors_essays_cv)\navg_w2v_vectors_project_title_cv=arr
ay(avg_w2v_vectors_project_title_cv)\navg_w2v_vectors_essays_test=array(av
g_w2v_vectors_essays_test)\navg_w2v_vectors_project_title_test=array(avg_w
2v_vectors_project_title_test)\n\nprint(avg_w2v_vectors_essays_train.shap
e)\nprint(avg_w2v_vectors_project_title_train.shape)\nprint(avg_w2v_vector
s_essays_cv.shape)\nprint(avg_w2v_vectors_project_title_cv.shape)\nprint(a
vg_w2v_vectors_essays_test.shape)\nprint(avg_w2v_vectors_project_title_tes
t.shape)\nprint(x_train_ohe.shape)\nprint(x_cv_ohe.shape)\nprint(x_test_oh
e.shape)'
```

In [198]:

```
print(type(x_train_ohe))
print(type(avg_w2v_vectors_essays_train))
print(type(avg_w2v_vectors_project_title_train))
```

```
<class 'numpy.ndarray'>
<class 'list'>
<class 'list'>
```

In [205]:

```
#https://stackoverflow.com/questions/43977463/valueerror-could-not-broadcast-input-array-from-shape-224-224-3-into-shape-2
#https://stackoverflow.com/questions/5951135/how-to-save-a-list-as-numpy-array-in-python
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)

x_train_AVGW2V = np.hstack((x_train_ohe, avg_w2v_vectors_essays_train, avg_w2v_vectors_project_title_train))

x_test_AVGW2V = np.hstack((x_test_ohe, avg_w2v_vectors_essays_test, avg_w2v_vectors_project_title_test))

print(x_train_AVGW2V.shape)

print(x_test_AVGW2V.shape)
```

```
(76471, 623)
(32774, 623)
```

In [206]:

```
type(x_test_AVGW2V)
```

Out[206]:

```
numpy.ndarray
```

GridsearchCV, SET 3

In [235]:

```
%time
from sklearn.model_selection import GridSearchCV,TimeSeriesSplit
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc

print("***************Grid search cv perform on train dataset******************")

DT = DecisionTreeClassifier(class_weight='balanced')
#params we need to try on classifier
param_grid = {'max_depth':[1, 5, 10, 50, 100, 500, 100],
              'min_samples_split':[5, 10, 100, 500]}
ts_cv = TimeSeriesSplit(n_splits=10) #For time based splitting
grid_bow = GridSearchCV(DT,param_grid,cv=ts_cv,verbose=1,n_jobs=-1,scoring='roc_auc',re
turn_train_score=True)
grid_bow.fit(x_train_AVGW2V,y_train)

split_hyperparameter_AVGW2V=grid_bow.best_params_['min_samples_split']
depth_hyperparameter_AVGW2V=grid_bow.best_params_['max_depth']

#savetofile(gsv,"Log Reg/gsv_uni")
print("Best HyperParameter: ",grid_bow.best_params_)


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

print("----------------------------------------------------")
```

```
Wall time: 0 ns
***************Grid search cv perform on train dataset******************
Fitting 10 folds for each of 28 candidates, totalling 280 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent worker
s.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed:   55.6s
[Parallel(n_jobs=-1)]: Done 192 tasks      | elapsed: 20.0min
[Parallel(n_jobs=-1)]: Done 280 out of 280 | elapsed: 34.2min finished

Best HyperParameter:  {'max_depth': 5, 'min_samples_split': 500}
----------------------------------------------------
```

3D plot of AUC with hyperparameter

In [236]:

```
import plotly
plotly.tools.set_credentials_file(username='Rana_Singh', api_key='jZjhDgnliBgNu6jqwfR7'
)
import plotly.plotly as py
import plotly.graph_objs as go

%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits import mplot3d
```

In [237]:

```
z1= list(train_auc)
x1 = pd.Series([1,1,1,1,5,5,5,5,10,10,10,10,50,50,50,50,100,100,100,100,500,500,500,500
])
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,1
00,500])
```

In [238]:

```
trace = go.Scatter3d(
    x=x1, y=y1, z=z1,
    marker=dict(
        size=4,
        color=z1,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)
```

In [239]:

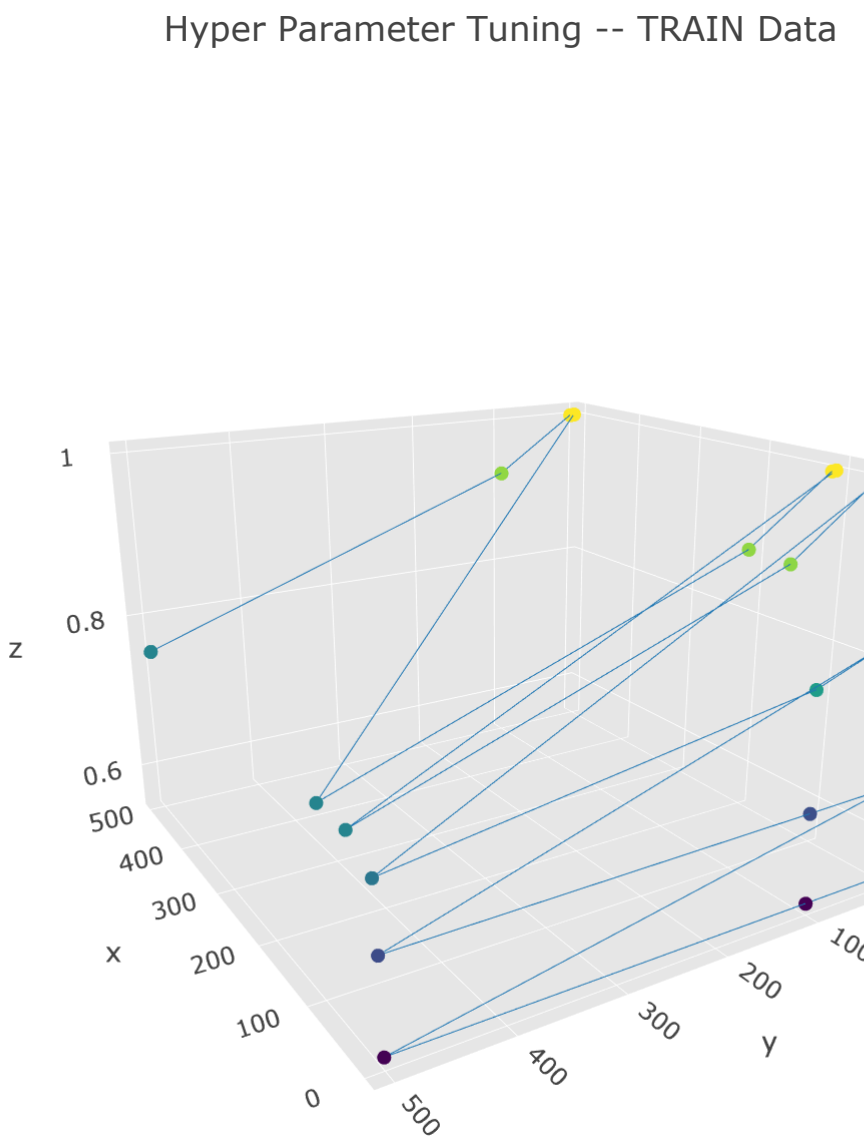
```
data = [trace]
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- TRAIN Data',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [240]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Decision-trees-AVGW2V', height=700)
```

```
C:\Users\IDM LAB-09\Anaconda3\lib\site-packages\IPython\core\display.py:68
9: UserWarning:

Consider using IPython.display.IFrame instead
```

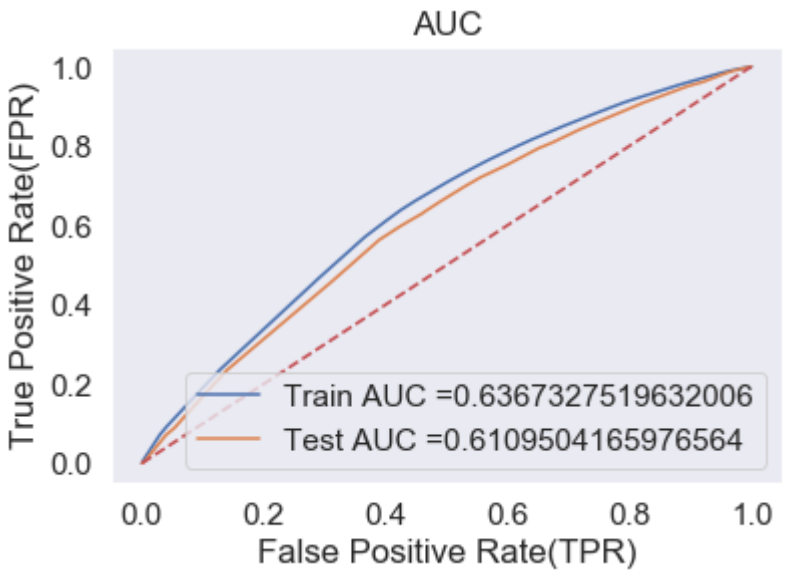
Out[240]:



ROC of tain , test and cv dataset, SET 3

In [429]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html

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

DT = DecisionTreeClassifier(max_depth = depth_hyperparameter_AVGW2V, min_samples_split = split_hyperparameter_AVGW2V,class_weight='balanced')

DT.fit(x_train_AVGW2V, y_train)

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

y_train_pred = batch_predict(DT, x_train_AVGW2V)
y_test_pred = batch_predict(DT, x_test_AVGW2V)

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)

AVGW2V_auc_train = auc(train_fpr, train_tpr)
AVGW2V_auc_test = auc(test_fpr, test_tpr)

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.plot([0,1],[0,1],'r--')
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



Confusion matrix, SET 3

In [432]:

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

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

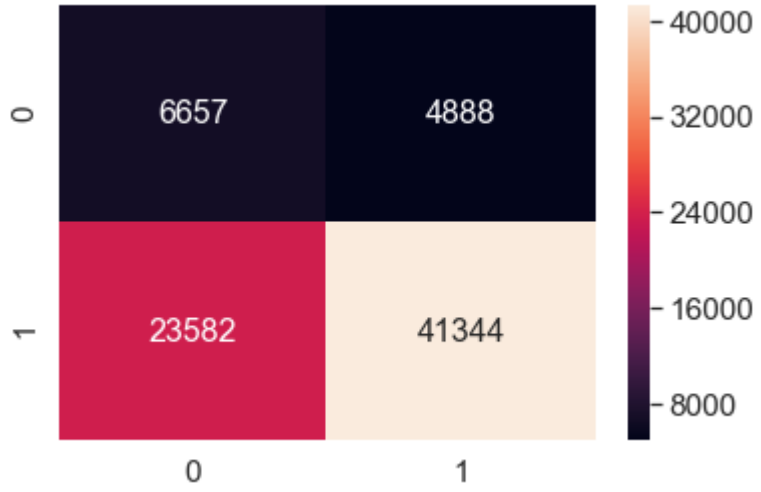
In [433]:

```
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("="*100)
print("TRAIN confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict_with_best_t(y_tra
in_pred, best_t)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
the maximum value of tpr*(1-fpr) 0.367179532251442 for threshold 0.528
====================================================================================
==========================
TRAIN confusion matrix
[[ 6657  4888]
 [23582 41344]]
```

Out[433]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x76fda4e0>
```



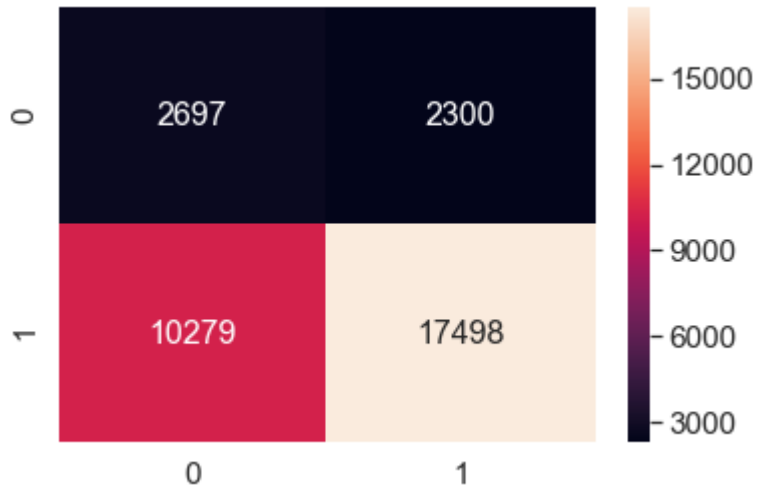
In [434]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict_with_best_t(y_test_
pred, best_t)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
Test confusion matrix
[[ 2697  2300]
 [10279 17498]]
```

Out[434]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x63e354a8>
```



obtaining false positive data points SET 3

In [435]:

```
#conver sparse to dense
AVGW2V_test = x_test_AVGW2V
AVGW2V_test.shape
```

Out[435]:

```
(32774, 623)
```

In [436]:

```
#find index of fp
y_test_converted = list(y_test[::])


false_positives_index_b = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if y_test_converted[i] == 0 and y_test_pred[i] <= best_t:
        false_positives_index_b.append(i)
        fp_count = fp_count + 1
    else :
        continue

print(fp_count)
```

```
100%|████████████████████████████████| 32774/32774 [00:00<00:00, 2340890.61
it/s]

2804
```

In [437]:

```
#get feature name vectorize preprocessed_essays
vectorizer_AVGW2V_essay = TfidfVectorizer()
vectorizer_AVGW2V_essay.fit_transform(x_train["preprocessed_essays"])

AVGW2V_features = vectorizer_AVGW2V_essay.get_feature_names()
len(AVGW2V_features)
```

Out[437]:

```
48972
```

In [438]:

```
import pandas as pd
df2 = pd.DataFrame(x_test_AVGW2V)
df2_final = df2.iloc[false_positives_index_b,:]
df2_final.shape
```

Out[438]:

```
(2804, 623)
```

In [439]:

```
#number of column
z=len(df2_final.columns)
print(z)
print("*"*30)
print(df2_final[0].sum())
```

```
623
******************************
2804.0
```

In [440]:

```
best_indices_AVGW2V = []

for j in range(z):

    s = df2_final[j].sum()

    if s >= 100 :
        best_indices_AVGW2V.append(j)
    else :
        continue


print(len(best_indices_AVGW2V))
print("*"*50)
print(best_indices_AVGW2V[0:10])
```

```
193
**************************************************
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

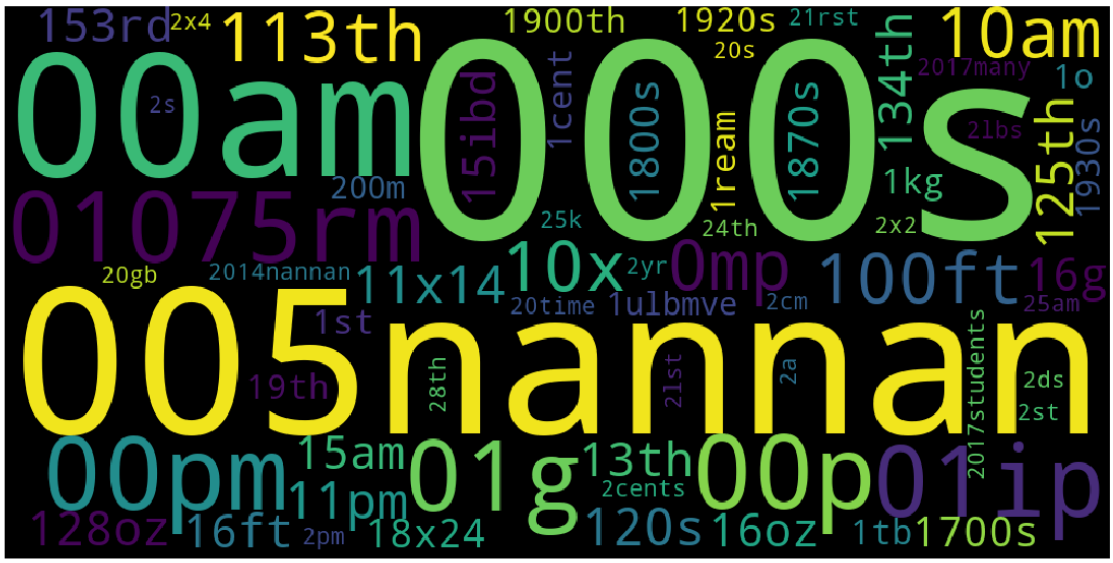
In [441]:

```
fp_words_AVGW2V = []

for a in best_indices_AVGW2V:
    fp_words_AVGW2V.append(str(AVGW2V_features[a]))
```

Word cloud for false positive class

In [442]:

```
#Word Cloud for False Positives words
#-----------------------------------------------
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words_AVGW2V)
wordcloud = WordCloud(width = 1000, height = 500).generate(unique_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("your_file_name"+".png", bbox_inches='tight')
plt.show()
plt.close()
```

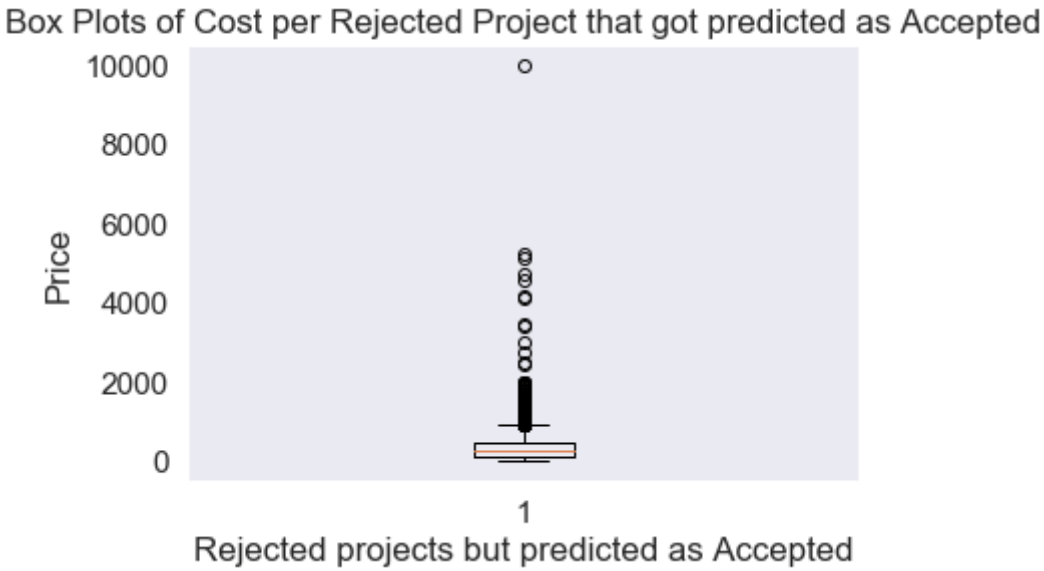


Box - Plot with the price of these False positive data points SET 3

In [443]:

```
print(len(false_positives_index_b))
print("*"*50)

#select all row of fp index
df2 = pd.DataFrame(x_test['price'])
df2_fina1 = df2.iloc[false_positives_index_b,:]

plt.boxplot(df2_fina1.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```

```
2804
**************************************************
```



Majority of the projects that were rejected but predicted as accepted Costs almost less than 1000 Dollars.

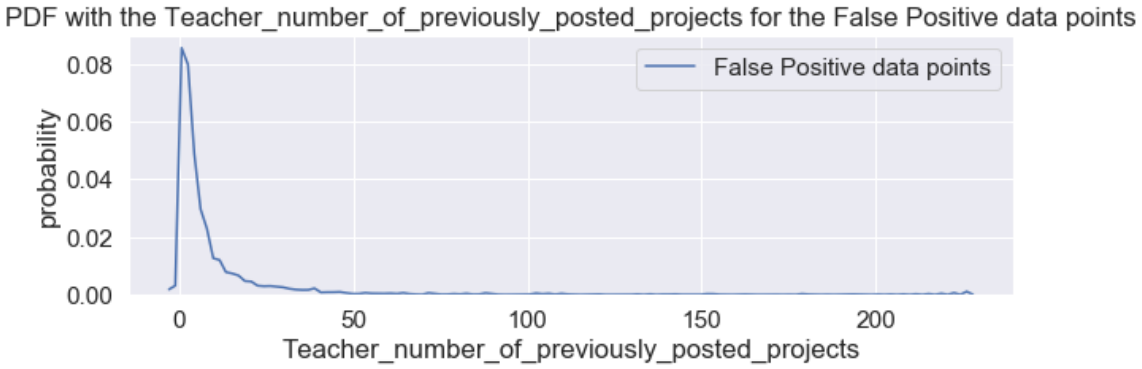
A Few of them are Extremely costs costing more than 4000 Dollars.

pdf with the `teacher_number_of_previously_posted_projects` of these `false positive data points` SET 3

In [444]:

```
df3 = pd.DataFrame(x_test['teacher_number_of_previously_posted_projects'])
df3_final = df3.iloc[false_positives_index_b,:]
print(df3_final.shape)

plt.figure(figsize=(10,3))
sns.distplot(df3_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Positive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```

```
(2804, 1)
```



Majority of the cases have Teachers with previously posted projects as zero (which is nearly 10% of the total data)

2.4.4 Applying Decision Trees on TFIDF W2V, SET 4

Vectorize using TFIDF W2V, SET 4

In [217]:

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

In [218]:

```
#Using Pretrained Models: TFIDFW weighted W2V on `essay
#_____________________________________

# average Word2Vec---train
# compute average word2vec for each review.
tfidf_w2v_vectors_essays_train = []; # the avg-w2v for each sentence/review is stored i
n this list
for sentence in tqdm(x_train['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_essays_train.append(vector)

print(len(tfidf_w2v_vectors_essays_train))
print(len(tfidf_w2v_vectors_essays_train[0]))
```

```
100%|████████████████████████████████████| 76471/76471 [02:42<00:00, 471.29
it/s]

76471
300
```

In [219]:

```
'''# average Word2Vec---cv
# compute average word2vec for each review.
tfidf_w2v_vectors_essays_cv = []; # the avg-w2v for each sentence/review is stored in t
his list
for sentence in tqdm(x_cv['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_essays_cv.append(vector)

print(len(tfidf_w2v_vectors_essays_cv))
print(len(tfidf_w2v_vectors_essays_cv[0]))'''
```

Out[219]:

```
"# average Word2Vec---cv\n# compute average word2vec for each review.\ntfi
df_w2v_vectors_essays_cv = []; # the avg-w2v for each sentence/review is s
tored in this list\nfor sentence in tqdm(x_cv['preprocessed_essays']): # f
or each review/sentence\n    vector = np.zeros(300) # as word vectors are
of zero length\n    tf_idf_weight =0; # num of words with a valid vector i
n the sentence/review\n    for word in sentence.split(): # for each word i
n a review/sentence\n        if (word in glove_words) and (word in tfidf_w
ords):\n            vec = model[word] # getting the vector for each word\n
# here we are multiplying idf value(dictionary[word]) and the tf value((se
ntence.count(word)/len(sentence.split())))\n            tf_idf = dictionar
y[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf v
alue for each word\n            vector += (vec * tf_idf) # calculating tfi
df weighted w2v\n            tf_idf_weight += tf_idf\n    if tf_idf_weight
!= 0:\n        vector /= tf_idf_weight\n    tfidf_w2v_vectors_essays_cv.ap
pend(vector)\n\nprint(len(tfidf_w2v_vectors_essays_cv))\nprint(len(tfidf_w
2v_vectors_essays_cv[0]))"
```

In [220]:

```
# average Word2Vec---test
# compute average word2vec for each review.
tfidf_w2v_vectors_essays_test = []; # the avg-w2v for each sentence/review is stored in
this list
for sentence in tqdm(x_test['preprocessed_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_essays_test.append(vector)

print(len(tfidf_w2v_vectors_essays_test))
print(len(tfidf_w2v_vectors_essays_test[0]))
```

```
100%|████████████████████████████████████| 32774/32774 [01:08<00:00, 479.07
it/s]

32774
300
```

In [221]:

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

In [222]:

```
#Using Pretrained Models: TFIDFW weighted W2V on "preprocessed_project_title"
#_____________________________________________
# average Word2Vec--train
# compute average word2vec for each review.
tfidf_w2v_vectors_project_title_train = []; # the avg-w2v for each sentence/review is s
tored in this list
for sentence in tqdm(x_train['preprocessed_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((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_project_title_train.append(vector)

print(len(tfidf_w2v_vectors_project_title_train))
print(len(tfidf_w2v_vectors_project_title_train[0]))
```

```
100%|██████████████████████████████████| 76471/76471 [00:02<00:00, 31046.13
it/s]

76471
300
```

In [223]:

```
'''# average Word2Vec--cv
# compute average word2vec for each review.
tfidf_w2v_vectors_project_title_cv = []; # the avg-w2v for each sentence/review is stor
ed in this list
for sentence in tqdm(x_cv['preprocessed_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((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_project_title_cv.append(vector)

print(len(tfidf_w2v_vectors_project_title_cv))
print(len(tfidf_w2v_vectors_project_title_cv[0]))'''
```

Out[223]:

```
"# average Word2Vec--cv\n# compute average word2vec for each review.\ntfid
f_w2v_vectors_project_title_cv = []; # the avg-w2v for each sentence/revie
w is stored in this list\nfor sentence in tqdm(x_cv['preprocessed_project_
title']): # for each review/sentence\n    vector = np.zeros(300) # as word
vectors are of zero length\n    tf_idf_weight =0; # num of words with a va
lid vector in the sentence/review\n    for word in sentence.split(): # for
each word in a review/sentence\n        if (word in glove_words) and (word
in tfidf_words):\n            vec = model[word] # getting the vector for e
ach word\n            # here we are multiplying idf value(dictionary[wor
d]) and the tf value((sentence.count(word)/len(sentence.split())))\n
tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # g
etting the tfidf value for each word\n            vector += (vec * tf_idf)
# calculating tfidf weighted w2v\n            tf_idf_weight += tf_idf\n
if tf_idf_weight != 0:\n        vector /= tf_idf_weight\n    tfidf_w2v_vec
tors_project_title_cv.append(vector)\n\nprint(len(tfidf_w2v_vectors_projec
t_title_cv))\nprint(len(tfidf_w2v_vectors_project_title_cv[0]))"
```

In [224]:

```
# average Word2Vec--test
# compute average word2vec for each review.
tfidf_w2v_vectors_project_title_test = []; # the avg-w2v for each sentence/review is st
ored in this list
for sentence in tqdm(x_test['preprocessed_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((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_project_title_test.append(vector)

print(len(tfidf_w2v_vectors_project_title_test))
print(len(tfidf_w2v_vectors_project_title_test[0]))
```

```
100%|██████████████████████████████████| 32774/32774 [00:01<00:00, 32544.31
it/s]

32774
300
```

merge all aparse data, SET 4

In [225]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
x_train_TFIDFW2V = np.hstack((x_train_ohe, tfidf_w2v_vectors_essays_train, tfidf_w2v_ve
ctors_project_title_train))
#x_cv_TFIDFW2V = np.hstack((x_cv_ohe, tfidf_w2v_vectors_essays_cv, tfidf_w2v_vectors_pr
oject_title_cv))
x_test_TFIDFW2V = np.hstack((x_test_ohe, tfidf_w2v_vectors_essays_test, tfidf_w2v_vecto
rs_project_title_test))

print(x_train_TFIDFW2V.shape)
#print(x_cv_TFIDFW2V.shape)
print(x_test_TFIDFW2V.shape)
```

```
(76471, 623)
(32774, 623)
```

GridsearchCV, SET 4

In [227]:

```
%time
from sklearn.model_selection import GridSearchCV,TimeSeriesSplit
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import roc_curve, auc

print("***************Grid search cv perform on train dataset******************")

DT = DecisionTreeClassifier(class_weight='balanced')
#params we need to try on classifier
param_grid = {'max_depth':[1, 5, 10, 50, 100, 500, 1000],
              'min_samples_split':[5, 10, 100, 500,1000]}
ts_cv = TimeSeriesSplit(n_splits=10) #For time based splitting
grid_bow = GridSearchCV(DT,param_grid,cv=ts_cv,verbose=1,n_jobs=-1,scoring='roc_auc',re
turn_train_score=True)
grid_bow.fit(x_train_TFIDFW2V,y_train)

split_hyperparameter_TFIDFW2V=grid_bow.best_params_['min_samples_split']
depth_hyperparameter_TFIDFW2V=grid_bow.best_params_['max_depth']

#savetofile(gsv,"Log Reg/gsv_uni")
print("Best HyperParameter: ",grid_bow.best_params_)



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

print("----------------------------------------------------")
```

```
Wall time: 0 ns
***************Grid search cv perform on train dataset******************
Fitting 10 folds for each of 35 candidates, totalling 350 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent worker
s.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed:   55.2s
[Parallel(n_jobs=-1)]: Done 192 tasks      | elapsed: 17.2min
[Parallel(n_jobs=-1)]: Done 350 out of 350 | elapsed: 40.4min finished

Best HyperParameter:  {'max_depth': 5, 'min_samples_split': 1000}
----------------------------------------------------
```

3D plot of AUC with Hyperparameter

In [228]:

```
import plotly
plotly.tools.set_credentials_file(username='Rana_Singh', api_key='jZjhDgnliBgNu6jqwfR7'
)
import plotly.plotly as py
import plotly.graph_objs as go

%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits import mplot3d



z1= list(train_auc)
x1 = pd.Series([1,1,1,1,5,5,5,5,10,10,10,10,50,50,50,50,100,100,100,100,500,500,500,500
])
y1 = pd.Series([5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,100,500,5,10,1
00,500])
```

In [229]:

```
trace = go.Scatter3d(
    x=x1, y=y1, z=z1,
    marker=dict(
        size=4,
        color=z1,
        colorscale='Viridis',
    ),
    line=dict(
        color='#1f77b4',
        width=1
    )
)
```

In [230]:

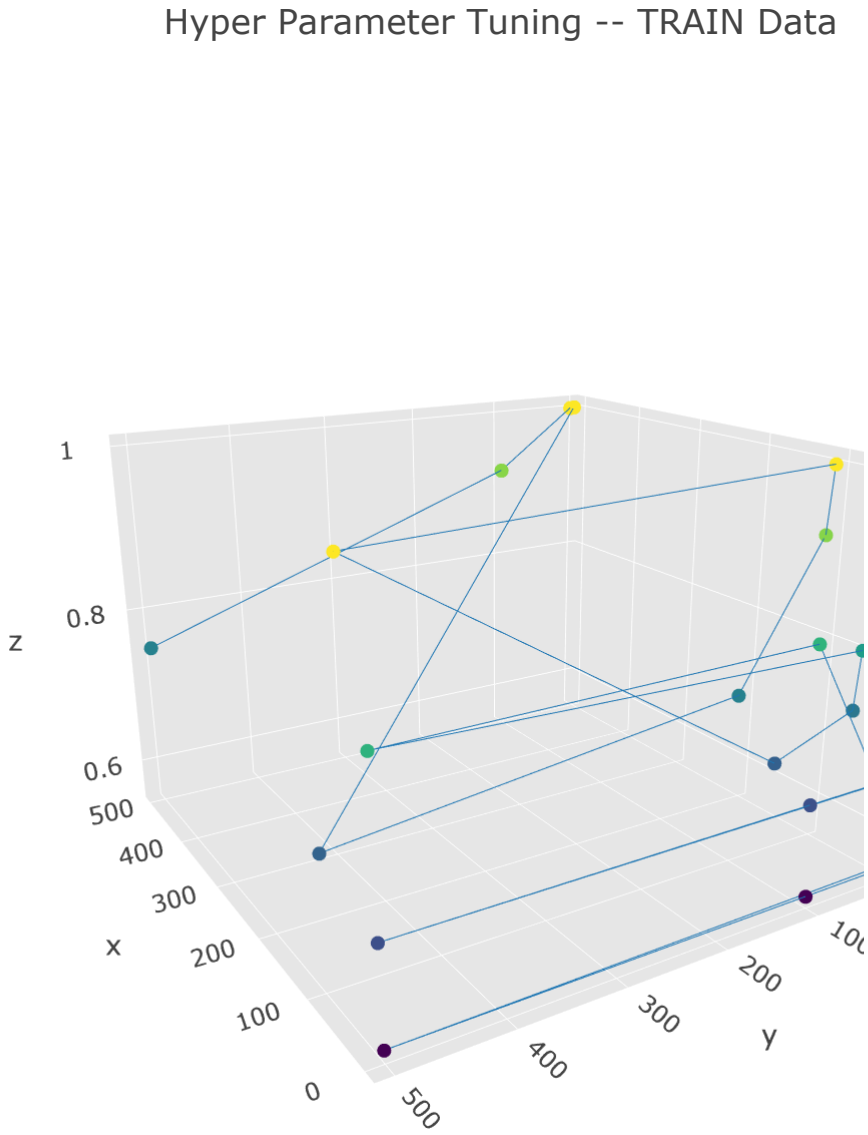
```
data = [trace]
layout = dict(
    width=800,
    height=700,
    autosize=False,
    title='Hyper Parameter Tuning -- TRAIN Data',
    scene=dict(
        xaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        yaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        zaxis=dict(
            gridcolor='rgb(255, 255, 255)',
            zerolinecolor='rgb(255, 255, 255)',
            showbackground=True,
            backgroundcolor='rgb(230, 230,230)'
        ),
        camera=dict(
            up=dict(
                x=0,
                y=0,
                z=1
            ),
            eye=dict(
                x=-1.7428,
                y=1.0707,
                z=0.7100,
            )
        ),
        aspectratio = dict( x=1, y=1, z=0.7 ),
        aspectmode = 'manual'
    ),
)
```

In [231]:

```
fig = dict(data=data, layout=layout)

py.iplot(fig, filename='Decision-trees-TFIDFW2V', height=700)
```

```
C:\Users\IDM LAB-09\Anaconda3\lib\site-packages\IPython\core\display.py:68
9: UserWarning:

Consider using IPython.display.IFrame instead
```

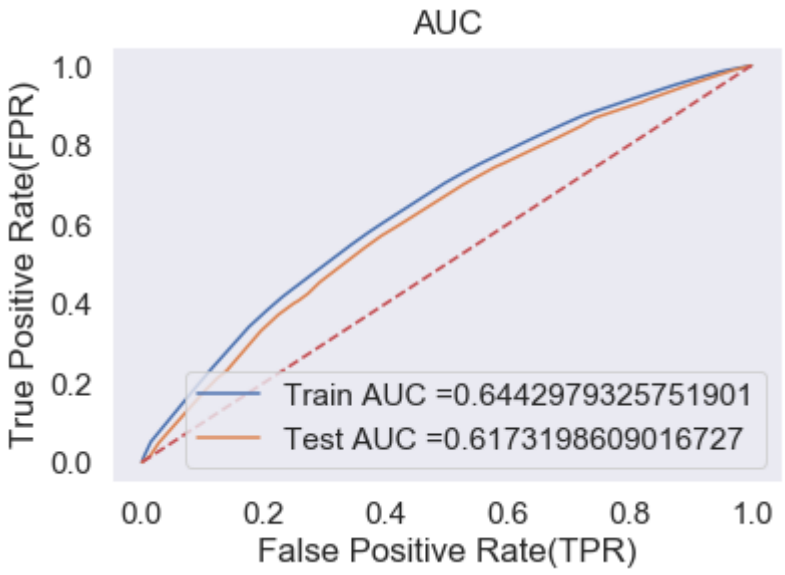
Out[231]:



ROC of tain , test and cv dataset, SET 4

In [445]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTreeClassifier.html

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

DT = DecisionTreeClassifier(max_depth = depth_hyperparameter_TFIDFW2V, min_samples_split = split_hyperparameter_TFIDFW2V,class_weight='balanced')

DT.fit(x_train_TFIDFW2V, y_train)

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

y_train_pred = batch_predict(DT, x_train_TFIDFW2V)
y_test_pred = batch_predict(DT, x_test_TFIDFW2V)

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)

TFIDFW2V_auc_train = auc(train_fpr, train_tpr)
TFIDFW2V_auc_test = auc(test_fpr, test_tpr)

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.plot([0,1],[0,1],'r--')
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



Confusion matrix, SET 4

In [446]:

```
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#-----------------------------------------------
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
def predict(proba, threshould, fpr, tpr):

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

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

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

In [447]:

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

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

print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
```

```
====================================================================================
==========================
the maximum value of tpr*(1-fpr) 0.3648798358132129 for threshold 0.506
```

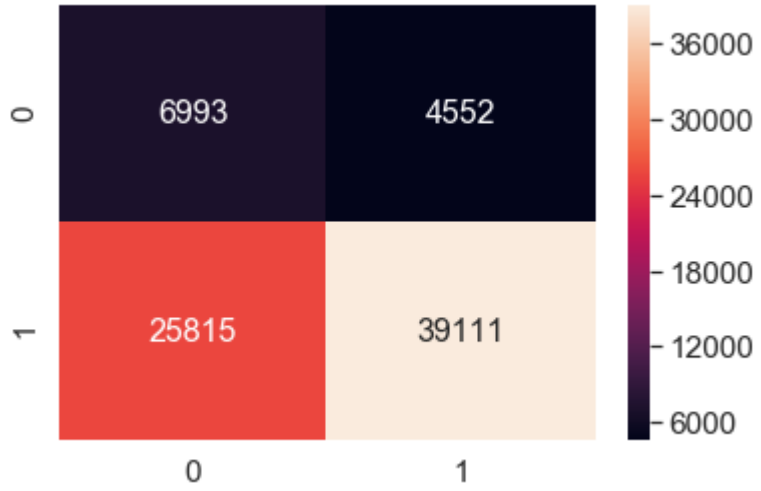
In [448]:

```
print("="*100)
print("TRAIN confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict_with_best_t(y_tra
in_pred, best_t)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
TRAIN confusion matrix
[[ 6993  4552]
 [25815 39111]]
```

Out[448]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x63e7d240>
```



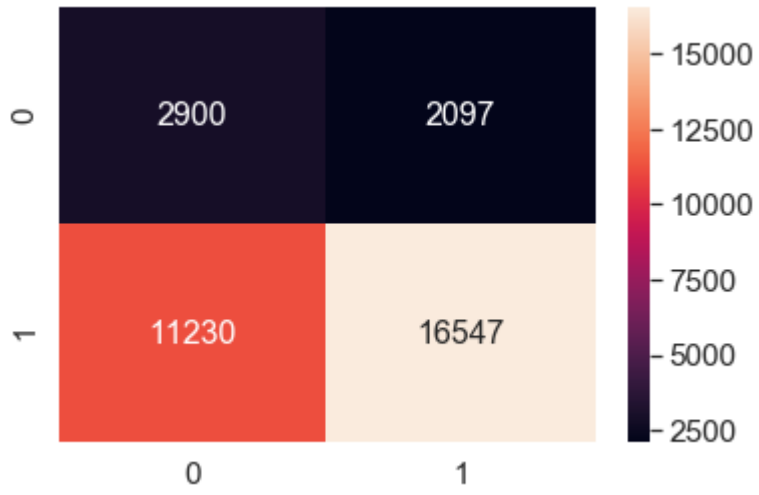
In [449]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict_with_best_t(y_test_
pred, best_t)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
Test confusion matrix
[[ 2900  2097]
 [11230 16547]]
```

Out[449]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x6a509dd8>
```



obtaining false positive data points SET 4

In [450]:

```
#conver sparse to dense
TFIDFW2V_test = x_test_TFIDFW2V
TFIDFW2V_test.shape
```

Out[450]:

```
(32774, 623)
```

In [451]:

```
type(x_test_TFIDFW2V)
```

Out[451]:

```
numpy.ndarray
```

In [452]:

```
#find index of fp
y_test_converted = list(y_test[::])


false_positives_index_b = []
fp_count = 0

for i in tqdm(range(len(y_test_pred))):
    if y_test_converted[i] == 0 and y_test_pred[i] <= best_t:
        false_positives_index_b.append(i)
        fp_count = fp_count + 1
    else :
        continue

print(fp_count)
```

```
100%|████████████████████████████████| 32774/32774 [00:00<00:00, 1057164.21
it/s]

3033
```

In [453]:

```
#get feature name vectorize preprocessed_essays
vectorizer_TFIDFW2V_essay = TfidfVectorizer()
vectorizer_TFIDFW2V_essay.fit_transform(x_train["preprocessed_essays"])

TFIDFW2V_features = vectorizer_TFIDFW2V_essay.get_feature_names()
len(TFIDFW2V_features)
```

Out[453]:

```
48972
```

In [454]:

```
import pandas as pd
df2 = pd.DataFrame(x_test_TFIDFW2V)
df2_final = df2.iloc[false_positives_index_b,:]
df2_final.shape
```

Out[454]:

```
(3033, 623)
```

In [455]:

```
#number of column
z=len(df2_final.columns)
print(z)
print("*"*30)
print(df2_final[0].sum())
```

```
623
******************************
3033.0
```

In [456]:

```
best_indices_TFIDFW2V = []

for j in range(z):

    s = df2_final[j].sum()

    if s >= 100 :
        best_indices_TFIDFW2V.append(j)
    else :
        continue


print(len(best_indices_TFIDFW2V))
print("*"*50)
print(best_indices_TFIDFW2V[0:10])
```

```
196
**************************************************
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

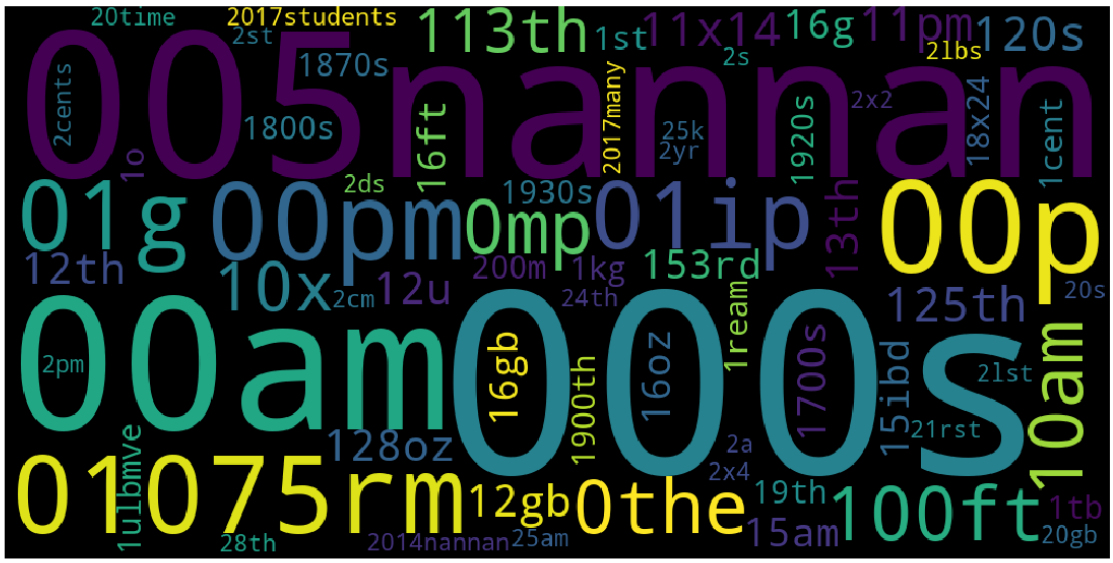
In [457]:

```
fp_words_TFIDFW2V = []

for a in best_indices_TFIDFW2V:
    fp_words_TFIDFW2V.append(str(TFIDFW2V_features[a]))
```

Word cloud for false positive grid

In [458]:

```
#Word Cloud for False Positives words
#-----------------------------------------------
from wordcloud import WordCloud
#convert list to string and generate
unique_string=(" ").join(fp_words_TFIDFW2V)
wordcloud = WordCloud(width = 1000, height = 500).generate(unique_string)
plt.figure(figsize=(25,10))
plt.imshow(wordcloud)
plt.axis("off")
plt.savefig("your_file_name"+".png", bbox_inches='tight')
plt.show()
plt.close()
```



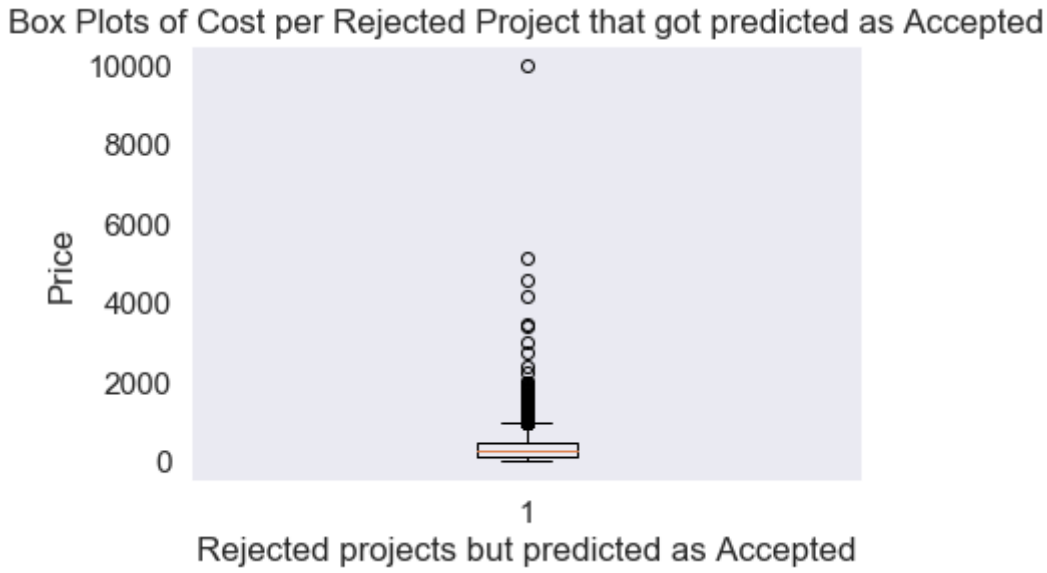
In [ ]:

Box - Plot with the price of these False positive data points SET 4

In [459]:

```
print(len(false_positives_index_b))
print("*"*50)

#select all row of fp index
df2 = pd.DataFrame(x_test['price'])
df2_fina1 = df2.iloc[false_positives_index_b,:]

plt.boxplot(df2_fina1.values)
plt.title('Box Plots of Cost per Rejected Project that got predicted as Accepted')
plt.xlabel('Rejected projects but predicted as Accepted')
plt.ylabel('Price')
plt.grid()
plt.show()
```

```
3033
**************************************************
```



Majority of the projects that were rejected but predicted as accepted Costs almost less than 1000 Dollars.

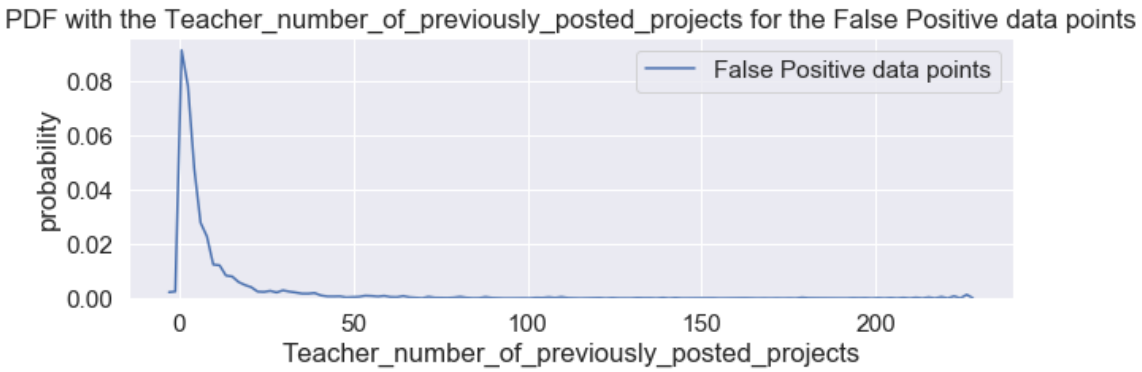
A Few of them are Extremely costs costing more than 4000 Dollars.

pdf with the `teacher_number_of_previously_posted_projects` of these `false positive` data points SET 4

In [460]:

```
df3 = pd.DataFrame(x_test['teacher_number_of_previously_posted_projects'])
df3_final = df3.iloc[false_positives_index_b,:]
print(df3_final.shape)

plt.figure(figsize=(10,3))
sns.distplot(df3_final.values, hist=False, label="False Positive data points")
plt.title('PDF with the Teacher_number_of_previously_posted_projects for the False Posi
tive data points')
plt.xlabel('Teacher_number_of_previously_posted_projects')
plt.ylabel('probability')
plt.legend()
plt.show()
```

```
(3033, 1)
```



Majority of the cases have Teachers with previously posted projects as zero (which is nearly 10% of the total data)

5k best features from features of Set 2 using`feature_importances SET 2

In [291]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

vectorize the essay and title data, SET 2

In [461]:

```
#convert the essay text to vector
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer_essay_tfidf = TfidfVectorizer()
vectorizer_essay_tfidf.fit(x_train['preprocessed_essays'].values)# fit has to apply onl
y on train data
z_tfidf1=vectorizer_essay_tfidf.fit(x_train['preprocessed_essays'].values)# fit has to
 apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_tfidf_essays = vectorizer_essay_tfidf.transform(x_train['preprocessed_essays'].
values)
#x_cv_tfidf_essays = vectorizer_essay_tfidf.transform(x_cv['preprocessed_essays'].value
s)
x_test_tfidf_essays = vectorizer_essay_tfidf.transform(x_test['preprocessed_essays'].va
lues)

print("Shape of matrix after one hot encodig ",x_train_tfidf_essays.shape, y_train.shap
e)
#print("Shape of matrix after one hot encodig ",x_cv_tfidf_essays.shape)
print("Shape of matrix after one hot encodig ",x_test_tfidf_essays.shape)
```

```
Shape of matrix after one hot encodig  (76471, 48972) (76471,)
Shape of matrix after one hot encodig  (32774, 48972)
```

In [462]:

```
#convert the title text to vector
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_title_tfidf = TfidfVectorizer()
vectorizer_title_tfidf.fit(x_train['preprocessed_project_title'].values)# fit has to ap
ply only on train data
z_tfidf2=vectorizer_title_tfidf.fit(x_train['preprocessed_project_title'].values)# fit
 has to apply only on train data

# we use fitted CountVectorizer to convert the text to vector
x_train_tfidf_title = vectorizer_title_tfidf.transform(x_train['preprocessed_project_ti
tle'].values)
#x_cv_tfidf_title = vectorizer_title_tfidf.transform(x_cv['preprocessed_project_titl
e'].values)
x_test_tfidf_title = vectorizer_title_tfidf.transform(x_test['preprocessed_project_titl
e'].values)

print("Shape of matrix after one hot encodig ",x_train_tfidf_title.shape)
#print("Shape of matrix after one hot encodig ",x_cv_tfidf_title.shape)
print("Shape of matrix after one hot encodig ",x_test_tfidf_title.shape)
```

```
Shape of matrix after one hot encodig  (76471, 14337)
Shape of matrix after one hot encodig  (32774, 14337)
```

merge all sparse data, SET 2

In [494]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx
:)
x_train_tfidf = hstack((x_train_ohe, x_train_tfidf_essays, x_train_tfidf_title)).tocsr
()
#x_cv_tfidf = hstack((x_cv_ohe, x_cv_tfidf_essays, x_cv_tfidf_title)).tocsr()
x_test_tfidf = hstack((x_test_ohe, x_test_tfidf_essays, x_test_tfidf_title)).tocsr()

print(x_train_tfidf.shape, y_train.shape)
#print(x_cv_tfidf.shape, y_cv.shape)
print(x_test_tfidf.shape, y_test.shape)
print(type(x_train_tfidf))
```

```
(76471, 63332) (76471,)
(32774, 63332) (32774,)
<class 'scipy.sparse.csr.csr_matrix'>
```

find best 5k feature

In [464]:

```
#https://stackoverflow.com/questions/49170296/scikit-learn-feature-importance-calculati
on-in-decision-trees

## Fit the Model to obtain the best 5k features

from sklearn.tree import DecisionTreeClassifier
from sklearn.tree.export import export_graphviz
from sklearn.feature_selection import mutual_info_classif

clf = DecisionTreeClassifier(class_weight='balanced')

clf.fit(x_train_tfidf, y_train)
```

Out[464]:

```
DecisionTreeClassifier(class_weight='balanced', criterion='gini',
                       max_depth=None, max_features=None, max_leaf_nodes=N
one,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=None, splitter='best')
```

In [465]:

```
## Compute the Feature importances for our Train Features

feat_importance = clf.tree_.compute_feature_importances(normalize=False)
```

In [466]:

```
print("feat importance = " + str(feat_importance))
```

```
feat importance = [0. 0. 0. ... 0. 0. 0.]
```

In [467]:

```
import pandas as pd
df = pd.DataFrame(feat_importance)

df = np.transpose(df)
```

In [468]:

```
## Store the indexes of the features with atleast some importance. Lets ignore the feat
ures with 0
## as the feature importance value and instead consider all the values other than these

best_ind = []

for j in range(14355):

    s = df[j].sum()

    if s > 0 :
        best_ind.append(j)
    else :
        continue
```

In [469]:

```
best_ind[0:2]
```

Out[469]:

```
[12, 16]
```

In [470]:

```
## Identify number of Features after feature importance step
len(best_ind)
```

Out[470]:

```
660
```

In [471]:

```
x_train_tfidf.shape
```

Out[471]:

```
(76471, 63332)
```

In [486]:

```
x_train_tfidf
```

Out[486]:

```
<76471x63332 sparse matrix of type '<class 'numpy.float64'>'
        with 10156399 stored elements in Compressed Sparse Row format>
```

In [493]:

```
print(type(x_train_tfidf))
print(x_train_tfidf.shape)
```

```
<class 'scipy.sparse.csr.csr_matrix'>
(76471, 63332)
```

In [499]:

```
df_x_train = pd.DataFrame(x_train_tfidf.todense())
df_x_train.shape
```

In [223]:

```
df_x_test = pd.DataFrame(x_test_tfidf.todense())
```

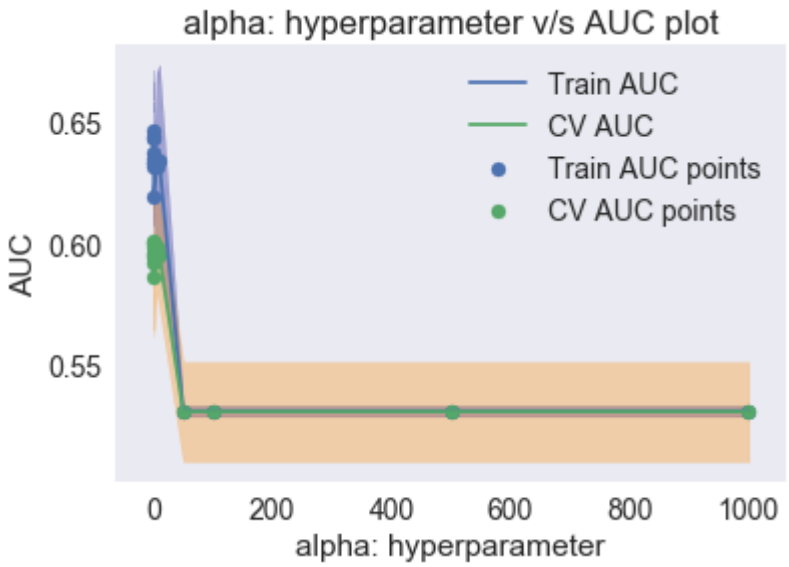
In [224]:

```
final_df_train = df_x_train.iloc[:, best_ind]
final_df_test = df_x_test.iloc[:, best_ind]
```

Gridsearch CV

In [225]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier


sv = SGDClassifier(loss='hinge', penalty='l2')

parameters = {'alpha':[1000,500,100,50,10,5,1,0.5,0.1,0.05,0.01,0.005,0.001,0.0005,0.00
01]}

clf = GridSearchCV(sv, parameters, cv= 10, n_jobs=-1,scoring='roc_auc',return_train_sco
re=True)

clf.fit(final_df_train, y_train)

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

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc + train_
auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alph
a=0.3,color='darkorange')

plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



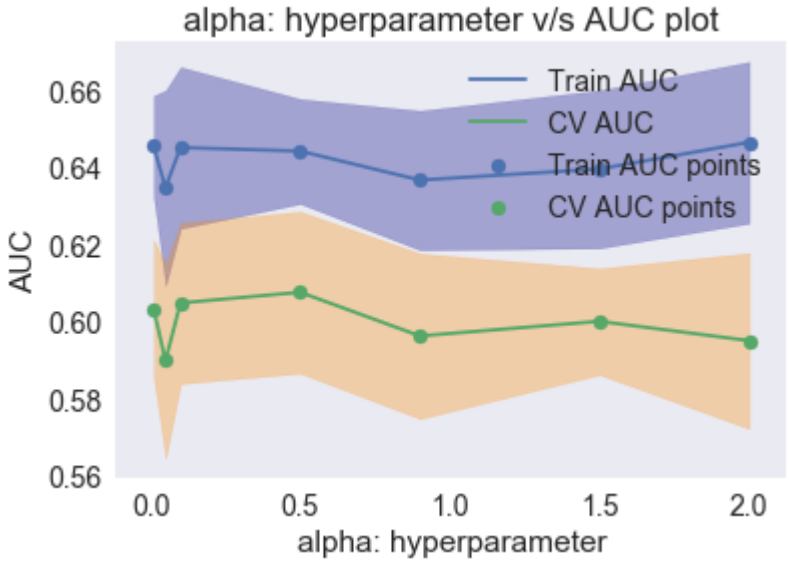
In [226]:

```
print(clf.best_score_)
print(clf.best_estimator_)
```

```
0.6015298130273076
SGDClassifier(alpha=0.5, average=False, class_weight=None, epsilon=0.1,
       eta0=0.0, fit_intercept=True, l1_ratio=0.15,
       learning_rate='optimal', loss='hinge', max_iter=None, n_iter=None,
       n_jobs=1, penalty='l2', power_t=0.5, random_state=None,
       shuffle=True, tol=None, verbose=0, warm_start=False)
```

In [227]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier


sv = SGDClassifier(loss='hinge', penalty='l2',class_weight='balanced')

parameters = {'alpha':[0.01, 0.05, 0.1, 0.5, 0.9, 1.5, 2.0]}

clf = GridSearchCV(sv, parameters, cv= 10, n_jobs=-1,scoring='roc_auc')

clf.fit(final_df_train, y_train)

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

plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc + train_
auc_std,alpha=0.3,color='darkblue')

plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alph
a=0.3,color='darkorange')

plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC plot")
plt.grid()
plt.show()
```



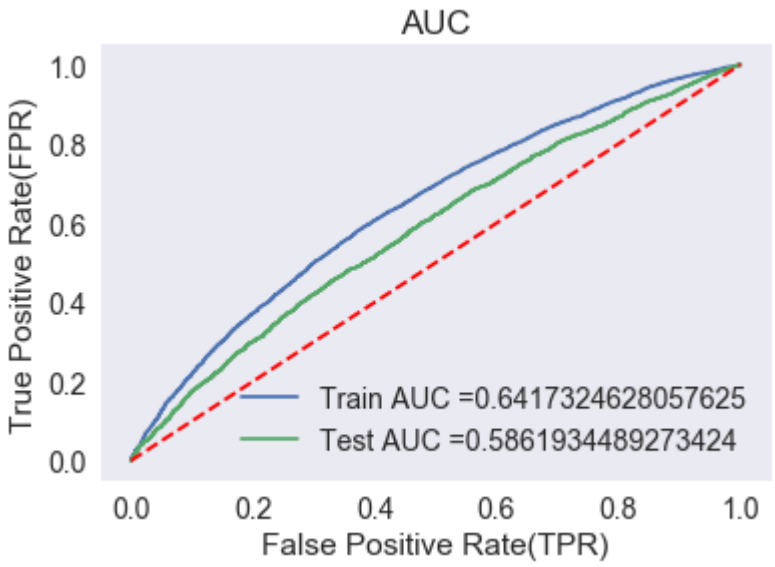
In [292]:

```
C_hyperparameter_set5=0.5
```

Implementing Best Hyperparameter

In [293]:

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

clf = SGDClassifier(loss='hinge', penalty='l2', alpha=C_hyperparameter_set5,class_weight='balanced')


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


best5k_auc_train = auc(train_fpr, train_tpr)
best5k_auc_auc_test = auc(test_fpr, test_tpr)

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.plot([0,1],[0,1],'r--')
plt.legend()
plt.xlabel("False Positive Rate(TPR)")
plt.ylabel("True Positive Rate(FPR)")
plt.title("AUC")
plt.grid()
plt.show()
```



Confusion matrix

In [231]:

```
#CONFUSION MATRIX
def predict(proba, threshould, fpr, tpr):

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

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

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

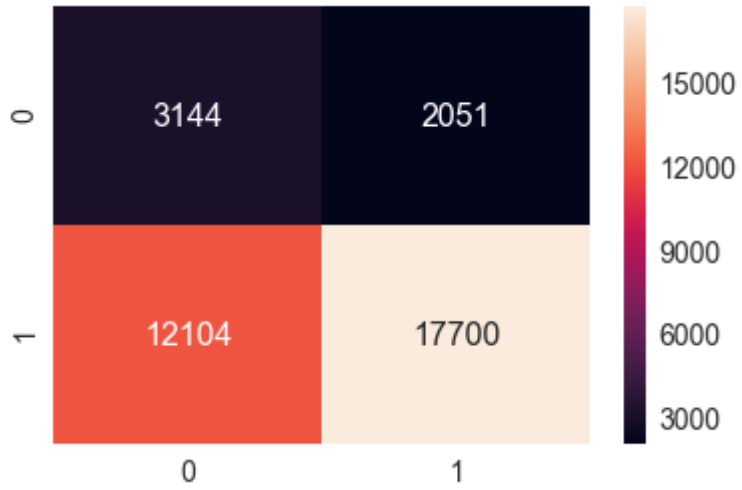
In [232]:

```
print("="*100)
print("TRAIN confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_t
pr)))


conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_
thresholds, train_fpr, train_tpr)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
TRAIN confusion matrix
the maximum value of tpr*(1-fpr) 0.36201908936266186 for threshold 1.0
[[ 3144  2051]
 [12104 17700]]
the maximum value of tpr*(1-fpr) 0.36201908936266186 for threshold 1.0
```

Out[232]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x22143a72550>
```



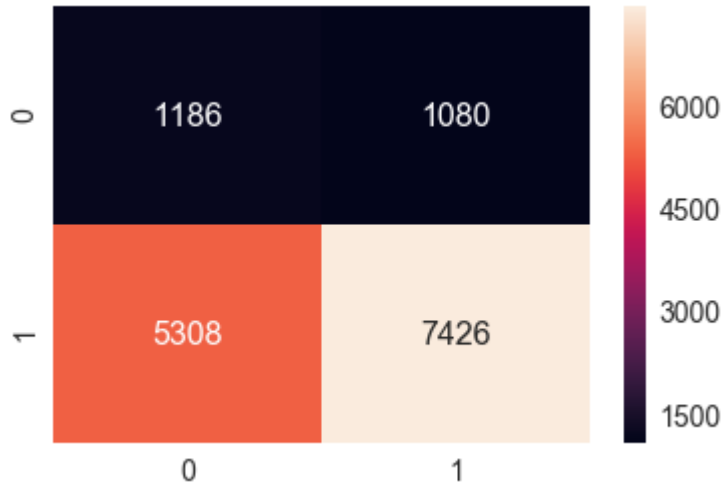
In [233]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr
)))


conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, te_thr
esholds, test_fpr, test_tpr)), range(2),range(2))

sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
====================================================================================
==========================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.3128698547827216 for threshold 1.0
[[1186 1080]
 [5308 7426]]
the maximum value of tpr*(1-fpr) 0.3128698547827216 for threshold 1.0
```

Out[233]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2215425a0f0>
```



In [ ]:

```

```

3. Conclusion

In [0]:

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

In [0]:

```
#!pip install prettytable
```

In [294]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model","Hyper parameter_penalty", "Hyper parameter_alph
a","AUC_Train", "AUC_test","depth","split"]
x.add_row(["BOW", "Decision tree", "l2","-----", BOW_auc_train,BOW_auc_test,depth_hyper
parameter_bow,split_hyperparameter_bow])
x.add_row(["TFIDF", "Decision tree", "l2","----", TFIDF_auc_train,TFIDF_auc_test,depth_
hyperparameter_tfidf,split_hyperparameter_tfidf])
x.add_row(["AVG W2V", "Decision tree", "l2","----", AVGW2V_auc_train,AVGW2V_auc_test,de
pth_hyperparameter_AVGW2V,split_hyperparameter_AVGW2V])
x.add_row(["TFIDF AVG W2V", "Decision tree", "l2","------",TFIDFW2V_auc_train,TFIDFW2V_
auc_test,depth_hyperparameter_TFIDFW2V,split_hyperparameter_TFIDFW2V])
x.add_row(["SET 5", "linear support vector", "l2", C_hyperparameter_set5, best5k_auc_tr
ain,best5k_auc_auc_test,"----","----"])
print(x)
```

```
+---------------+----------------------+-------------------------+-------
----------------+--------------------+--------------------+-------+-------
+
|   Vectorizer  |         Model        | Hyper parameter_penalty | Hyper
parameter_alpha |     AUC_Train      |      AUC_test      | depth | split
|
+---------------+----------------------+-------------------------+-------
----------------+--------------------+--------------------+-------+-------
+
|      BOW      |     Decision tree    |            l2           |
-----         | 0.667038720991259  | 0.6090163888407943 |   10  |  500  |
|     TFIDF     |     Decision tree    |            l2           |
----          | 0.6510709009481128 | 0.6096337289679478 |   10  |  500  |
|    AVG W2V    |     Decision tree    |            l2           |
----          | 0.7017654870337344 | 0.5931936323255488 |   10  |  500  |
| TFIDF AVG W2V |     Decision tree    |            l2           |
------        | 0.6548367363599383 | 0.6109708689346033 |   5   |   10  |
|     SET 5     | linear support vector |            l2           |
0.5           | 0.6548367363599383 | 0.6109708689346033 |  ---- |  ---- |
+---------------+----------------------+-------------------------+-------
----------------+--------------------+--------------------+-------+-------
+
```

Observation:

1)BOW, TFIDF and Set 5(combine all except vectorized dataset) give optimal result with L2 Regularizer while AVG W2W and TFIDF weighted AVG W2V shows optimality with L1 Regularization.

2) Hyper parameter prefer high value for model with AVG W2V vectorizer. Lo wvalue for model having BOW and TFIDF vectorizer.

3)AUC value of training, test , cv dataset nearly same which show that model in all case is not underfit, nor overfit.

In [0]: