DonorsChoose

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

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

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

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

About the DonorsChoose Data Set

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

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

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

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

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

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

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

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

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

Notes on the Essay Data

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

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

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

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

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

In [1]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

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

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

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

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

from tqdm import tqdm
import os

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

In [2]:
```
## import dill
# reload notebook
## dill.load_session('test_dill.env')
```

1.1 Reading Data

In [3]:
```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

In [4]:
```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

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

In [5]:
```
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

Out[5]:

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

1.2 preprocessing of project_subject_categories

In [6]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

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

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

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

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

1.3 preprocessing of project_subject_subcategories

In [7]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

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

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

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

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

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

1.3 Text preprocessing

In [8]:
```
# 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 [9]:
```
project_data.head(2)
```

Out[9]:

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

In [10]:
```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [11]:
```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
print(project_data['essay'].values[99999])
print("="*50)
```

```
My students are English learners that are working on English as their second or third languages. We are
a melting pot of refugees, immigrants, and native-born Americans bringing the gift of language to our sc
hool. \r\n\r\n We have over 24 languages represented in our English Learner program with students at eve
ry level of mastery.  We also have over 40 countries represented with the families within our school.  E
ach student brings a wealth of knowledge and experiences to us that open our eyes to new cultures, belie
fs, and respect.\"The limits of your language are the limits of your world.\"-Ludwig Wittgenstein  Our E
nglish learner's have a strong support system at home that begs for more resources.  Many times our pare
nts are learning to read and speak English along side of their children.  Sometimes this creates barrier
s for parents to be able to help their child learn phonetics, letter recognition, and other reading skil
ls.\r\n\r\nBy providing these dvd's and players, students are able to continue their mastery of the Engl
ish language even if no one at home is able to assist.  All families with students within the Level 1 pr
oficiency status, will be a offered to be a part of this program.  These educational videos will be spec
ially chosen by the English Learner Teacher and will be sent home regularly to watch.  The videos are to
help the child develop early reading skills.\r\n\r\nParents that do not have access to a dvd player will
have the opportunity to check out a dvd player to use for the year.  The plan is to use these videos and
educational dvd's for the years to come for other EL students.\r\nnannan
==================================================
The 51 fifth grade students that will cycle through my classroom this year all love learning, at least m
ost of the time. At our school, 97.3% of the students receive free or reduced price lunch. Of the 560 st
udents, 97.3% are minority students. \r\nThe school has a vibrant community that loves to get together a
nd celebrate. Around Halloween there is a whole school parade to show off the beautiful costumes that st
udents wear. On Cinco de Mayo we put on a big festival with crafts made by the students, dances, and gam
es. At the end of the year the school hosts a carnival to celebrate the hard work put in during the scho
ol year, with a dunk tank being the most popular activity.My students will use these five brightly color
ed Hokki stools in place of regular, stationary, 4-legged chairs. As I will only have a total of ten in
the classroom and not enough for each student to have an individual one, they will be used in a variety
of ways. During independent reading time they will be used as special chairs students will each use on o
ccasion. I will utilize them in place of chairs at my small group tables during math and reading times.
The rest of the day they will be used by the students who need the highest amount of movement in their l
ife in order to stay focused on school.\r\n\r\nWhenever asked what the classroom is missing, my students
always say more Hokki Stools. They can't get their fill of the 5 stools we already have. When the studen
ts are sitting in group with me on the Hokki Stools, they are always moving, but at the same time doing
their work. Anytime the students get to pick where they can sit, the Hokki Stools are the first to be ta
ken. There are always students who head over to the kidney table to get one of the stools who are disapp
ointed as there are not enough of them. \r\n\r\nWe ask a lot of students to sit for 7 hours a day. The H
okki stools will be a compromise that allow my students to do desk work and move at the same time. These
stools will help students to meet their 60 minutes a day of movement by allowing them to activate their
core muscles for balance while they sit. For many of my students, these chairs will take away the barrie
r that exists in schools for a child who can't sit still.nannan
==================================================
How do you remember your days of school? Was it in a sterile environment with plain walls, rows of desk
s, and a teacher in front of the room? A typical day in our room is nothing like that. I work hard to cr
eate a warm inviting themed room for my students look forward to coming to each day.\r\n\r\nMy class is
made up of 28 wonderfully unique boys and girls of mixed races in Arkansas.\r\nThey attend a Title I sch
ool, which means there is a high enough percentage of free and reduced-price lunch to qualify. Our schoo
l is an \"open classroom\" concept, which is very unique as there are no walls separating the classroom
s. These 9 and 10 year-old students are very eager learners; they are like sponges, absorbing all the in
formation and experiences and keep on wanting more.With these resources such as the comfy red throw pill
ows and the whimsical nautical hanging decor and the blue fish nets, I will be able to help create the m
ood in our classroom setting to be one of a themed nautical environment. Creating a classroom environmen
t is very important in the success in each and every child's education. The nautical photo props will be
used with each child as they step foot into our classroom for the first time on Meet the Teacher evenin
g. I'll take pictures of each child with them, have them developed, and then hung in our classroom ready
for their first day of 4th grade.  This kind gesture will set the tone before even the first day of scho
ol! The nautical thank you cards will be used throughout the year by the students as they create thank y
ou cards to their team groups.\r\n\r\nYour generous donations will help me to help make our classroom a
fun, inviting, learning environment from day one.\r\n\r\nIt costs lost of money out of my own pocket on
resources to get our classroom ready. Please consider helping with this project to make our new school y
ear a very successful one. Thank you!nannan
==================================================
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
```

```
working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I
teach in a Title I school where most of the students receive free or reduced price lunch.  Despite their
disabilities and limitations, my students love coming to school and come eager to learn and explore.Have
you ever felt like you had ants in your pants and you needed to groove and move as you were in a meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e chairs are the answer and I love then because they develop their core, which enhances gross motor and
in Turn fine motor skills. \r\nThey also want to learn through games, my kids don't want to sit and do w
orksheets. They want to learn to count by jumping and playing. Physical engagement is the key to our suc
cess. The number toss and color and shape mats can make that happen. My students will forget they are do
ing work and just have the fun a 6 year old deserves.nannan
==================================================
The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teac
her inspires. -William A. Ward\r\n\r\nMy school has 803 students which is makeup is 97.6% African-Americ
an, making up the largest segment of the student body. A typical school in Dallas is made up of 23.2% Af
rican-American students. Most of the students are on free or reduced lunch. We aren't receiving doctors,
lawyers, or engineers children from rich backgrounds or neighborhoods. As an educator I am inspiring min
ds of young children and we focus not only on academics but one smart, effective, efficient, and discipl
ined students with good character.In our classroom we can utilize the Bluetooth for swift transitions du
ring class. I use a speaker which doesn't amplify the sound enough to receive the message. Due to the vo
lume of my speaker my students can't hear videos or books clearly and it isn't making the lessons as mea
ningful. But with the bluetooth speaker my students will be able to hear and I can stop, pause and repla
y it at any time.\r\nThe cart will allow me to have more room for storage of things that are needed for
the day and has an extra part to it I can use.  The table top chart has all of the letter, words and pic
tures for students to learn about different letters and it is more accessible.nannan
==================================================
```

In [12]:
```python
# https://stackoverflow.com/a/47091490/4084039
import re

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

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

In [13]:
```python
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I
teach in a Title I school where most of the students receive free or reduced price lunch.  Despite their
disabilities and limitations, my students love coming to school and come eager to learn and explore.Have
you ever felt like you had ants in your pants and you needed to groove and move as you were in a meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e chairs are the answer and I love then because they develop their core, which enhances gross motor and
in Turn fine motor skills. \r\nThey also want to learn through games, my kids do not want to sit and do
worksheets. They want to learn to count by jumping and playing. Physical engagement is the key to our su
ccess. The number toss and color and shape mats can make that happen. My students will forget they are d
oing work and just have the fun a 6 year old deserves.nannan
==================================================
```

In [14]:
```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations.     The materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price lunch.  Despite their di
sabilities and limitations, my students love coming to school and come eager to learn and explore.Have y
ou ever felt like you had ants in your pants and you needed to groove and move as you were in a meeting?
This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobble c
hairs are the answer and I love then because they develop their core, which enhances gross motor and in
Turn fine motor skills.   They also want to learn through games, my kids do not want to sit and do works
heets. They want to learn to count by jumping and playing. Physical engagement is the key to our succes
s. The number toss and color and shape mats can make that happen. My students will forget they are doing
work and just have the fun a 6 year old deserves.nannan
```

In [15]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitive dela
ys gross fine motor delays to autism They are eager beavers and always strive to work their hardest work
ing past their limitations The materials we have are the ones I seek out for my students I teach in a Ti
tle I school where most of the students receive free or reduced price lunch Despite their disabilities a
nd limitations my students love coming to school and come eager to learn and explore Have you ever felt
like you had ants in your pants and you needed to groove and move as you were in a meeting This is how m
y kids feel all the time The want to be able to move as they learn or so they say Wobble chairs are the
answer and I love then because they develop their core which enhances gross motor and in Turn fine motor
skills They also want to learn through games my kids do not want to sit and do worksheets They want to l
earn to count by jumping and playing Physical engagement is the key to our success The number toss and c
olor and shape mats can make that happen My students will forget they are doing work and just have the f
un a 6 year old deserves nannan
```

In [16]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself',
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'befor
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", '
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [17]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [01:09<00:00, 1564.20it/s]
```

In [18]:
```
# after preprocesing
preprocessed_essays[20000]
```

Out[18]:
```
'my kindergarten students varied disabilities ranging speech language delays cognitive delays gross fine
motor delays autism they eager beavers always strive work hardest working past limitations the materials
ones i seek students i teach title i school students receive free reduced price lunch despite disabiliti
es limitations students love coming school come eager learn explore have ever felt like ants pants neede
d groove move meeting this kids feel time the want able move learn say wobble chairs answer i love devel
op core enhances gross motor turn fine motor skills they also want learn games kids not want sit workshe
ets they want learn count jumping playing physical engagement key success the number toss color shape ma
ts make happen my students forget work fun 6 year old deserves nannan'
```

1.4 Preprocessing of `project_title`

In [19]:
```
# similarly you can preprocess the titles also
project_data.head(2)
```

Out[19]:

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

In [20]:
```
# printing some random project titles.
print(project_data['project_title'].values[54])
print("="*50)
print(project_data['project_title'].values[89])
print("="*50)
print(project_data['project_title'].values[999])
print("="*50)
print(project_data['project_title'].values[11156])
print("="*50)
print(project_data['project_title'].values[89436])
print("="*50)
```

```
Swim For Life At YMCA!
==================================================
Education Through Technology
==================================================
Focus Pocus
==================================================
Making Math Interactive!
==================================================
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [21]:
```
#Removing phrases from the title features
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
    phrase = re.sub(r"Gotta", "Got to", 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 [22]:
```
#Checkingt titles after removing phrases
sent = decontracted(project_data['project_title'].values[89436])
print(sent)
print("="*50)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [23]:
```
# Remove \\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)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
```

In [24]:
```
#Removing numbers & symbols form the titles
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
Classroom Supplies Help a New Teacher Organize the Classroom
```

In [25]:
```
# 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', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'aga
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", '
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [26]:
```
#Combining all the above preprocessed statements
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles.append(sent.lower().strip())
```

```
100%|██████████| 109248/109248 [00:03<00:00, 33426.16it/s]
```

In [27]:
```
#checking cleaned text after preprocesing
print(preprocessed_titles[54])
print("="*50)
print(preprocessed_titles[89])
print("="*50)
print(preprocessed_titles[999])
print("="*50)
print(preprocessed_titles[11156])
print("="*50)
print(preprocessed_titles[89436])
```

```
swim for life at ymca
==================================================
education through technology
==================================================
focus pocus
==================================================
making math interactive
==================================================
classroom supplies help new teacher organize classroom
```

1.5 Preparing data for models

In [28]:
```
project_data.columns
```

Out[28]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'project_submitted_datetime', 'project_grade_category', 'project_title',
       'project_essay_1', 'project_essay_2', 'project_essay_3',
       'project_essay_4', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'essay'],
      dtype='object')
```

we are going to consider

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

- project_title : text data
- text : text data
- project_resource_summary: text data (optinal)

- quantity : numerical (optinal)
- teacher_number_of_previously_posted_projects : numerical
- price : numerical

1.5.1 Vectorizing Categorical data

- https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/ (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/)

In [29]:
```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True)
categories_one_hot = vectorizer.fit_transform(project_data['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",categories_one_hot.shape)
```

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

In [30]:
```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=True)
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Literature_Writing', 'TeamSports', 'Care_Hunger', 'SpecialNeeds', 'EnvironmentalScience', 'Extracurric
ular', 'Other', 'ParentInvolvement', 'SocialSciences', 'College_CareerPrep', 'Warmth', 'Gym_Fitness', 'M
athematics', 'FinancialLiteracy', 'Literacy', 'AppliedSciences', 'Health_LifeScience', 'ForeignLanguage
s', 'EarlyDevelopment', 'CommunityService', 'Economics', 'PerformingArts', 'ESL', 'NutritionEducation',
'Health_Wellness', 'Civics_Government', 'History_Geography', 'Music', 'CharacterEducation', 'VisualArt
s']
Shape of matrix after one hot encodig  (109248, 30)
```

In [31]:
```
# you can do the similar thing with state, teacher_prefix and project_grade_category also
#Converting states text into smaller case
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].value_counts()
```

Out[31]:
```
ca    15388
tx     7396
ny     7318
fl     6185
nc     5091
il     4350
ga     3963
sc     3936
mi     3161
pa     3109
in     2620
mo     2576
oh     2467
la     2394
ma     2389
wa     2334
ok     2276
nj     2237
az     2147
va     2045
wi     1827
al     1762
ut     1731
tn     1688
ct     1663
md     1514
nv     1367
ms     1323
ky     1304
or     1242
mn     1208
co     1111
ar     1049
id      693
ia      666
ks      634
nm      557
dc      516
hi      507
me      505
wv      503
nh      348
ak      345
de      343
ne      309
sd      300
ri      285
mt      245
nd      143
wy       98
vt       80
Name: school_state, dtype: int64
```

In [32]:
```
#Replacing spaces & hyphens in the text of project grade category with underscore
#converting Capital letters in the string to smaller letters
#Performing avalue count of project grade category
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-onp
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[32]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [33]:
```
# check if we have any nan values are there in the column
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.sum())
```

```
True
number of nan values 3
```

In [34]:
```
#Replacing the Nan values with most frequent value in the column
project_data['teacher_prefix']=project_data['teacher_prefix'].fillna('Mrs.')
```

In [35]:
```
# check if we have any nan values are there in the column
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.sum())
```

```
False
number of nan values 0
```

In [36]:
```
#Converting teacher prefix text into smaller case
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
project_data['teacher_prefix'].value_counts()
```

Out[36]:
```
mrs.       57272
ms.        38955
mr.        10648
teacher     2360
dr.           13
Name: teacher_prefix, dtype: int64
```

In [37]:
```
project_data.isnull().any(axis=0)
```

Out[37]:
```
Unnamed: 0                                      False
id                                              False
teacher_id                                      False
teacher_prefix                                  False
school_state                                    False
project_submitted_datetime                      False
project_grade_category                          False
project_title                                   False
project_essay_1                                 False
project_essay_2                                 False
project_essay_3                                  True
project_essay_4                                  True
project_resource_summary                        False
teacher_number_of_previously_posted_projects    False
project_is_approved                             False
clean_categories                                False
clean_subcategories                             False
essay                                           False
dtype: bool
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [38]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer = CountVectorizer(min_df=10)
text_bow = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_bow.shape)
```

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

In [39]:
```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

1.5.2.2 TFIDF vectorizer

In [40]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_tfidf.shape)
```

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

1.5.2.3 Using Pretrained Models: Avg W2V

In [41]:
```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

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

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

# ============================

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

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

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

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


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

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


'''
```

Out[41]:
```
'\n# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039\ndef (https://stackoverflow.com/a/38230349/4084039\ndef) loadGloveModel(gloveFile):\n    print ("Loading Glove Model")\n    f = open(gloveFile,\'r\', encoding="utf8")\n    model = {}\n    for line in tqdm(f):\n        splitLine = line.split()\n        word = splitLine[0]\n        embedding = np.array([float(val) for val in splitLine[1:]])\n        model[word] = embedding\n    print ("Done.",len(model)," words loaded!")\n    return model\nmodel = loadGloveModel(\'glove.42B.300d.txt\')\n\n# ============================\nOutput:\n    \nLoading Glove Model\n1917495it [06:32, 4879.69it/s]\nDone. 1917495  words loaded!\n\n# ============================\n\nwords = []\nfor i in preproced_texts:\n    words.extend(i.split(\' \'))\n\nfor i in preproced_titles:\n    words.extend(i.split(\' \'))\nprint("all the words in the coupus", len(words))\nwords = set(words)\nprint("the unique words in the coupus", len(words))\n\ninter_words = set(model.keys()).intersection(words)\nprint("The number of words that are present in both glove vectors and our coupus", len(inter_words),"(",np.round(len(inter_words)/len(words)*100,3),"%)")\n\nwords_courpus = {}\nwords_glove = set(model.keys())\nfor i in words:\n    if i in words_glove:\n        words_courpus[i] = model[i]\nprint("word 2 vec length", len(words_courpus))\n\n\n# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport (http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/\n\nimport) pickle\nwith open(\'glove_vectors\', \'wb\') as f:\n    pickle.dump(words_courpus, f)\n\n\n'
```

In [42]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-l
# 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 [43]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors.append(vector)

print(len(avg_w2v_vectors))
print(len(avg_w2v_vectors[0]))
```

```
100%|██████████| 109248/109248 [00:35<00:00, 3097.68it/s]

109248
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [44]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [45]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors.append(vector)

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

```
100%|██████████| 109248/109248 [03:41<00:00, 493.97it/s]

109248
300
```

In [46]:
```
# Similarly you can vectorize for title also
```

1.5.3 Vectorizing Numerical features

In [47]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [48]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Standar
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.   287.73   5.5
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data['price'].values.reshape(-1,1)) # finding the mean and standard deviation of
f_mean = price_scalar.mean_[0]
Standard_deviation = (np.sqrt(price_scalar.var_[0]))
print(f_mean)
print(Standard_deviation)

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

```
298.1193425966608
367.49634838483496
```

In [49]:
```
price_standardized
```

Out[49]:
```
array([[-0.3905327 ],
       [ 0.00239637],
       [ 0.59519138],
       ...,
       [-0.15825829],
       [-0.61243967],
       [-0.51216657]])
```

1.5.4 Merging all the above features

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

In [50]:
```
print(categories_one_hot.shape)
print(sub_categories_one_hot.shape)
print(text_bow.shape)
print(price_standardized.shape)
```

```
(109248, 9)
(109248, 30)
(109248, 16623)
(109248, 1)
```

In [51]:
```
# 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 = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
X.shape
```

Out[51]:
```
(109248, 16663)
```

In [52]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

__ Computing Sentiment Scores__

In [53]:
```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

# import nltk
# nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest students with the
for learning my students learn in many different ways using all of our senses and multiple intelligences i
of techniques to help all my students succeed students in my class come from a variety of different backgr
for wonderful sharing of experiences and cultures including native americans our school is a caring commun
learners which can be seen through collaborative student project based learning in and out of the classroo
in my class love to work with hands on materials and have many different opportunities to practice a skill
mastered having the social skills to work cooperatively with friends is a crucial aspect of the kindergart
montana is the perfect place to learn about agriculture and nutrition my students love to role play in our
in the early childhood classroom i have had several kids ask me can we try cooking with real food i will t
and create common core cooking lessons where we learn important math and writing concepts while cooking de
food for snack time my students will have a grounded appreciation for the work that went into making the f
of where the ingredients came from as well as how it is healthy for their bodies this project would expand
nutrition and agricultural cooking recipes by having us peel our own apples to make homemade applesauce ma
and mix up healthy plants from our classroom garden in the spring we will also create our own cookbooks to
shared with families students will gain math and literature skills as well as a life long enjoyment for he
nannan'
ss = sid.polarity_scores(for_sentiment)

for k in ss:
    print('{0}: {1}, '.format(k, ss[k]), end='')

# we can use these 4 things as features/attributes (neg, neu, pos, compound)
# neg: 0.0, neu: 0.753, pos: 0.247, compound: 0.93
```

```
pos: 0.245, neu: 0.745, compound: 0.9975, neg: 0.01,
```

Assignment 8: DT

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/)

2. Decision Tree

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

In [54]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
data = project_data
data.head(5)
```

Out[54]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grade
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	mr.	fl	2016-10-25 09:22:10	gr
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	ms.	az	2016-08-31 12:03:56	gr
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	mrs.	ky	2016-10-06 21:16:17	grade
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	mrs.	tx	2016-07-11 01:10:09	grade

In [55]:
```
data.shape
```

Out[55]:
```
(109248, 20)
```

In [56]:
```
y = data['project_is_approved'].values
data.drop(['project_is_approved'], axis=1, inplace=True)
data.head(1)
```

Out[56]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_submitted_datetime	project_grade_c
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	mrs.	in	2016-12-05 13:43:57	grades

In [57]:
```
X = data
```

In [58]:
```
# check if we have any nan values are there in the column
print(X['teacher_prefix'].isnull().values.any())
print("number of nan values",X['teacher_prefix'].isnull().values.sum())
```

```
False
number of nan values 0
```

In [59]:
```
#Converting teacher prefix text into smaller case
X['teacher_prefix'] = X['teacher_prefix'].str.lower()
X['teacher_prefix'].value_counts()
```

Out[59]:
```
mrs.       57272
ms.        38955
mr.        10648
teacher     2360
dr.           13
Name: teacher_prefix, dtype: int64
```

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

In [60]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
#Splitting data into test & train set
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_split.html
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X,y,test_size = 0.33,stratify=y)
```

In [61]:
```
#Splitting training data into training & cross validation sets
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train,
                                                stratify= y_train,
                                                test_size = 0.33)
```

In [62]:
```
# printing some random reviews
print(X_train['essay'].values[0])
print("="*50)
print(X_train['essay'].values[100])
print("="*50)
print(X_train['essay'].values[300])
print("="*50)
print(X_train['essay'].values[5000])
print("="*50)
print(X_train['essay'].values[20000])
print("="*50)
```

```
My students have a large range of backgrounds, home life, and support. As a title 1 school, we serve a c
ommunity with lower income students, as well as a pocket of students who come from upper middle class ho
mes. This massive diversity can make teaching difficult at times, but ultimately creates a wonderful cul
ture in which children grow.\r\nMiddle school students could be classified as a different species. The h
ormones, the in between child and teenager, and the learning new \"words\", makes for an ever adventurou
s day. But in the end, they are my children, my students, my little creative brains waiting to be sparke
d. \r\n\r\nWe create a lot of clay projects in my class, and sadly we have no glazes to add color to the
m. After the clay is fired in the kiln it can be painted with glaze. This adds a glossy finish to any cl
ay project and gives it a more professional look. \r\nAztec inspired pottery, African masks, face mugs,
and Picasso inspired vases are all projects created by my artistic students. I would love the opportunit
y to show them how to use glaze and color in fun and imaginative ways.\r\nGlaze also allows students to
put more functionality to their creation. You can drink or eat from pottery if it is properly glazed and
sealed. \r\n\r\nnannan
==================================================
My students attend a magnet school for gifted students in a large urban setting.  While all students hav
e been classified as gifted students, many of them are also classified as being \"twice exceptional.\"
This means that while they may be gifted in one area, such as math, they may struggle in another area or
even deal with a learning disability.  Many students who are twice exceptional are able to mask their st
ruggles through their gifts, but not all are able to do this.  Additionally, by doing this, it prevents
the students from having all their needs met.  Our goal for this coming school year is to provide a clas
s for students who struggle in math or language arts, particularly if they are performing below grade le
vel.  In this class, we will be able meet the needs of these students and help them realize success in a
ll academic areas.\r\n\r\nWe are a 100% Free Lunch school that is about 60% African American, 40% Caucas
ian, and 10% other ethnicities.  Our students value learning and all have strong goals for their future
s.  Most students reside in the city, but some do come in from the county areas as part of the desegrega
tion plan.I will be teaching a new class at our school to help meet the needs of gifted students who are
bright, but struggle in either reading or math--or both.  The goal is to make sure that all of our stude
nts are brought up to grade level within one year of being identified as having a need in either reading
or math--or both!  We want our students to be as successful as possible and for some students this means
additional intervention.\r\n\r\nResearch shows that gifted students who struggle tend to have more issue
s with depression and even a higher rate of dropping out.  We want to intervene before it is too late.
Sometimes a different approach such as small groups or targeted intervention can have a profound impact.
Additionally, I plan on working to encourage these students to track their own growth and work toward su
rpassing their goals.\r\n\r\nBecause this is a new class, I do not have a budget for the class.  Most ac
tivities will be teacher designed and differentiated based on the needs of the students, but I also want
to make sure we have some basic supplies so that students can be successful in the class and demonstrate
their increase in learning.nannan
==================================================
\"Sitting still is overrated. It makes sense for the opera or for meditating, but in most classrooms and
child care centers, it's given far more honor than it deserves. Children need to move.\" ~Tom Hunter, Na
tional Association for the Education of Young ChildrenI teach 100 students a day. My students are real p
eople who deserve respect and the right to make choices even if it is something as small as how they sit
comfortably in their classroom. If making a change to flexible seating in the classroom can help make a
difference in the engagement and performance of my students lives then it is worth trying.Research says
flexible seating benefits include burning more calories, using up excess energy, improving metabolism, i
ncreased motivation and engagement, creating a better oxygen flow to the brain, and improving core stren
gth and overall posture. It's no surprise that physical activity is linked to higher academic performanc
e, better health, and improved behavior.Students will be able learn more in a more comfortable setting w
ith your appreciated donations to the cause. These children are the future and deserve the best efforts
of their teachers even if they cannot afford it on our own.
==================================================
My Kindergarten students come from a high poverty and very low income area.  Most come to school seeing
and using technology for the very first time. We have a very high migrant population with families const
antly moving and then returning as the field work shifts and moves.  \r\n\r\nYet, however many obstacles
they may face they are very eager and willing to try new technologies.  They have the potential for grea
t things, but just need the tools to get them there.These 2 iPad minis will continue to grow upon our se
t which we hope will grow to entire class set that will be able to be serviced through small groups, ind
ividual groups, teacher-led intervention groups and even have the access to take them home for education
al use. Our end goal is to have an entire classroom set that can be used throughout the Grade Level.\r\n
\r\nNot only will these children be able to use something they've only seen but they will be able to cre
ate and innovate new ways in which to use it.\r\nThey are the creators of our collected futures; given t
he right tools early on will only enable them to become more successful sooner.nannan
```

```
==================================================
I have not even met my students for the upcoming school year, but already know they will be a special bu
nch. You see the students in an unincorporated area just south of Seagoville, TX (a small city of 15k) l
ive with a problem most of us rarely face: they have no running water. They do not have access to clean
water for everyday things we all take advantage of such as washing our hands, taking a drink of tap wate
r, taking a bath, and washing our clothes. \r\nThe houses here in Sandbranch community have no running w
ater. Their only water comes from 25 foot deep wells that have been contaminated by their surrounding en
vironment. Sandbranch, a community of about 500 people, sits in what is known as the Trinity River Valle
y, an area that has been inundated with aggregate companies since the 50's that has contributed to the u
nstable environment. Also contributing to the problem is illegal trash and chemical dumping, hog associa
ted problems, and mosquito infestation. \r\nIf I were a child living in this condition, it would be impo
ssible for me to concentrate on my studies when I have conditions such as these waiting for me at my hom
e.The requirements of 3rd grade scientists in Texas include many lab experiments and investigational stu
dies. All of the Jr. Scientist products I have requested represents each specific unit that must be taug
ht in 3rd grade science per \"No Child Left Behind.\" (NCLB) The composition books will be used as inter
active science journals that will record our observations, investigations, thoughts, notes, conclusions,
and everything else science! The brads can be used to make moving objects inside the notebooks (such as
planets or even charts.) The paper will be used for drawings to paste in our journals or even copies mad
e for our journals. The colored pencils will be for coloring our drawings.\r\nNCLB advocates for the equ
al educational opportunities for all children, but without some assistance to purchase materials for our
science projects these kids WILL be left behind. These kids deserve an equal chance, just as all others
do.\r\nnannan
==================================================
```

In [63]:
```
# 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 [64]:
```
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations. \r\n\r\nThe materials we have are the ones I seek out for my students. I
teach in a Title I school where most of the students receive free or reduced price lunch.  Despite their
disabilities and limitations, my students love coming to school and come eager to learn and explore.Have
you ever felt like you had ants in your pants and you needed to groove and move as you were in a meetin
g? This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobbl
e chairs are the answer and I love then because they develop their core, which enhances gross motor and
in Turn fine motor skills. \r\nThey also want to learn through games, my kids do not want to sit and do
worksheets. They want to learn to count by jumping and playing. Physical engagement is the key to our su
ccess. The number toss and color and shape mats can make that happen. My students will forget they are d
oing work and just have the fun a 6 year old deserves.nannan
==================================================
```

In [65]:
```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays, cognitive del
ays, gross/fine motor delays, to autism. They are eager beavers and always strive to work their hardest
working past their limitations.     The materials we have are the ones I seek out for my students. I tea
ch in a Title I school where most of the students receive free or reduced price lunch.  Despite their di
sabilities and limitations, my students love coming to school and come eager to learn and explore.Have y
ou ever felt like you had ants in your pants and you needed to groove and move as you were in a meeting?
This is how my kids feel all the time. The want to be able to move as they learn or so they say.Wobble c
hairs are the answer and I love then because they develop their core, which enhances gross motor and in
Turn fine motor skills.   They also want to learn through games, my kids do not want to sit and do works
heets. They want to learn to count by jumping and playing. Physical engagement is the key to our succes
s. The number toss and color and shape mats can make that happen. My students will forget they are doing
work and just have the fun a 6 year old deserves.nannan
```

In [66]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
My kindergarten students have varied disabilities ranging from speech and language delays cognitive dela
ys gross fine motor delays to autism They are eager beavers and always strive to work their hardest work
ing past their limitations The materials we have are the ones I seek out for my students I teach in a Ti
tle I school where most of the students receive free or reduced price lunch Despite their disabilities a
nd limitations my students love coming to school and come eager to learn and explore Have you ever felt
like you had ants in your pants and you needed to groove and move as you were in a meeting This is how m
y kids feel all the time The want to be able to move as they learn or so they say Wobble chairs are the
answer and I love then because they develop their core which enhances gross motor and in Turn fine motor
skills They also want to learn through games my kids do not want to sit and do worksheets They want to l
earn to count by jumping and playing Physical engagement is the key to our success The number toss and c
olor and shape mats can make that happen My students will forget they are doing work and just have the f
un a 6 year old deserves nannan
```

In [67]:
```
# 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', 'the
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', '
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do'
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'agai
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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'
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't"
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'n
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

Preprocessing for Train Data

In [68]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xtr = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['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.lower() not in stopwords)
    preprocessed_essays_xtr.append(sent.lower().strip())
```

```
100%|██████████| 49041/49041 [00:31<00:00, 1580.55it/s]
```

In [69]:
```
# after preprocesing
preprocessed_essays_xtr[300]
```

Out[69]:
```
'sitting still overrated makes sense opera meditating classrooms child care centers given far honor dese
rves children need move tom hunter national association education young childreni teach 100 students day
students real people deserve respect right make choices even something small sit comfortably classroom m
aking change flexible seating classroom help make difference engagement performance students lives worth
trying research says flexible seating benefits include burning calories using excess energy improving me
tabolism increased motivation engagement creating better oxygen flow brain improving core strength overa
ll posture no surprise physical activity linked higher academic performance better health improved behav
ior students able learn comfortable setting appreciated donations cause children future deserve best eff
orts teachers even cannot afford'
```

In [70]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xcv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['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.lower() not in stopwords)
    preprocessed_essays_xcv.append(sent.lower().strip())
```

```
100%|██████████| 24155/24155 [00:15<00:00, 1583.86it/s]
```

In [71]:
```
# after preprocesing
preprocessed_essays_xcv[300]
```

Out[71]:
```
'school counselor proudly support 570 students k 8 discovering social emotional wellness support student
s students come support everyday life guidance get day come help problem solving making educational deci
sions students represent wide variety socio economic levels learning styles cultural backgrounds urban s
chool services 570 students 70 come low income families many students lack strong support system home th
erefore need resources get school last year counselor held individual classroom guidance small group ses
sions examples issues students family problems grades death bullying friendship problems anxiety career
interests social issues behavior anger counselor needed afternoons recess duty kindergarten first grade
classes need equipment 3 days week spend auditorium recess usually watch movie requested classroom dance
offs students need dance wii structured dancing time would sitting recess students active asked movement
indoor recess time wii tv would make possible whole classrooms participate one time dancing would rotate
classrooms would get chance multiple songs every recess students would increase movement 60 minutes week
kindergarten first grade classrooms students requested dancing recess playing dance wii tv gives perfect
opportunity increase physical activity 3 times week nannan'
```

In [72]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays_xte = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['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.lower() not in stopwords)
    preprocessed_essays_xte.append(sent.lower().strip())
```

```
100%|██████████| 36052/36052 [00:22<00:00, 1582.70it/s]
```

In [73]:
```
# after preprocesing
preprocessed_essays_xte[300]
```

Out[73]:
```
'rangeland elementary title school 92 students qualifying free reduced lunch first grade classroom consi
sts 23 students 19 qualify free reduced lunch also diverse classroom students representing 7 different c
ountries 6 languages spoken numerous backgrounds upbringings playing field uneven comes academic abiliti
es language barriers home lowered socioeconomic statuses students receive academic learning classroom se
tting even many barriers students face daily basis eager learn everyday requesting 4 ipads used daily re
ading comprehension instruction math computation instruction download following reading math apps iread
starfall ixl math kids learning ensure students receive content respective level spoken language goal ig
nite desire learning bridging language barrier giving individual student tools need successful not first
grade future academic experiences well want students enjoy learn new experiences daily nannan'
```

In [74]:
```
# similarly you can preprocess the titles also
#printing random titles
print(data['project_title'].values[49])
print("="*50)
print(data['project_title'].values[89])
print("="*50)
print(data['project_title'].values[999])
print("="*50)
print(data['project_title'].values[11156])
print("="*50)
print(data['project_title'].values[20000])
print("="*50)
```

```
Rainy Day Run Around!
==================================================
Education Through Technology
==================================================
Focus Pocus
==================================================
Making Math Interactive!
==================================================
We Need To Move It While We Input It!
==================================================
```

In [75]:
```
#Removing phrases from the title features
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)
    phrase = re.sub(r"Gotta",  "Got to",  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 [76]:
```
#Checkingt titles after removing phrases
sent = decontracted(project_data['project_title'].values[89436])
print(sent)
print("="*50)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
==================================================
```

In [77]:
```
# Remove \\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)
```

```
Classroom Supplies: Help a New Teacher Organize the Classroom!
```

In [78]:
```
#Removing stop words from the preprocessed titles
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', 'thei
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 't
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do',
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while',
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'agai
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each',
            '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',
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't"
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'n
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'we
            'won', "won't", 'wouldn', "wouldn't"]
```

In [79]:
```
preprocessed_titles_xtr = []
# tqdm is for printing the status bar
for sentance in tqdm(X_train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', 'ac ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xtr.append(sent.lower().strip())
```

```
100%|██████████| 49041/49041 [00:01<00:00, 33975.85it/s]
```

In [80]:
```
#checking cleaned text after preprocesing
print(preprocessed_titles_xtr[89])
print("="*50)
```

```
challenging texts advanced readers
==================================================
```

In [81]:
```
preprocessed_titles_xcv = []
# tqdm is for printing the status bar
for sentance in tqdm(X_cv['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xcv.append(sent.lower().strip())
```

```
100%|██████████| 24155/24155 [00:00<00:00, 33548.85it/s]
```

In [82]:
```
print(preprocessed_titles_xcv[89])
print("="*50)
```

```
let keep our chromebooks charged safe
==================================================
```

In [83]:
```
preprocessed_titles_xte = []
# tqdm is for printing the status bar
for sentance in tqdm(X_test['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_xte.append(sent.lower().strip())
```

```
100%|██████████| 36052/36052 [00:01<00:00, 33904.38it/s]
```

In [84]:
```
print(preprocessed_titles_xte[89])
print("="*50)
```

```
live lab science action
==================================================
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [85]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
#We use fit only for train data
vectorizer_state = CountVectorizer(binary=True)
vectorizer_state.fit(X_train['school_state'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer_state.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer_state.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer_state.transform(X_test['school_state'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer_state.get_feature_names())
print("="*75)
ft_state = vectorizer_state.get_feature_names()
```

```
After vectorizations
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'ks',
'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'n
y', 'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
===========================================================================
```

2.2.2 One hot encoding the categorical features : teacher_prefix

In [86]:
```
# we use count vectorizer to convert the values into one
#We use fit only for train data
vectorizer_tp = CountVectorizer(binary=True)
vectorizer_tp.fit(X_train['teacher_prefix'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer_tp.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer_tp.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer_tp.transform(X_test['teacher_prefix'].values)

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer_tp.get_feature_names())
print("="*50)

ft_teacher_prefix = vectorizer_tp.get_feature_names()
```

```
After vectorizations
(49041, 5) (49041,)
(24155, 5) (24155,)
(36052, 5) (36052,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
==================================================
```

2.2.3 One hot encoding the categorical features : grades

In [87]:
```
#Replacing spaces & hyphens in the text of project grade category with underscore
#converting Capital letters in the string to smaller letters
#Performing avalue count of project grade category
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-on-
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[87]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [88]:
```
#We use fit only for train data
vectorizer_grade = CountVectorizer()
vectorizer_grade.fit(X_train['project_grade_category'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer_grade.transform(X_train['project_grade_category'].values)
X_cv_grade_ohe = vectorizer_grade.transform(X_cv['project_grade_category'].values)
X_test_grade_ohe = vectorizer_grade.transform(X_test['project_grade_category'].values)

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer_grade.get_feature_names())
print("="*70)
ft_grade = vectorizer_grade.get_feature_names()
```

```
After vectorizations
(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
======================================================================
```

2.2.4 One hot encoding the categorical features : project subject category

In [89]:
```
#We use fit only for train data
vectorizer_category = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), binary=True)
vectorizer_category.fit(X_train['clean_categories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_cat_ohe = vectorizer_category.transform(X_train['clean_categories'].values)
X_cv_cat_ohe = vectorizer_category.transform(X_cv['clean_categories'].values)
X_test_cat_ohe = vectorizer_category.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_cat_ohe.shape, y_train.shape)
print(X_cv_cat_ohe.shape, y_cv.shape)
print(X_test_cat_ohe.shape, y_test.shape)
print(vectorizer_category.get_feature_names())
print("="*70)

ft_cat = vectorizer_category.get_feature_names()
```

```
After vectorizations
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
['Math_Science', 'History_Civics', 'Care_Hunger', 'Warmth', 'Literacy_Language', 'AppliedLearning', 'Mus
ic_Arts', 'SpecialNeeds', 'Health_Sports']
======================================================================
```

In [90]:
```
#We use fit only for train data
vectorizer_subcat = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), binary=True)
vectorizer_subcat.fit(X_train['clean_subcategories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_subcat_ohe = vectorizer_subcat.transform(X_train['clean_subcategories'].values)
X_cv_subcat_ohe = vectorizer_subcat.transform(X_cv['clean_subcategories'].values)
X_test_subcat_ohe = vectorizer_subcat.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_subcat_ohe.shape, y_train.shape)
print(X_cv_subcat_ohe.shape, y_cv.shape)
print(X_test_subcat_ohe.shape, y_test.shape)
print(vectorizer_subcat.get_feature_names())
print("="*70)

ft_subcat = vectorizer_subcat.get_feature_names()
```

```
After vectorizations
(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
['Literature_Writing', 'TeamSports', 'Care_Hunger', 'SpecialNeeds', 'EnvironmentalScience', 'Extracurric
ular', 'Other', 'ParentInvolvement', 'SocialSciences', 'College_CareerPrep', 'Warmth', 'Gym_Fitness', 'M
athematics', 'FinancialLiteracy', 'Literacy', 'AppliedSciences', 'Health_LifeScience', 'ForeignLanguage
s', 'EarlyDevelopment', 'CommunityService', 'Economics', 'PerformingArts', 'ESL', 'NutritionEducation',
'Health_Wellness', 'Civics_Government', 'History_Geography', 'Music', 'CharacterEducation', 'VisualArt
s']
======================================================================
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [91]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

i) BoW Encoding

1.5.2.1 Bag of words on Essay Feature

In [92]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
#Applying BoW on essays feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)

from sklearn.feature_extraction.text import CountVectorizer
vectorizer_essay_bow = CountVectorizer(min_df=10)
vectorizer_essay_bow.fit(preprocessed_essays_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xtr)
X_cv_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xcv)
X_test_essay_bow = vectorizer_essay_bow.transform(preprocessed_essays_xte)

print("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)

ft_bow_essay = vectorizer_essay_bow.get_feature_names()
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 12057) (49041,)
(24155, 12057) (24155,)
(36052, 12057) (36052,)
====================================================================================================
```

1.5.2.2 Bag of words on Project Title feature

In [93]:
```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
#Applying BoW on project titles feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)



from sklearn.feature_extraction.text import CountVectorizer
vectorizer_titles_bow = CountVectorizer(min_df=10)
vectorizer_titles_bow.fit(preprocessed_titles_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xtr)
X_cv_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xcv)
X_test_titles_bow = vectorizer_titles_bow.transform(preprocessed_titles_xte)

print("After vectorizations")
print(X_train_titles_bow.shape, y_train.shape)
print(X_cv_titles_bow.shape, y_cv.shape)
print(X_test_titles_bow.shape, y_test.shape)
print("="*100)

ft_bow_title = vectorizer_titles_bow.get_feature_names()
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 2100) (49041,)
(24155, 2100) (24155,)
(36052, 2100) (36052,)
====================================================================================================
```

ii) TFIDF Vectorization

TFIDF vectorizer on essay feature

In [94]:
```
#Applying TF-IDF on essays feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)

from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_essay_tfidf = TfidfVectorizer(min_df=10)
vectorizer_essay_tfidf.fit(preprocessed_essays_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xtr)
X_cv_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xcv)
X_test_essay_tfidf = vectorizer_essay_tfidf.transform(preprocessed_essays_xte)

print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
print("="*100)

ft_tfidf_essay = vectorizer_essay_tfidf.get_feature_names()
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 12057) (49041,)
(24155, 12057) (24155,)
(36052, 12057) (36052,)
====================================================================================================
```

TFIDF on Project Title feature

In [95]:
```
#Applying Tfidf on project titles feature
#Considering only the words which appear atleast in 10 documents or reviews
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)


from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_title = TfidfVectorizer(min_df=10)
vectorizer_tfidf_title.fit(preprocessed_titles_xtr) # fiting only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xtr)
X_cv_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xcv)
X_test_titles_tfidf = vectorizer_tfidf_title.transform(preprocessed_titles_xte)

print("After vectorizations")
print(X_train_titles_tfidf.shape, y_train.shape)
print(X_cv_titles_tfidf.shape, y_cv.shape)
print(X_test_titles_tfidf.shape, y_test.shape)
print("="*100)

ft_tfidf_title = vectorizer_tfidf_title.get_feature_names()
```

```
(49041, 19) (49041,)
(24155, 19) (24155,)
(36052, 19) (36052,)
====================================================================================================
After vectorizations
(49041, 2100) (49041,)
(24155, 2100) (24155,)
(36052, 2100) (36052,)
====================================================================================================
```

iii) Using Pre-Trained Models : AvgW2v

In [96]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-l
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words = set(model.keys())
```

Applying to Train set for Essay feature

In [97]:
```
preprocessed_essays_xtr[0]
```

Out[97]:
```
'students large range backgrounds home life support title 1 school serve community lower income students
well pocket students come upper middle class homes massive diversity make teaching difficult times ultim
ately creates wonderful culture children grow middle school students could classified different species
hormones child teenager learning new words makes ever adventurous day end children students little creat
ive brains waiting sparked create lot clay projects class sadly no glazes add color clay fired kiln pain
ted glaze adds glossy finish clay project gives professional look aztec inspired pottery african masks f
ace mugs picasso inspired vases projects created artistic students would love opportunity show use glaze
color fun imaginative ways glaze also allows students put functionality creation drink eat pottery prope
rly glazed sealed nannan'
```

In [98]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_extr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xtr): # 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_extr.append(vector)

print(len(avg_w2v_vectors_extr))
print(len(avg_w2v_vectors_extr[0]))
```

```
100%|██████████| 49041/49041 [00:14<00:00, 3442.35it/s]

49041
300
```

Applying to Cross validation set for Essay feature

In [99]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_excv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xcv): # 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_excv.append(vector)

print(len(avg_w2v_vectors_excv))
print(len(avg_w2v_vectors_excv[0]))
```

```
100%|██████████| 24155/24155 [00:07<00:00, 3406.66it/s]

24155
300
```

Applying to test set for Essay feature

In [100]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_exte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xte): # 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_exte.append(vector)

print(len(avg_w2v_vectors_exte))
print(len(avg_w2v_vectors_exte[0]))
```

```
100%|██████████| 36052/36052 [00:10<00:00, 3390.79it/s]

36052
300
```

Applying to Train set for Project title feature

In [101]:
```
# Vectorizing project_title using avgw2v method
avg_w2v_vectors_txtr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xtr): # 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_txtr.append(vector)

print(len(avg_w2v_vectors_txtr))
print(len(avg_w2v_vectors_txtr[0]))
```

```
100%|██████████| 49041/49041 [00:00<00:00, 57935.48it/s]

49041
300
```

Applying to Cross validation set for Project title feature

In [102]:
```
# Vectorizing project_title using avgw2v method
avg_w2v_vectors_txcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xcv): # 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_txcv.append(vector)

print(len(avg_w2v_vectors_txcv))
print(len(avg_w2v_vectors_txcv[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 58252.82it/s]

24155
300
```

Applying to Test set for Project title feature

In [103]:
```
# Vectorizing project_title using avgw2v method
avg_w2v_vectors_txte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xte): # 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_txte.append(vector)

print(len(avg_w2v_vectors_txte))
print(len(avg_w2v_vectors_txte[0]))
```

```
100%|██████████| 36052/36052 [00:00<00:00, 59154.73it/s]

36052
300
```

iv) Using Pretrained Models: TFIDF weighted W2V

Applying on Training set of essays feature

In [104]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_xtr)
# 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 [105]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_extr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xtr): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            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_extr.append(vector)

print(len(tfidf_w2v_vectors_extr))
print(len(tfidf_w2v_vectors_extr[0]))
```

```
100%|██████████| 49041/49041 [01:25<00:00, 575.28it/s]

49041
300
```

Applying on Cross validation set of essays feature

In [106]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_excv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xcv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            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_excv.append(vector)

print(len(tfidf_w2v_vectors_excv))
print(len(tfidf_w2v_vectors_excv[0]))
```

```
100%|██████████| 24155/24155 [00:41<00:00, 576.25it/s]

24155
300
```

Applying on test set of essays feature

In [107]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_exte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_xte): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            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_exte.append(vector)

print(len(tfidf_w2v_vectors_exte))
print(len(tfidf_w2v_vectors_exte[0]))
```

```
100%|██████████| 36052/36052 [01:01<00:00, 582.17it/s]

36052
300
```

Applying on Training set of project title feature

In [108]:
```
# Similarly you can vectorize for title also
# vectorizing project_title using TFIDF weighted W2V pretrained model
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles_xtr)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [109]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_txtr = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xtr): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf val
            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_txtr.append(vector)

print(len(tfidf_w2v_vectors_txtr))
print(len(tfidf_w2v_vectors_txtr[0]))
```

```
100%|██████████| 49041/49041 [00:01<00:00, 25373.95it/s]

49041
300
```

Applying on Cross validation set of project title feature

In [110]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_txcv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xcv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            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_txcv.append(vector)

print(len(tfidf_w2v_vectors_txcv))
print(len(tfidf_w2v_vectors_txcv[0]))
```

```
100%|██████████| 24155/24155 [00:00<00:00, 25427.64it/s]

24155
300
```

Applying on test set of project title feature

In [111]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_txte = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_xte): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/l
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf va
            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_txte.append(vector)

print(len(tfidf_w2v_vectors_txte))
print(len(tfidf_w2v_vectors_txte[0]))
```

```
100%|██████████| 36052/36052 [00:01<00:00, 25148.93it/s]

36052
300
```

1.5.3 Vectorizing Numerical features

For Price feature

In [112]:
```
from sklearn.preprocessing import Normalizer
price_normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
price_normalizer.fit(X_train['price'].values.reshape(1,-1))

X_train_price_norm = price_normalizer.transform(X_train['price'].values.reshape(1,-1))
X_cv_price_norm = price_normalizer.transform(X_cv['price'].values.reshape(1,-1))
X_test_price_norm = price_normalizer.transform(X_test['price'].values.reshape(1,-1))

print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(1, 49041) (49041,)
(1, 24155) (24155,)
(1, 36052) (36052,)
====================================================================================================
```

In [113]:
```
X_train_price_norm = X_train_price_norm.T
X_cv_price_norm = X_cv_price_norm.T
X_test_price_norm = X_test_price_norm.T

print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

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

For Quantity

In [114]:
```
#Normalizing quantity
from sklearn.preprocessing import Normalizer
quan_normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
quan_normalizer.fit(X_train['quantity'].values.reshape(1,-1))

X_train_quantity_norm = quan_normalizer.transform(X_train['quantity'].values.reshape(1,-1))
X_cv_quantity_norm = quan_normalizer.transform(X_cv['quantity'].values.reshape(1,-1))
X_test_quantity_norm = quan_normalizer.transform(X_test['quantity'].values.reshape(1,-1))

print("After vectorizations")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(1, 49041) (49041,)
(1, 24155) (24155,)
(1, 36052) (36052,)
====================================================================================================
```

In [115]:
```
X_train_quantity_norm = X_train_quantity_norm.T
X_cv_quantity_norm = X_cv_quantity_norm.T
X_test_quantity_norm = X_test_quantity_norm.T

print("Final Matrix")
print(X_train_quantity_norm.shape, y_train.shape)
print(X_cv_quantity_norm.shape, y_cv.shape)
print(X_test_quantity_norm.shape, y_test.shape)
print("="*100)
```

```
Final Matrix
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

For teacher previously posted projects

In [116]:
```
# Normalizing teacher previously posted projects
from sklearn.preprocessing import Normalizer
tpp_normalizer = Normalizer()
# normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
tpp_normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

X_train_tpp_norm = tpp_normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values
X_cv_tpp_norm = tpp_normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.resha
X_test_tpp_norm = tpp_normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.r

print("After vectorizations")
print(X_train_tpp_norm.shape, y_train.shape)
print(X_cv_tpp_norm.shape, y_cv.shape)
print(X_test_tpp_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(1, 49041) (49041,)
(1, 24155) (24155,)
(1, 36052) (36052,)
====================================================================================================
```

In [117]:
```
X_train_tpp_norm = X_train_tpp_norm.T
X_cv_tpp_norm = X_cv_tpp_norm.T
X_test_tpp_norm = X_test_tpp_norm.T

print(X_train_tpp_norm.shape, y_train.shape)
print(X_cv_tpp_norm.shape, y_cv.shape)
print(X_test_tpp_norm.shape, y_test.shape)
print("="*100)
```

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

Merging Numerical & Categorical features

- we need to merge all the numerical vectors & catogorical features

In [118]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_numcat = hstack((X_train_state_ohe, X_train_teacher_ohe, X_train_grade_ohe, X_train_price_norm, X_tra
X_cv_numcat = hstack((X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe, X_cv_price_norm, X_cv_cat_ohe, X_
X_te_numcat = hstack((X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe, X_test_price_norm, X_test_ca

print("Final Data matrix")
print(X_tr_numcat.shape, y_train.shape)
print(X_cv_numcat.shape, y_cv.shape)
print(X_te_numcat.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 102) (49041,)
(24155, 102) (24155,)
(36052, 102) (36052,)
====================================================================================================
```

2.4 Appling 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

In [119]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

2.4.1 Applying Decision Trees on BOW, SET 1

In [120]:
```
# Please write all the code with proper documentation
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set1 = hstack((X_train_essay_bow, X_train_titles_bow, X_tr_numcat )).tocsr()
X_cv_set1 = hstack((X_cv_essay_bow, X_cv_titles_bow, X_cv_numcat)).tocsr()
X_te_set1 = hstack((X_test_essay_bow, X_test_titles_bow, X_te_numcat )).tocsr()

print("Final Data matrix")
print(X_tr_set1.shape, y_train.shape)
print(X_cv_set1.shape, y_cv.shape)
print(X_te_set1.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 14259) (49041,)
(24155, 14259) (24155,)
(36052, 14259) (36052,)
====================================================================================================
```

In [121]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

#https://scikit-learn.org/stable/modules/grid_search.html
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}


clf  = DecisionTreeClassifier(class_weight='balanced')

model = GridSearchCV(clf, parameters, cv=5, scoring='roc_auc', return_train_score=True, verbose=10, n_jobs
model.fit(X_tr_set1, y_train)

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

```
Fitting 5 folds for each of 28 candidates, totalling 140 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 10 concurrent workers.
[Parallel(n_jobs=-1)]: Done   5 tasks      | elapsed:    2.0s
[Parallel(n_jobs=-1)]: Done  12 tasks      | elapsed:    2.4s
[Parallel(n_jobs=-1)]: Done  21 tasks      | elapsed:    4.6s
[Parallel(n_jobs=-1)]: Done  30 tasks      | elapsed:    4.9s
[Parallel(n_jobs=-1)]: Done  41 tasks      | elapsed:   15.8s
[Parallel(n_jobs=-1)]: Done  52 tasks      | elapsed:   22.5s
[Parallel(n_jobs=-1)]: Done  65 tasks      | elapsed:  1.3min
[Parallel(n_jobs=-1)]: Done  78 tasks      | elapsed:  1.9min
[Parallel(n_jobs=-1)]: Done  93 tasks      | elapsed:  3.5min
[Parallel(n_jobs=-1)]: Done 108 tasks      | elapsed:  5.4min
[Parallel(n_jobs=-1)]: Done 136 out of 140 | elapsed:  9.1min remaining:   16.0s
[Parallel(n_jobs=-1)]: Done 140 out of 140 | elapsed:  9.3min finished
```

In [122]:
```
#Results of grid Search
best_params = model.best_params_
print(model.best_score_)
print(model.best_params_)
```

```
0.673515348488412
{'min_samples_split': 500, 'max_depth': 10}
```

Plotting Heatmap for HyperParameter vs AUC score

In [123]:
```
model.cv_results_
```

Out[123]:
```
{'mean_fit_time': array([  0.47773576,   0.44945784,   0.41273394,   0.4214952 ,
          2.08411207,   2.06538358,   2.06862335,   1.93798151,
          9.58565249,   9.37443619,   8.04633551,   5.62911954,
         54.07772779,  52.05370159,  38.22765174,  19.56746759,
         71.73160844,  70.22246428,  54.22226553,  26.27825761,
        101.09760976, 100.3333776 ,  81.99378624,  44.23576665,
        100.84515915,  98.76685348,  79.0012013 ,  44.22132807]),
 'mean_score_time': array([0.02005033, 0.02084308, 0.01845999, 0.01769872, 0.01979108,
        0.02021265, 0.02043948, 0.02128916, 0.01987324, 0.01986818,
        0.01927567, 0.02036076, 0.02145557, 0.0209549 , 0.02067161,
        0.02014742, 0.02142353, 0.02121797, 0.02127085, 0.0206615 ,
        0.02194219, 0.02187643, 0.02172604, 0.0208241 , 0.02185597,
        0.02170749, 0.01712451, 0.01760297]),
 'mean_test_score': array([0.56881812, 0.56881812, 0.56881812, 0.56881812, 0.65517268,
        0.65505378, 0.65541562, 0.65615592, 0.66254844, 0.66210825,
        0.66338965, 0.67351535, 0.5977322 , 0.59767677, 0.62447229,
        0.65199981, 0.58581051, 0.58643802, 0.60997786, 0.63618666,
        0.57157894, 0.57725325, 0.59446333, 0.61545168, 0.57508077,
        0.57691704, 0.59102992, 0.61615376]),
```

In [124]:
```
#https://towardsdatascience.com/using-3d-visualizations-to-tune-hyperparameters-of-ml-models-with-python-b
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
#https://qiita.com/bmj0114/items/8009f282c99b77780563
#Saving the obtained results from gridsearch in two dimensional array as dataframe
results = pd.DataFrame(model.cv_results_)
results.head()
```

Out[124]:

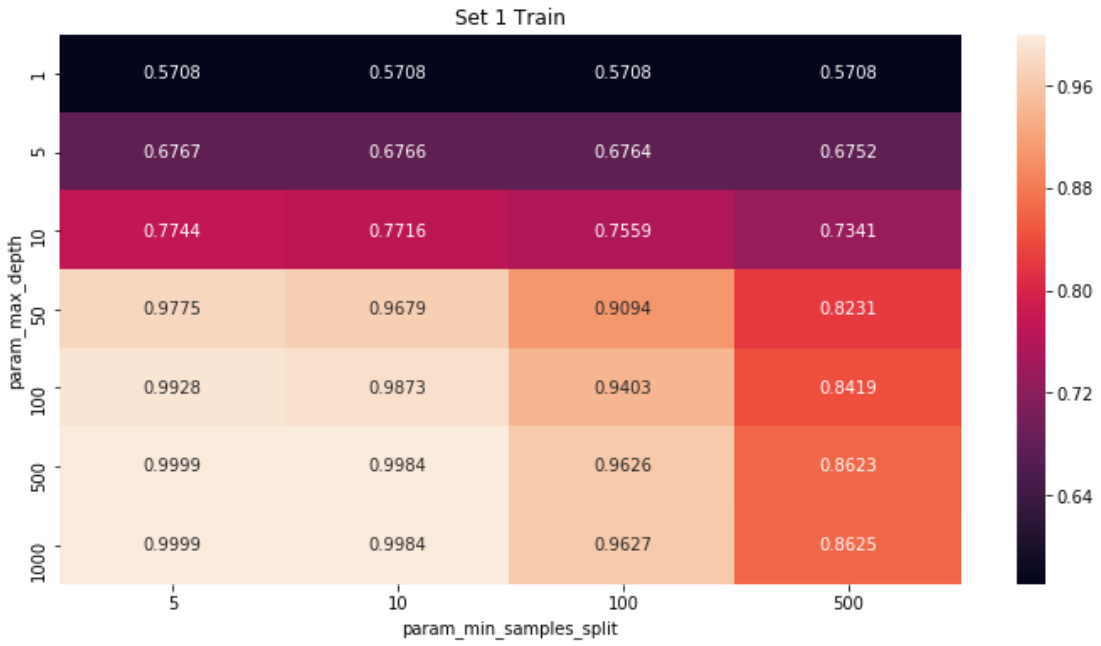
	mean_fit_time	mean_score_time	mean_test_score	mean_train_score	param_max_depth	param_min_samples_split	p
0	0.477736	0.020050	0.568818	0.570781	1	5	{'min_samples 5, 'max_de
1	0.449458	0.020843	0.568818	0.570781	1	10	{'min_samples 10, 'max_de
2	0.412734	0.018460	0.568818	0.570781	1	100	{'min_samples 100, 'max_de
3	0.421495	0.017699	0.568818	0.570781	1	500	{'min_samples 500, 'max_de
4	2.084112	0.019791	0.655173	0.676672	5	5	{'min_samples 5, 'max_de

5 rows × 22 columns

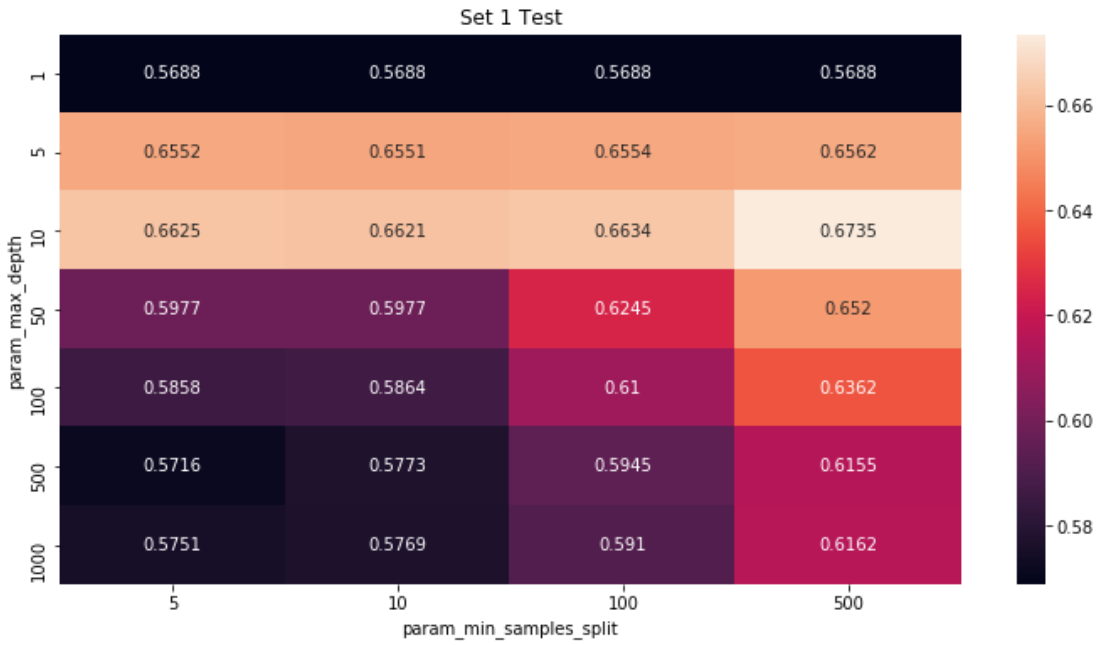
In [125]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
best_scores = results.groupby(['param_max_depth','param_min_samples_split']).max().unstack()[['mean_test_s
print(best_scores)
```

```
                        mean_test_score                                \
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.568818  0.568818  0.568818  0.568818
5                              0.655173  0.655054  0.655416  0.656156
10                             0.662548  0.662108  0.663390  0.673515
50                             0.597732  0.597677  0.624472  0.652000
100                            0.585811  0.586438  0.609978  0.636187
500                            0.571579  0.577253  0.594463  0.615452
1000                           0.575081  0.576917  0.591030  0.616154

                        mean_train_score
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.570781  0.570781  0.570781  0.570781
5                              0.676672  0.676618  0.676384  0.675194
10                             0.774402  0.771587  0.755881  0.734064
50                             0.977452  0.967914  0.909385  0.823125
100                            0.992849  0.987250  0.940318  0.841940
500                            0.999906  0.998380  0.962590  0.862336
1000                           0.999902  0.998411  0.962746  0.862543
```

In [126]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 1 Train'
fmt = 'png'
sns.heatmap(best_scores.mean_train_score, annot=True, fmt='.4g');
plt.title(title);
```

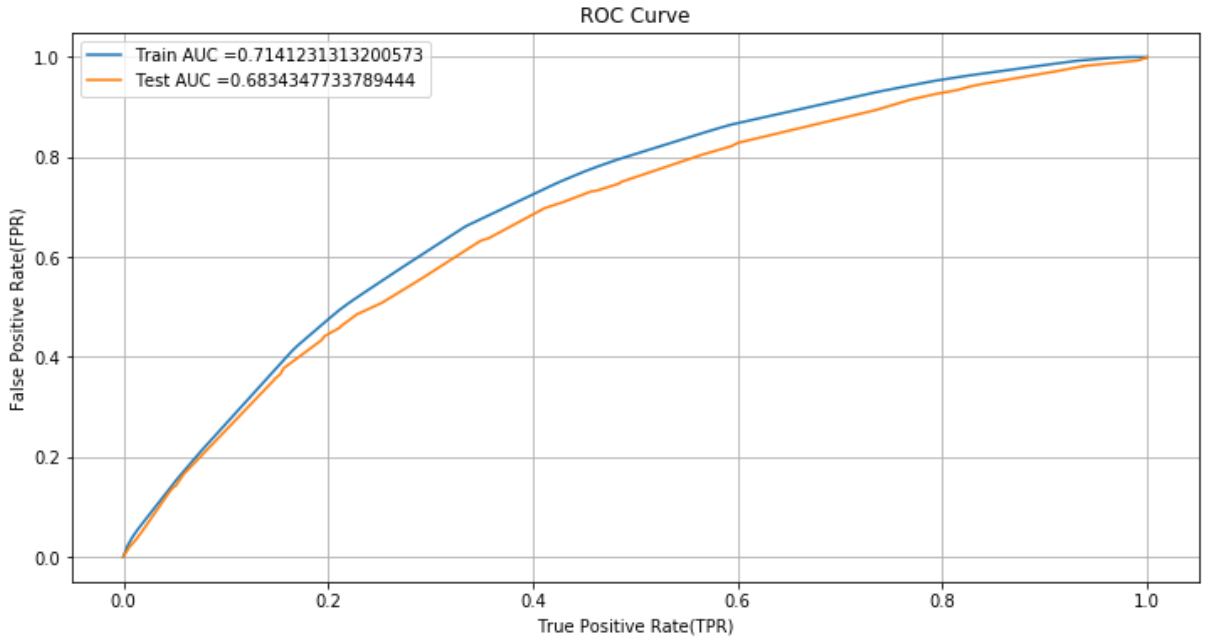


In [127]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 1 Test'
fmt = 'png'
sns.heatmap(best_scores.mean_test_score, annot=True, fmt='.4g');
plt.title(title);
```



In [128]:
```
def batch_predict(clf, data):

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

    return y_data_pred
```

In [129]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc

parameters = best_params
dt = DecisionTreeClassifier(**parameters)

dt.fit(X_tr_set1, 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 = dt.predict_proba(X_tr_set1)[:,1]
y_test_pred = dt.predict_proba(X_te_set1)[:,1]

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

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



In [130]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

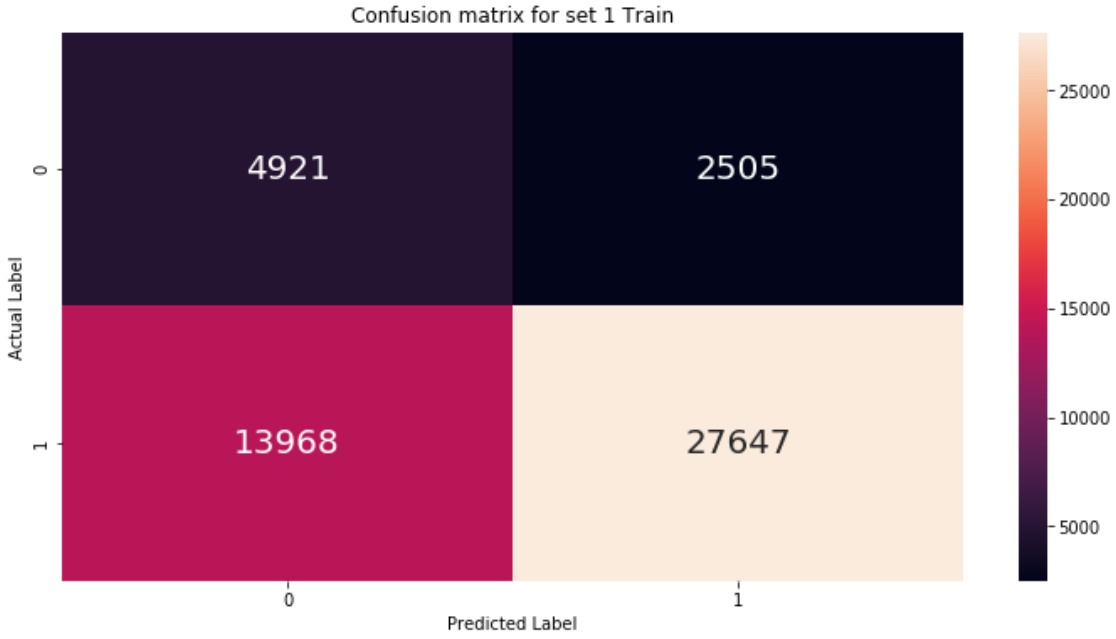
In [131]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.44024713024975104 for threshold 0.853
[[ 4921  2505]
 [13968 27647]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.44024713024975104 for threshold 0.853
[[ 3513  1946]
 [11100 19493]]
```

In [132]:
```
conf_mat_set1_train=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_train,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 1 Train')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.44024713024975104 for threshold 0.853
```

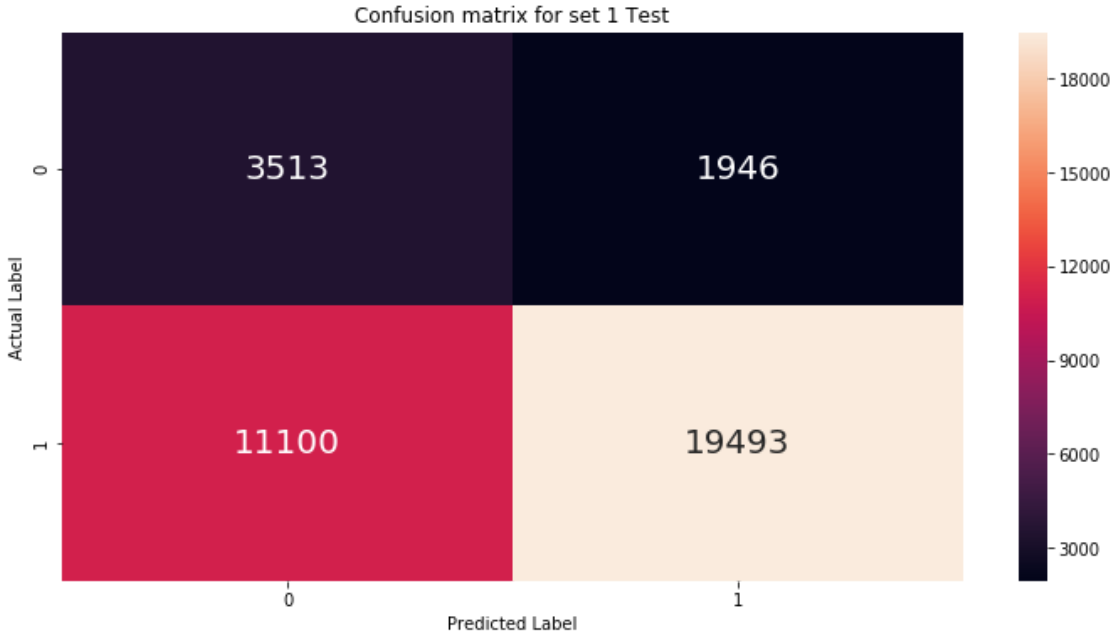
Out[132]:
```
Text(87.0, 0.5, 'Actual Label')
```



In [133]:
```
conf_mat_set1_test=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_test,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 1 Test')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.44024713024975104 for threshold 0.853
```

Out[133]:
```
Text(87.0, 0.5, 'Actual Label')
```



In [134]:
```
threshold_value = 0.853
```

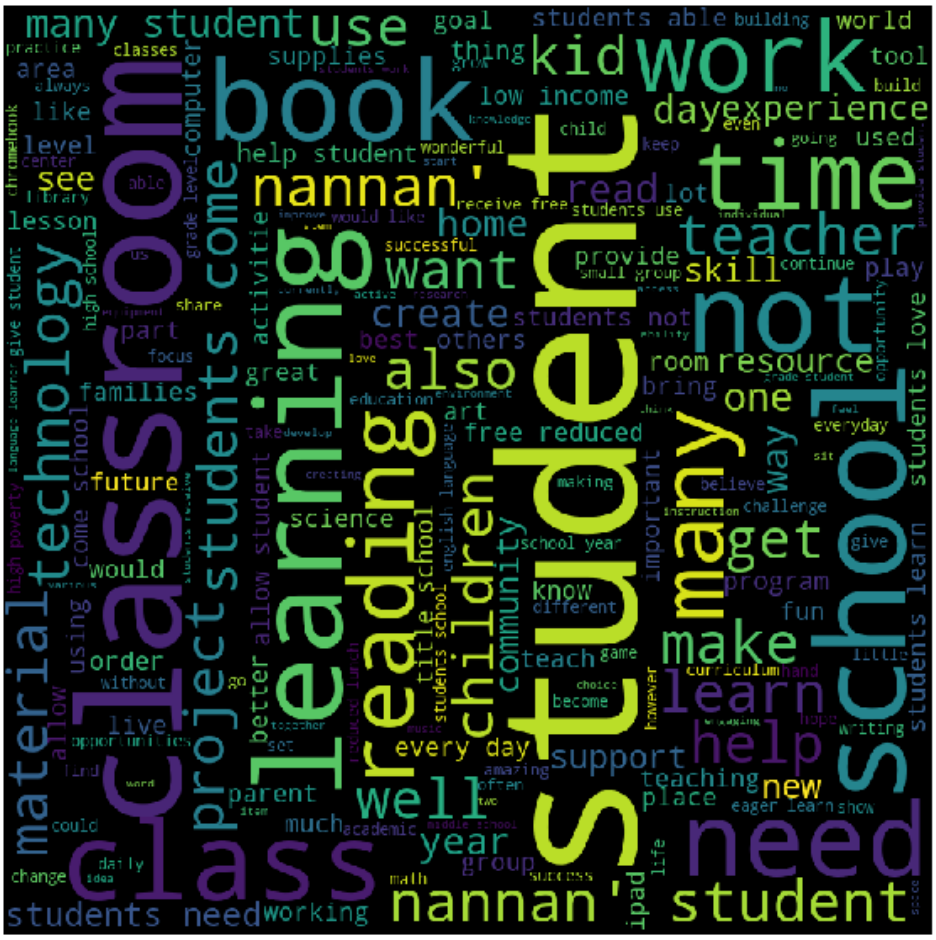
In [135]:
```
fp_list = []
fp_word_count = 0
w = len(y_test)
for i in tqdm(range(w)):
    if y_test[i] == 0 and y_test_pred[i] >= threshold_value:
            fp_list.append(i)
            fp_word_count = fp_word_count + 1
print(fp_word_count)
```

```
100%|██████████| 36052/36052 [00:00<00:00, 1242516.77it/s]

1946
```

In [136]:
```
words = []
z = preprocessed_essays_xte
for x in range(0,len(z)):
    for y in fp_list:
        if (x==y):
            words.append(z[x])
```

In [137]:
```
words = str(words)
```

In [138]:
```
# https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
import pandas as pd
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = stopwords,
                min_font_size = 10).generate(words)

# plot the WordCloud image
plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```



Box Plot for Price

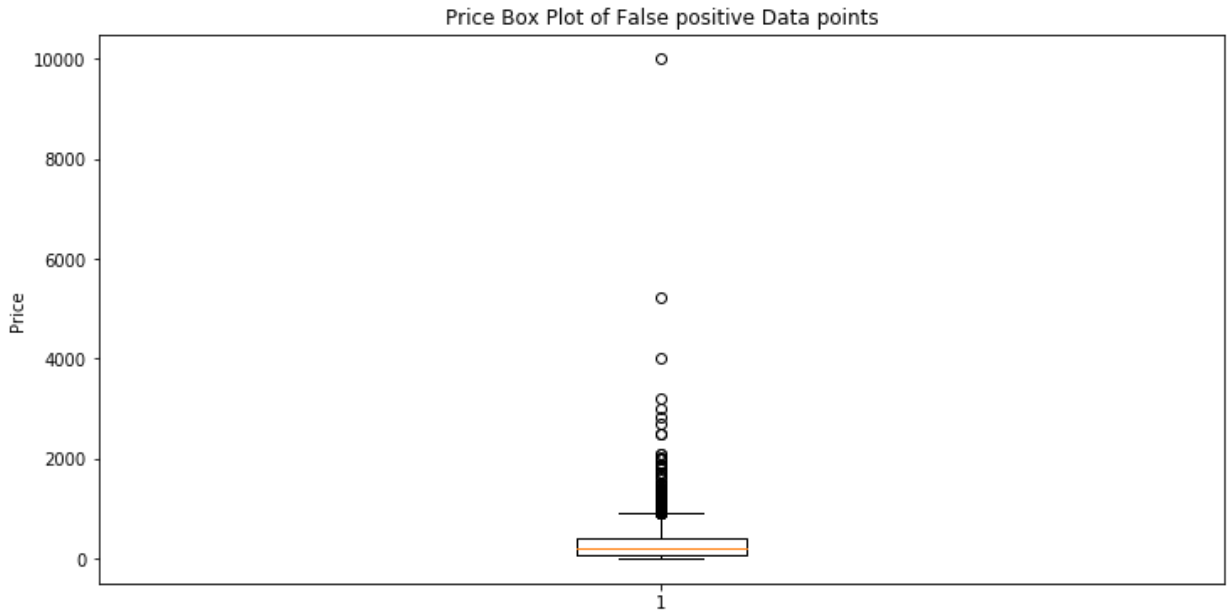
In [139]:
```
box_plot_df = pd.DataFrame(X_test['price'])
```

In [140]:
```
box_plot_price = box_plot_df.iloc[fp_list,:]
```

In [141]:
```
box_plot_price.shape
```

Out[141]:
```
(1946, 1)
```

In [142]:
```
plt.boxplot(box_plot_price.values)
plt.title('Price Box Plot of False positive Data points')
plt.ylabel('Price')
plt.show()
```



Observation :-

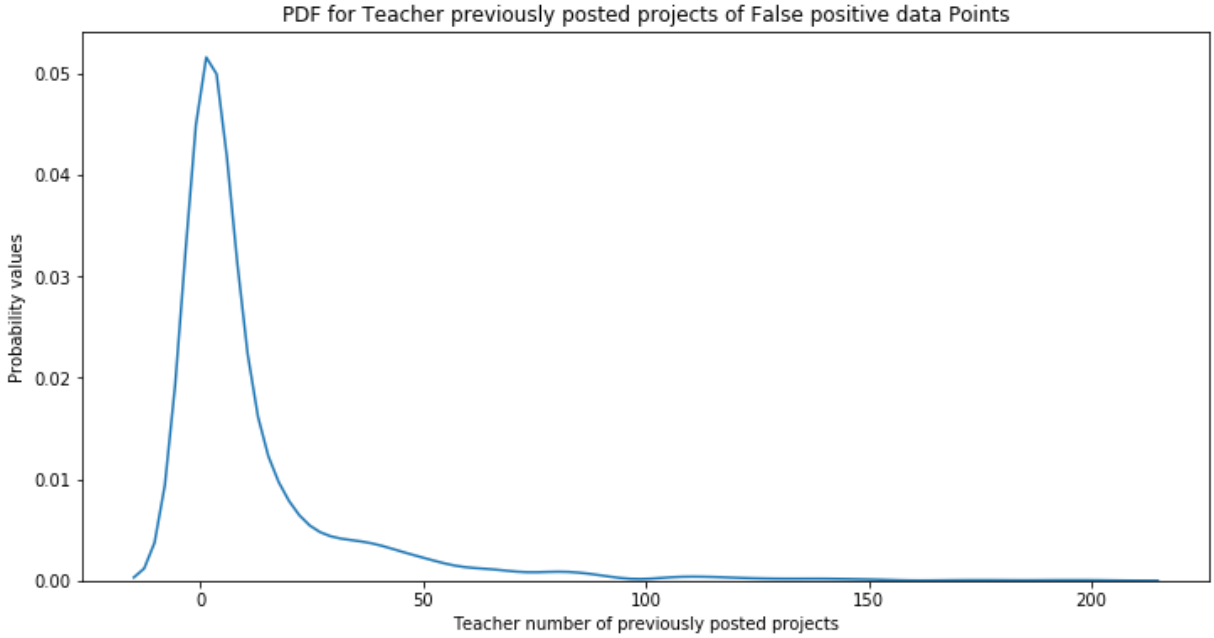
Most of the false positive points have price range of 0 to 2500.

PDF of Teacher previously posted projects for False positive Data points

In [143]:
```
tpp = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
```

In [144]:
```
tpp_pdf = tpp.iloc[fp_list,:]
```

In [145]:
```
sns.distplot(tpp_pdf.values, hist=False)
plt.xlabel('Teacher number of previously posted projects')
plt.ylabel('Probability values')
plt.title('PDF for Teacher previously posted projects of False positive data Points')
plt.show()
```



Observation :-

There's a spike in the false positive values of teacher previously posted projects between the range of 0 to 30 approximately.

2.4.1.1 Graphviz visualization of Decision Tree on BOW, SET 1

In [146]:
```
# https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa394176
from itertools import chain
feature_set = list(chain(ft_state, ft_teacher_prefix, ft_grade, ft_cat, ft_subcat, ft_bow_essay, ft_bow_t
```

In [147]:
```
len(feature_set)
```

Out[147]:
```
14259
```

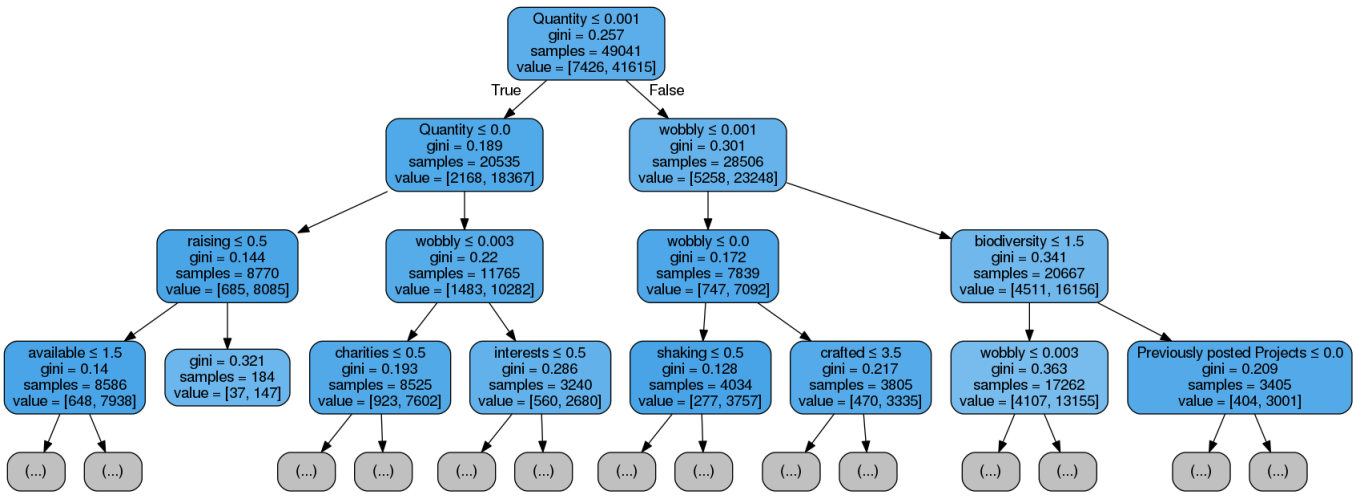
In [148]:
```
pip install graphviz
```

```
Collecting graphviz
  Using cached https://files.pythonhosted.org/packages/17/51/d6de512dbbbab95f0adb53fb2a4396b79722f7c3fbe
8ecc2d8c6ab7de00a/graphviz-0.12-py2.py3-none-any.whl (https://files.pythonhosted.org/packages/17/51/d6de
512dbbbab95f0adb53fb2a4396b79722f7c3fbe8ecc2d8c6ab7de00a/graphviz-0.12-py2.py3-none-any.whl)
Installing collected packages: graphviz
Successfully installed graphviz-0.12
Note: you may need to restart the kernel to use updated packages.
```

In [149]:
```
# Please write all the code with proper documentation
# https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa394176
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus

dot_data = StringIO()
export_graphviz(dt, out_file=dot_data,
                filled=True, max_depth =3, feature_names = feature_set, rounded=True,
                special_characters=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

```
/usr/local/lib/python3.5/dist-packages/sklearn/externals/six.py:31: DeprecationWarning:

The module is deprecated in version 0.21 and will be removed in version 0.23 since we've dropped support
for Python 2.7. Please rely on the official version of six (https://pypi.org/project/six/).
```

Out[149]:



2.4.2 Applying Decision Trees on TFIDF, SET 2

In [150]:
```
# Please write all the code with proper documentation
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set2 = hstack((X_train_essay_tfidf, X_train_titles_tfidf, X_tr_numcat )).tocsr()
X_cv_set2 = hstack((X_cv_essay_tfidf, X_cv_titles_tfidf, X_cv_numcat)).tocsr()
X_te_set2 = hstack((X_test_essay_tfidf, X_test_titles_tfidf, X_te_numcat )).tocsr()
print("Final Data matrix")
print(X_tr_set2.shape, y_train.shape)
print(X_cv_set2.shape, y_cv.shape)
print(X_te_set2.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 14259) (49041,)
(24155, 14259) (24155,)
(36052, 14259) (36052,)
====================================================================================================
```

In [151]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

#https://scikit-learn.org/stable/modules/grid_search.html
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}


clf  = DecisionTreeClassifier(class_weight='balanced')

model = GridSearchCV(clf, parameters, cv=5, scoring='roc_auc', return_train_score=True, verbose=10, n_jobs
model.fit(X_tr_set2, y_train)

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

```
Fitting 5 folds for each of 28 candidates, totalling 140 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 10 concurrent workers.
[Parallel(n_jobs=-1)]: Done   5 tasks      | elapsed:    2.5s
[Parallel(n_jobs=-1)]: Done  12 tasks      | elapsed:    3.5s
[Parallel(n_jobs=-1)]: Done  21 tasks      | elapsed:    8.3s
[Parallel(n_jobs=-1)]: Done  30 tasks      | elapsed:    9.1s
[Parallel(n_jobs=-1)]: Done  41 tasks      | elapsed:   27.9s
[Parallel(n_jobs=-1)]: Done  52 tasks      | elapsed:   39.4s
[Parallel(n_jobs=-1)]: Done  65 tasks      | elapsed:  1.7min
[Parallel(n_jobs=-1)]: Done  78 tasks      | elapsed:  2.5min
[Parallel(n_jobs=-1)]: Done  93 tasks      | elapsed:  4.4min
[Parallel(n_jobs=-1)]: Done 108 tasks      | elapsed:  6.2min
[Parallel(n_jobs=-1)]: Done 136 out of 140 | elapsed:  9.6min remaining:   16.9s
[Parallel(n_jobs=-1)]: Done 140 out of 140 | elapsed:  9.7min finished
```

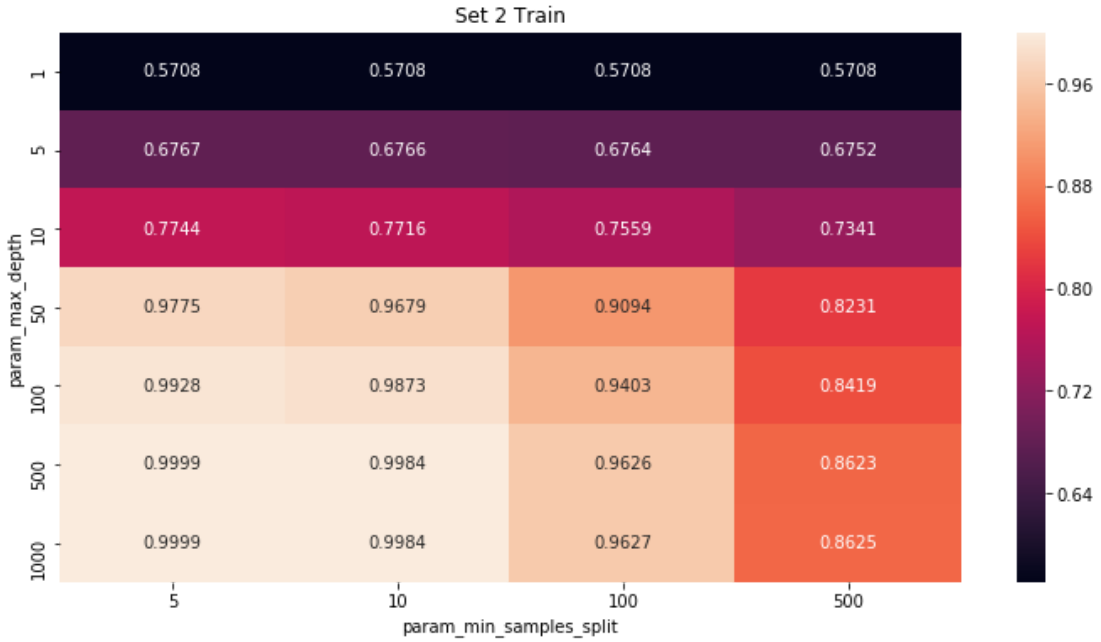
In [152]:
```
#Results of grid Search
best_params = model.best_params_
print(model.best_score_)
print(model.best_params_)
```

```
0.6685907005856884
{'min_samples_split': 500, 'max_depth': 10}
```

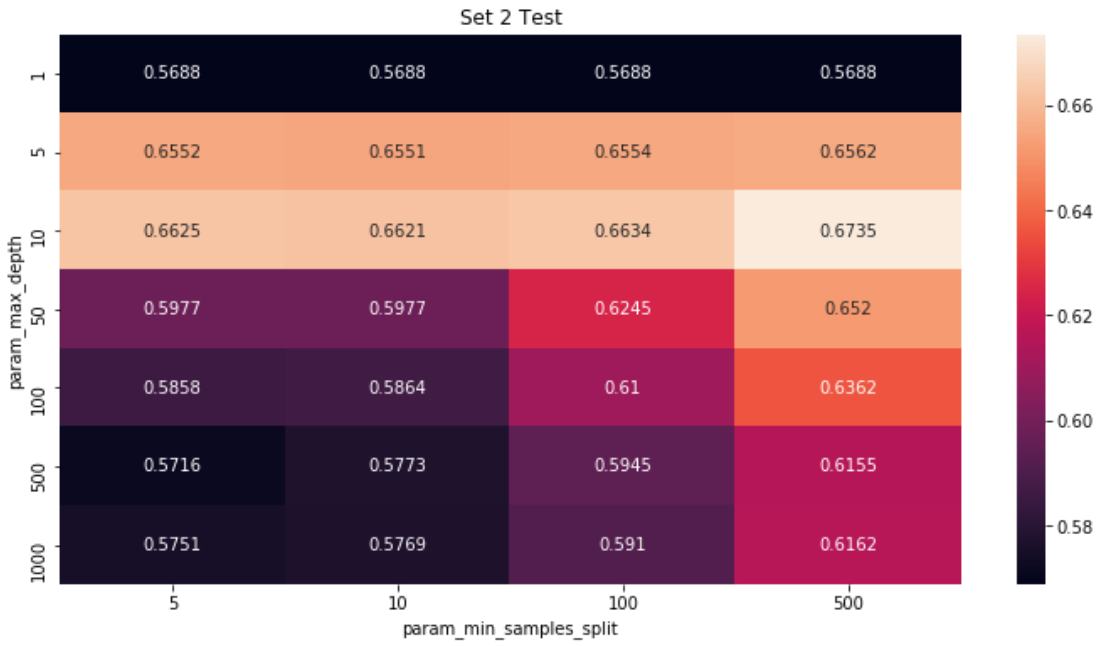
In [153]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
best_scores = results.groupby(['param_max_depth','param_min_samples_split']).max().unstack()[['mean_test_s
print(best_scores)
```

```
                        mean_test_score                                \
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.568818  0.568818  0.568818  0.568818
5                              0.655173  0.655054  0.655416  0.656156
10                             0.662548  0.662108  0.663390  0.673515
50                             0.597732  0.597677  0.624472  0.652000
100                            0.585811  0.586438  0.609978  0.636187
500                            0.571579  0.577253  0.594463  0.615452
1000                           0.575081  0.576917  0.591030  0.616154

                        mean_train_score
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.570781  0.570781  0.570781  0.570781
5                              0.676672  0.676618  0.676384  0.675194
10                             0.774402  0.771587  0.755881  0.734064
50                             0.977452  0.967914  0.909385  0.823125
100                            0.992849  0.987250  0.940318  0.841940
500                            0.999906  0.998380  0.962590  0.862336
1000                           0.999902  0.998411  0.962746  0.862543
```

In [154]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 2 Train'
fmt = 'png'
sns.heatmap(best_scores.mean_train_score, annot=True, fmt='.4g');
plt.title(title);
```

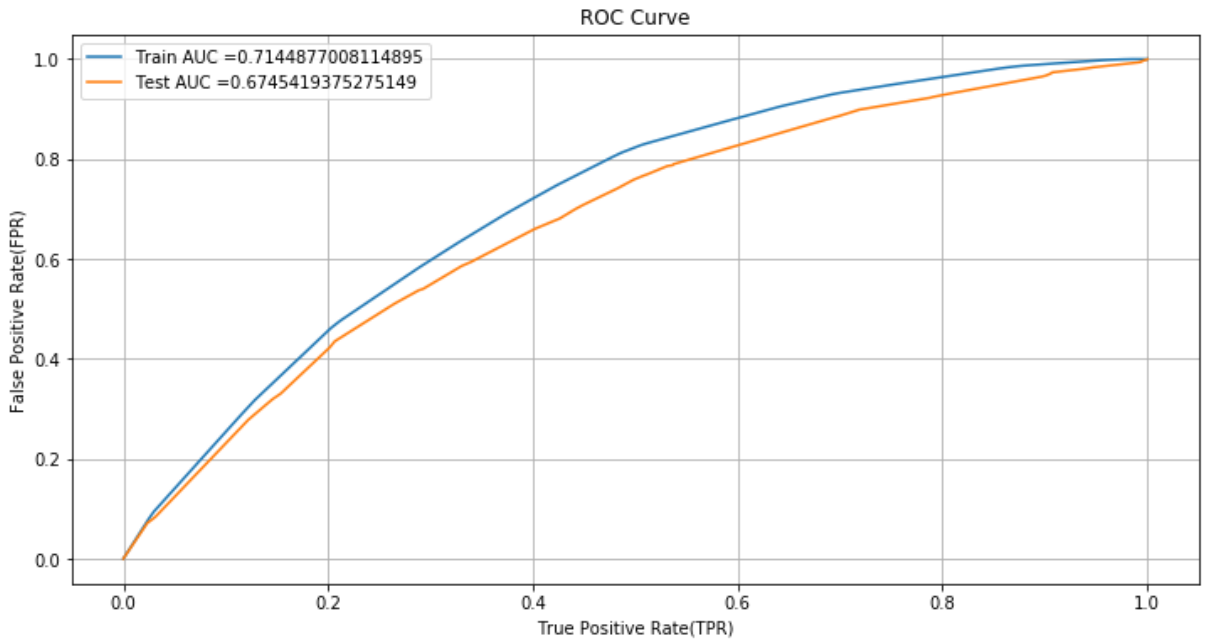


In [155]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 2 Test'
fmt = 'png'
sns.heatmap(best_scores.mean_test_score, annot=True, fmt='.4g');
plt.title(title);
```



In [156]:
```
def batch_predict(clf, data):

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

    return y_data_pred
```

In [157]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc

parameters = best_params
dt = DecisionTreeClassifier(**parameters)

dt.fit(X_tr_set2, 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 = dt.predict_proba(X_tr_set2)[:,1]
y_test_pred = dt.predict_proba(X_te_set2)[:,1]

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

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



In [158]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

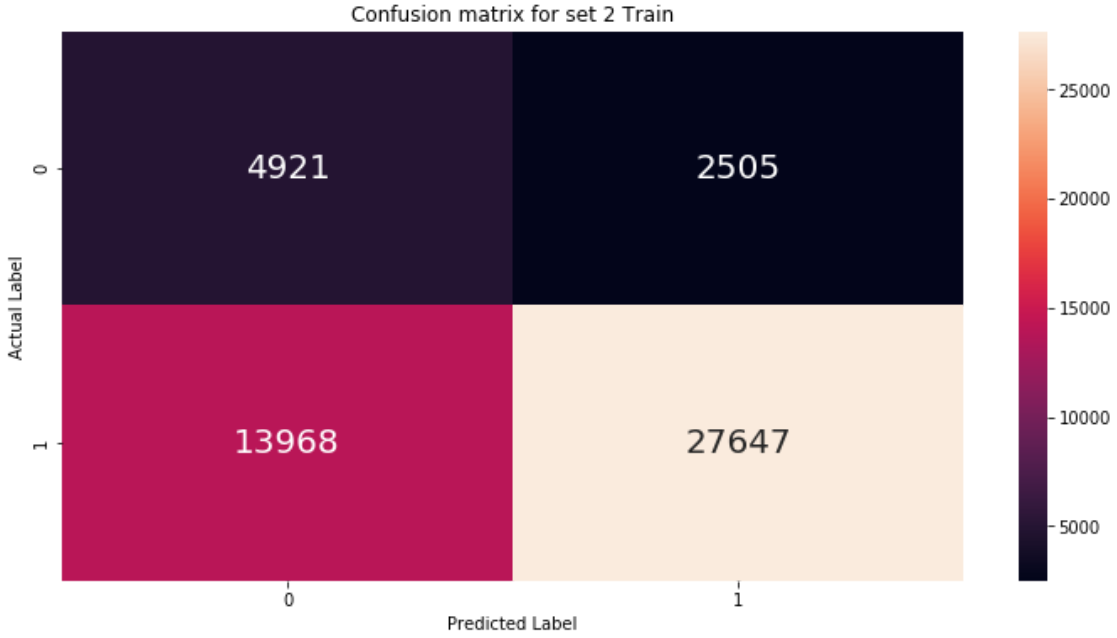
In [159]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.4327056959193904 for threshold 0.866
[[ 4473  2953]
 [11720 29895]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.4327056959193904 for threshold 0.866
[[ 3132  2327]
 [ 9757 20836]]
```

In [160]:
```
conf_mat_set2_train=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_train,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 2 Train')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.4327056959193904 for threshold 0.866
```

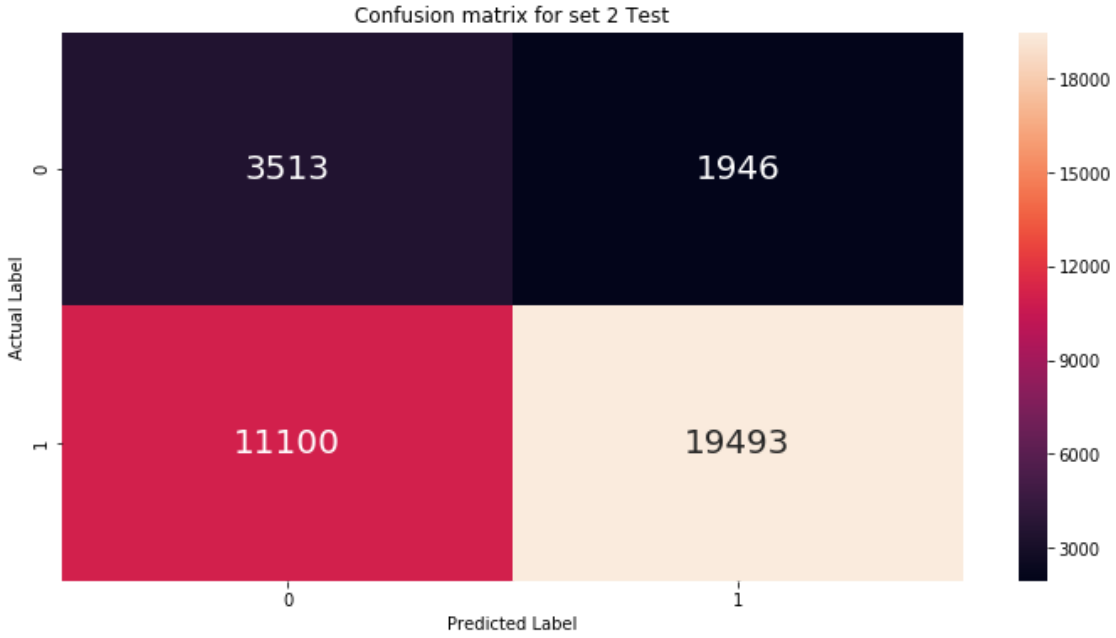
Out[160]:
```
Text(87.0, 0.5, 'Actual Label')
```



In [161]:
```
conf_mat_set2_test=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_test,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 2 Test')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.4327056959193904 for threshold 0.866
```

Out[161]:
```
Text(87.0, 0.5, 'Actual Label')
```



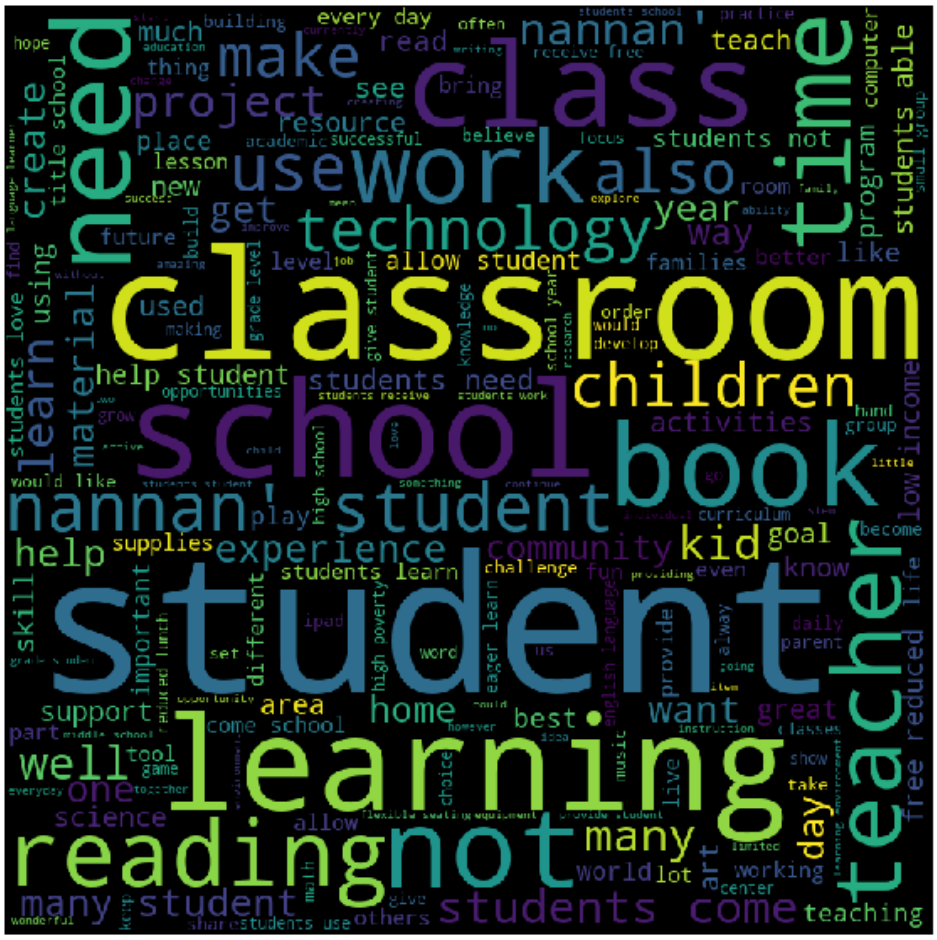
In [162]:
```
threshold_value = 0.866
fp_list = []
fp_word_count = 0
w = len(y_test)
for i in tqdm(range(w)):
    if y_test[i] == 0 and y_test_pred[i] >= threshold_value:
            fp_list.append(i)
            fp_word_count = fp_word_count + 1
print(fp_word_count)
```

```
100%|██████████| 36052/36052 [00:00<00:00, 1288542.57it/s]

2327
```

In [163]:
```
words = []
z = preprocessed_essays_xte
for x in range(0,len(z)):
    for y in fp_list:
        if (x==y):
            words.append(z[x])
```

In [164]:
```
words = str(words)
```

In [165]:
```
# https://www.geeksforgeeks.org/generating-word-cloud-python/
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt
import pandas as pd
wordcloud = WordCloud(width = 800, height = 800,
                background_color ='black',
                stopwords = stopwords,
                min_font_size = 10).generate(words)

# plot the WordCloud image
plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(wordcloud)
plt.axis("off")
plt.tight_layout(pad = 0)
plt.show()
```

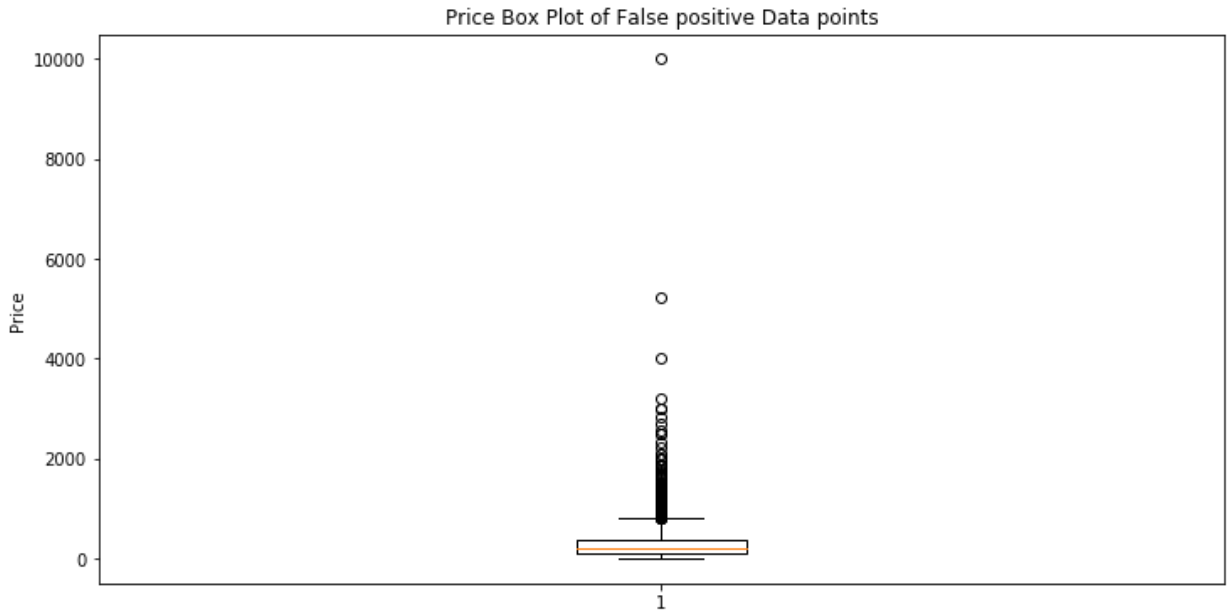


Box Plot for Price

In [166]:
```
box_plot_df = pd.DataFrame(X_test['price'])
box_plot_price = box_plot_df.iloc[fp_list,:]
box_plot_price.shape
```

Out[166]:
```
(2327, 1)
```

In [167]:
```
plt.boxplot(box_plot_price.values)
plt.title('Price Box Plot of False positive Data points')
plt.ylabel('Price')
plt.show()
```



Observation :-

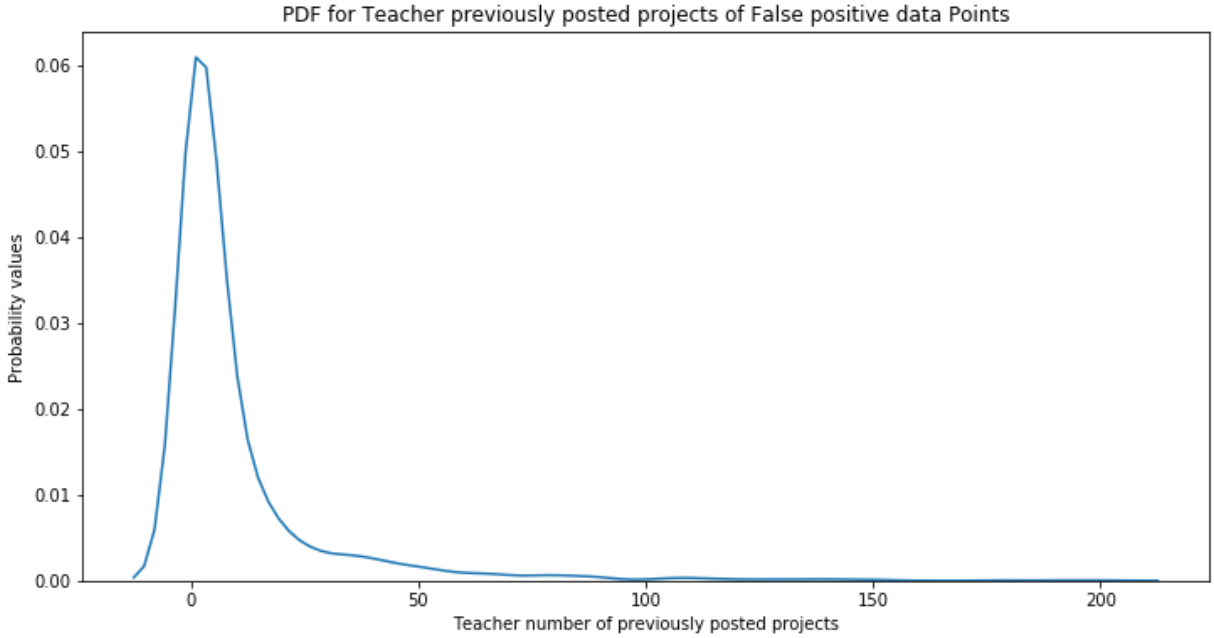
Most of the false positive points have price range of 0 to 2500.

PDF of Teacher previously posted projects for False positive Data points

In [168]:
```
tpp = pd.DataFrame(X_test['teacher_number_of_previously_posted_projects'])
```

In [169]:
```
tpp_pdf = tpp.iloc[fp_list,:]
```

In [170]:
```
sns.distplot(tpp_pdf.values, hist=False)
plt.xlabel('Teacher number of previously posted projects')
plt.ylabel('Probability values')
plt.title('PDF for Teacher previously posted projects of False positive data Points')
plt.show()
```



Observation :-

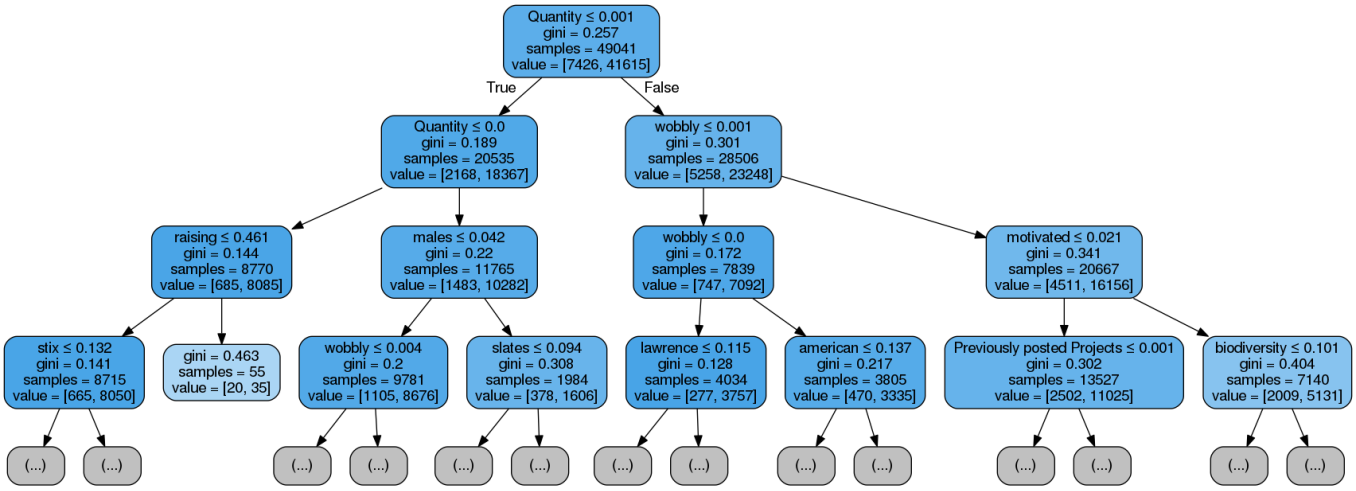
There's a spike in the false positive values of teacher previously posted projects between the range of 0 to 30 approximately.

2.4.2.1 Graphviz visualization of Decision Tree on TFIDF, SET 2

In [172]:
```
# Please write all the code with proper documentation
# https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa394176
feature_set_tfidf = list(chain(ft_state, ft_teacher_prefix, ft_grade, ft_cat, ft_subcat, ft_tfidf_essay, 
```

In [173]:
```
# Please write all the code with proper documentation
# https://medium.com/@rnbrown/creating-and-visualizing-decision-trees-with-python-f8e8fa394176
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus

dot_data = StringIO()
export_graphviz(dt, out_file=dot_data,
                filled=True, max_depth =3, feature_names = feature_set, rounded=True,
                special_characters=True)
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png())
```

Out[173]:



2.4.3 Applying Decision Trees on AVG W2V, SET 3

In [246]:
```
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set3 = hstack((avg_w2v_vectors_extr, avg_w2v_vectors_txtr, X_tr_numcat)).tocsr()
X_cv_set3 = hstack((avg_w2v_vectors_excv, avg_w2v_vectors_txcv, X_cv_numcat)).tocsr()
X_te_set3 = hstack((avg_w2v_vectors_exte, avg_w2v_vectors_txte, X_te_numcat )).tocsr()
print("Final Data matrix")
print(X_tr_set3.shape, y_train.shape)
print(X_cv_set3.shape, y_cv.shape)
print(X_te_set3.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 702) (49041,)
(24155, 702) (24155,)
(36052, 702) (36052,)
====================================================================================================
```

In [247]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h

#https://scikit-learn.org/stable/modules/grid_search.html
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}


clf  = DecisionTreeClassifier(class_weight='balanced')

model = GridSearchCV(clf, parameters, cv=5, scoring='roc_auc', return_train_score=True, verbose=10, n_jobs
model.fit(X_tr_set3, y_train)

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

```
Fitting 5 folds for each of 28 candidates, totalling 140 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 10 concurrent workers.
[Parallel(n_jobs=-1)]: Done   5 tasks      | elapsed:    9.6s
[Parallel(n_jobs=-1)]: Done  12 tasks      | elapsed:   16.2s
[Parallel(n_jobs=-1)]: Done  21 tasks      | elapsed:   45.8s
[Parallel(n_jobs=-1)]: Done  30 tasks      | elapsed:   46.7s
[Parallel(n_jobs=-1)]: Done  41 tasks      | elapsed:  2.6min
[Parallel(n_jobs=-1)]: Done  52 tasks      | elapsed:  3.7min
[Parallel(n_jobs=-1)]: Done  65 tasks      | elapsed:  7.0min
[Parallel(n_jobs=-1)]: Done  78 tasks      | elapsed:  9.8min
[Parallel(n_jobs=-1)]: Done  93 tasks      | elapsed: 14.6min
[Parallel(n_jobs=-1)]: Done 108 tasks      | elapsed: 18.7min
[Parallel(n_jobs=-1)]: Done 136 out of 140 | elapsed: 26.5min remaining:   46.7s
[Parallel(n_jobs=-1)]: Done 140 out of 140 | elapsed: 26.8min finished
```

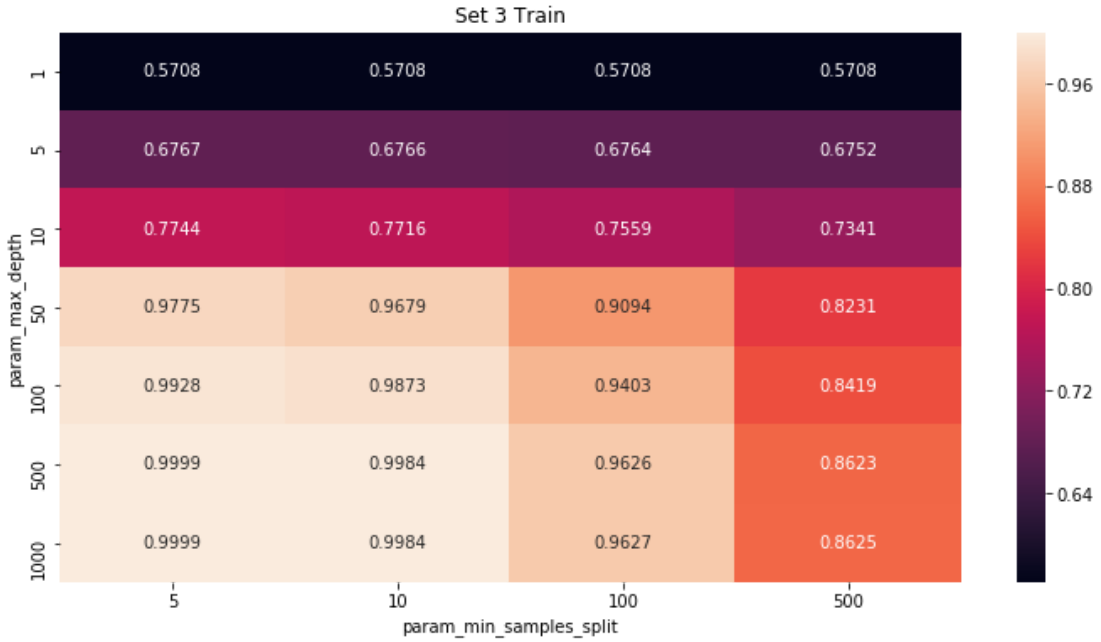
In [248]:
```
#Results of grid Search
best_params = model.best_params_
print(model.best_score_)
print(model.best_params_)
```

```
0.6573717978233258
{'min_samples_split': 500, 'max_depth': 5}
```

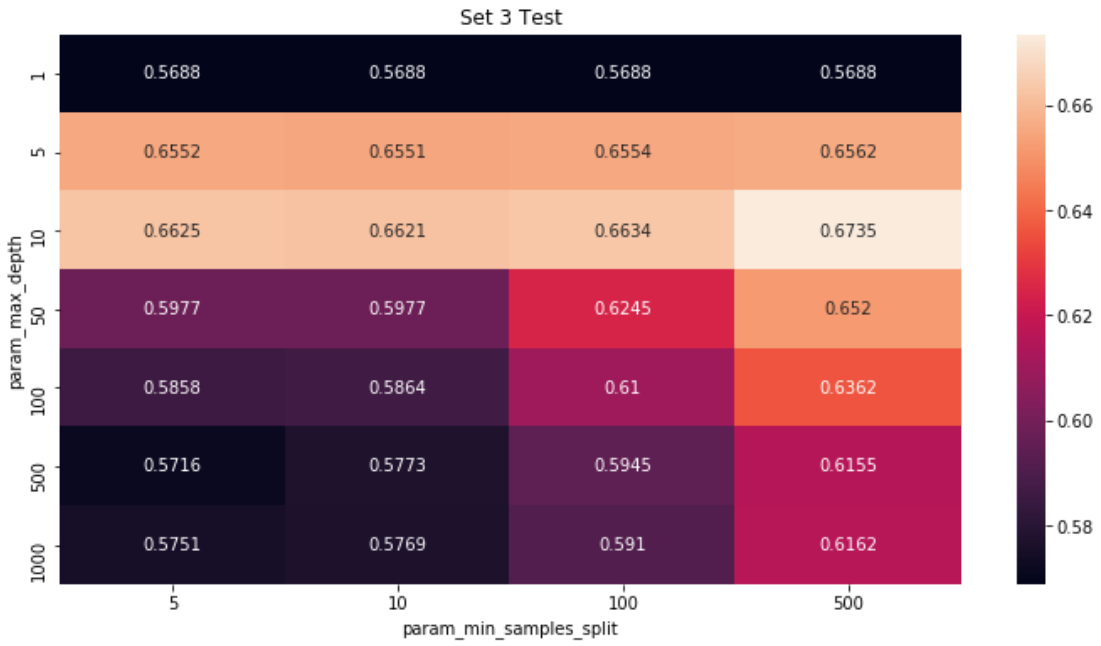
In [249]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
best_scores = results.groupby(['param_max_depth','param_min_samples_split']).max().unstack()[['mean_test_s
print(best_scores)
```

```
                       mean_test_score                                \
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.568818  0.568818  0.568818  0.568818
5                              0.655173  0.655054  0.655416  0.656156
10                             0.662548  0.662108  0.663390  0.673515
50                             0.597732  0.597677  0.624472  0.652000
100                            0.585811  0.586438  0.609978  0.636187
500                            0.571579  0.577253  0.594463  0.615452
1000                           0.575081  0.576917  0.591030  0.616154

                       mean_train_score
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.570781  0.570781  0.570781  0.570781
5                              0.676672  0.676618  0.676384  0.675194
10                             0.774402  0.771587  0.755881  0.734064
50                             0.977452  0.967914  0.909385  0.823125
100                            0.992849  0.987250  0.940318  0.841940
500                            0.999906  0.998380  0.962590  0.862336
1000                           0.999902  0.998411  0.962746  0.862543
```

In [250]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 3 Train'
fmt = 'png'
sns.heatmap(best_scores.mean_train_score, annot=True, fmt='.4g');
plt.title(title);
```

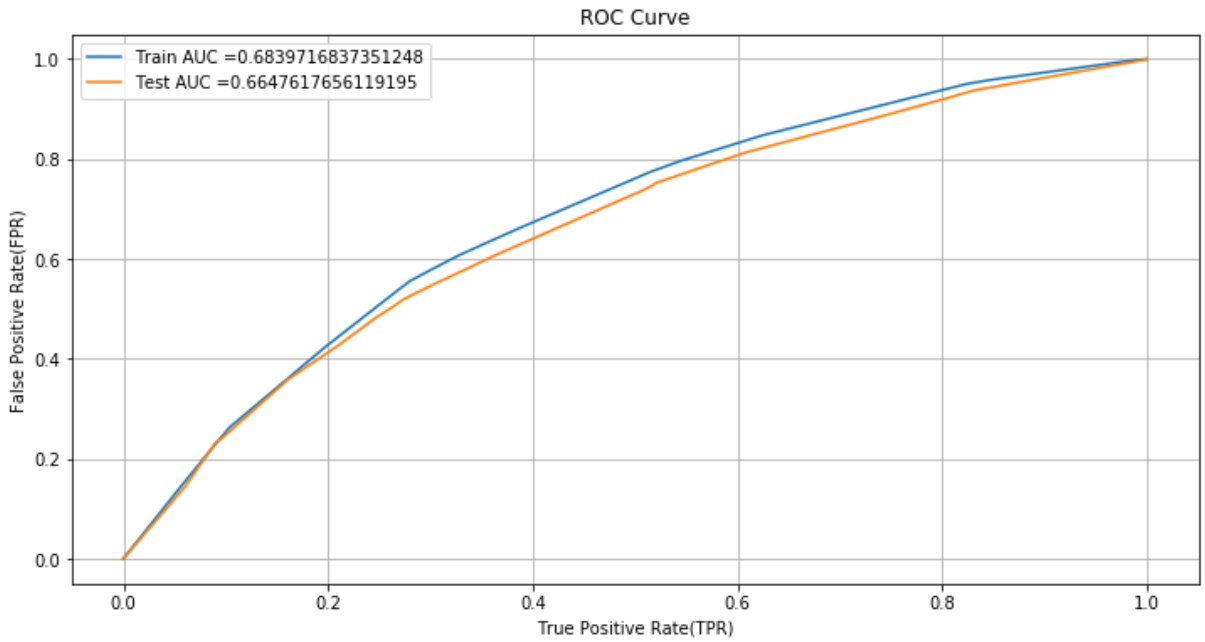


In [251]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 3 Test'
fmt = 'png'
sns.heatmap(best_scores.mean_test_score, annot=True, fmt='.4g');
plt.title(title);
```



In [252]:
```
def batch_predict(clf, data):

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

    return y_data_pred
```

In [253]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc

parameters = best_params
dt = DecisionTreeClassifier(**parameters)

dt.fit(X_tr_set3, 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 = dt.predict_proba(X_tr_set3)[:,1]
y_test_pred = dt.predict_proba(X_te_set3)[:,1]

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

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



In [254]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

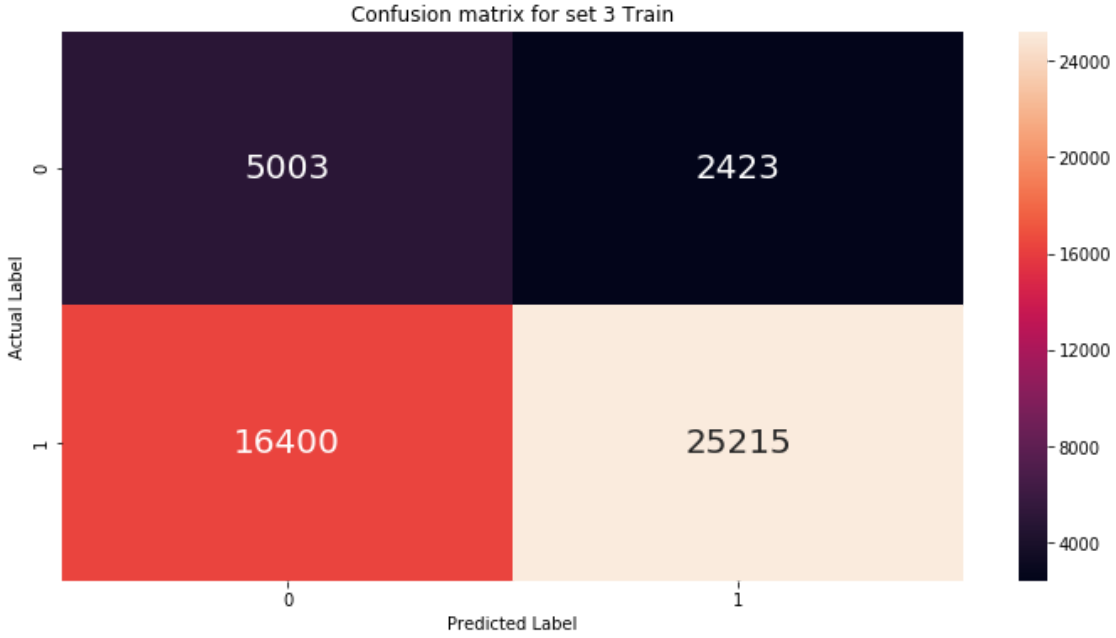
In [255]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.40821093243151807 for threshold 0.857
[[ 5003  2423]
 [16400 25215]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.40821093243151807 for threshold 0.857
[[ 3802  1657]
 [13771 16822]]
```

In [256]:
```
conf_mat_set1_train=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_train,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 3 Train')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.40821093243151807 for threshold 0.857
```

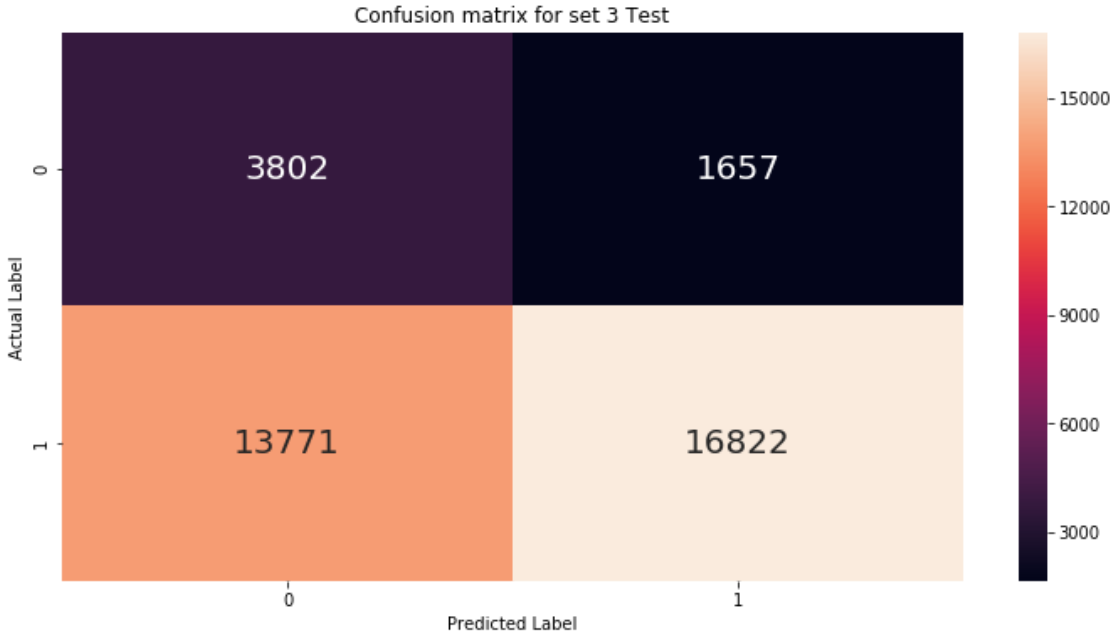
Out[256]:
```
Text(87.0, 0.5, 'Actual Label')
```



In [257]:
```
conf_mat_set1_test=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_test,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 3 Test')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.40821093243151807 for threshold 0.857
```

Out[257]:
```
Text(87.0, 0.5, 'Actual Label')
```



2.4.4 Applying Decision Trees on TFIDF W2V, SET 4

In [268]:
```
# Please write all the code with proper documentation
# Please write all the code with proper documentation
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_set4 = hstack((tfidf_w2v_vectors_extr, tfidf_w2v_vectors_txtr, X_tr_numcat)).tocsr()
X_cv_set4 = hstack((tfidf_w2v_vectors_excv, tfidf_w2v_vectors_txcv, X_cv_numcat)).tocsr()
X_te_set4 = hstack((tfidf_w2v_vectors_exte, tfidf_w2v_vectors_txte, X_te_numcat)).tocsr()
print("Final Data matrix")
print(X_tr_set4.shape, y_train.shape)
print(X_cv_set4.shape, y_cv.shape)
print(X_te_set4.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 702) (49041,)
(24155, 702) (24155,)
(36052, 702) (36052,)
====================================================================================================
```

In [269]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
import matplotlib.pyplot as plt

data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h
#https://scikit-learn.org/stable/modules/grid_search.html
parameters = {'max_depth': [1, 5, 10, 50, 100, 500, 1000], 'min_samples_split':[5, 10, 100, 500]}


clf  = DecisionTreeClassifier(class_weight='balanced')

model = GridSearchCV(clf, parameters, cv=5, scoring='roc_auc', return_train_score=True, verbose=10, n_jobs
model.fit(X_tr_set4, y_train)

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

```
Fitting 5 folds for each of 28 candidates, totalling 140 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 10 concurrent workers.
[Parallel(n_jobs=-1)]: Done   5 tasks      | elapsed:    7.0s
[Parallel(n_jobs=-1)]: Done  12 tasks      | elapsed:   13.8s
[Parallel(n_jobs=-1)]: Done  21 tasks      | elapsed:   44.0s
[Parallel(n_jobs=-1)]: Done  30 tasks      | elapsed:   44.6s
[Parallel(n_jobs=-1)]: Done  41 tasks      | elapsed:  2.6min
[Parallel(n_jobs=-1)]: Done  52 tasks      | elapsed:  3.7min
[Parallel(n_jobs=-1)]: Done  65 tasks      | elapsed:  6.9min
[Parallel(n_jobs=-1)]: Done  78 tasks      | elapsed:  9.5min
[Parallel(n_jobs=-1)]: Done  93 tasks      | elapsed: 14.0min
[Parallel(n_jobs=-1)]: Done 108 tasks      | elapsed: 17.5min
[Parallel(n_jobs=-1)]: Done 136 out of 140 | elapsed: 24.7min remaining:   43.5s
[Parallel(n_jobs=-1)]: Done 140 out of 140 | elapsed: 25.0min finished
```

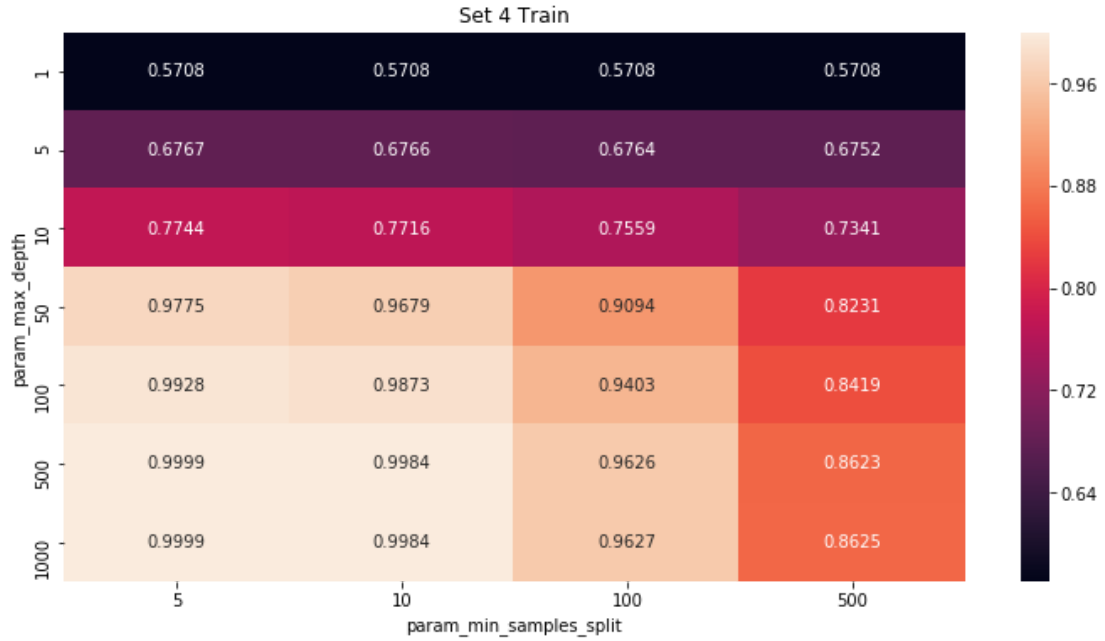
In [270]:
```
#Results of grid Search
best_params = model.best_params_
print(model.best_score_)
print(model.best_params_)
```

```
0.6576610154174987
{'min_samples_split': 500, 'max_depth': 5}
```

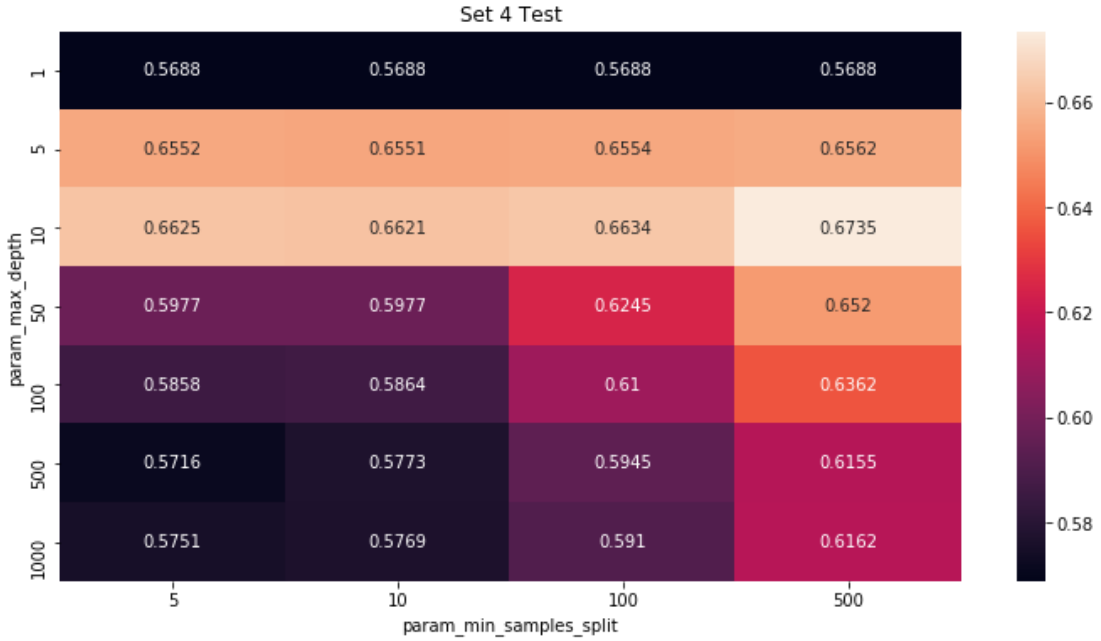
In [271]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
best_scores = results.groupby(['param_max_depth','param_min_samples_split']).max().unstack()[['mean_test_s
print(best_scores)
```

```
                        mean_test_score                                \
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.568818  0.568818  0.568818  0.568818
5                              0.655173  0.655054  0.655416  0.656156
10                             0.662548  0.662108  0.663390  0.673515
50                             0.597732  0.597677  0.624472  0.652000
100                            0.585811  0.586438  0.609978  0.636187
500                            0.571579  0.577253  0.594463  0.615452
1000                           0.575081  0.576917  0.591030  0.616154

                        mean_train_score
param_min_samples_split               5         10        100       500
param_max_depth
1                              0.570781  0.570781  0.570781  0.570781
5                              0.676672  0.676618  0.676384  0.675194
10                             0.774402  0.771587  0.755881  0.734064
50                             0.977452  0.967914  0.909385  0.823125
100                            0.992849  0.987250  0.940318  0.841940
500                            0.999906  0.998380  0.962590  0.862336
1000                           0.999902  0.998411  0.962746  0.862543
```

In [272]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 4 Train'
fmt = 'png'
sns.heatmap(best_scores.mean_train_score, annot=True, fmt='.4g');
plt.title(title);
```

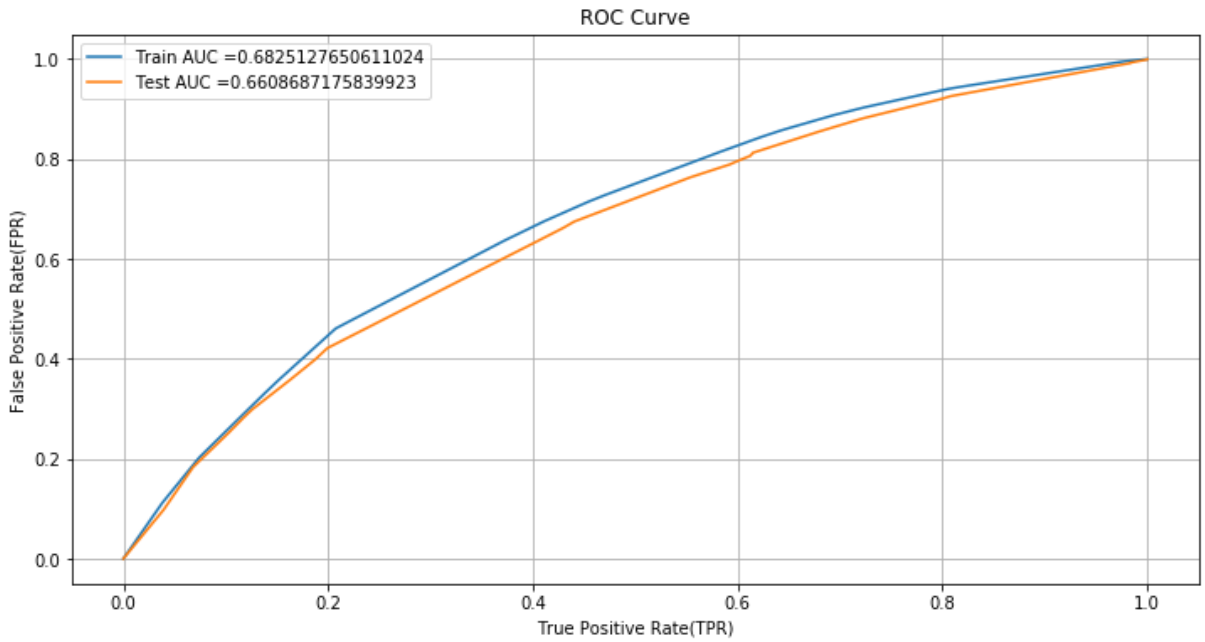


In [273]:
```
#https://github.com/xoelop/Medium-posts/blob/master/3d%20cross%20validation/ML%206%20-%20Gridsearch%20visu
import matplotlib.pyplot as plt
plt.rcParams["figure.figsize"] = (12, 6)
title = 'Set 4 Test'
fmt = 'png'
sns.heatmap(best_scores.mean_test_score, annot=True, fmt='.4g');
plt.title(title);
```



In [274]:
```
def batch_predict(clf, data):

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

    return y_data_pred
```

In [275]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
#https://scikit-learn.org/stable/modules/svm.html
from sklearn.metrics import roc_curve, auc

parameters = best_params
dt = DecisionTreeClassifier(**parameters)

dt.fit(X_tr_set4, 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 = dt.predict_proba(X_tr_set4)[:,1]
y_test_pred = dt.predict_proba(X_te_set4)[:,1]

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

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



In [276]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

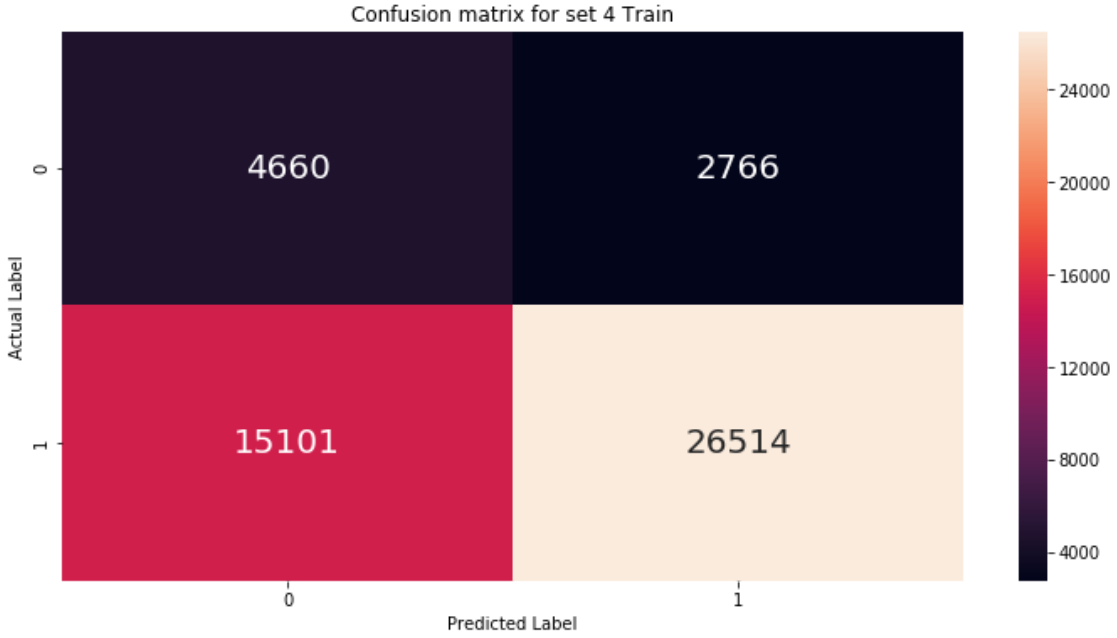
In [277]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.39981246015190813 for threshold 0.857
[[ 4660  2766]
 [15101 26514]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.39981246015190813 for threshold 0.857
[[ 3439  2020]
 [12242 18351]]
```

In [278]:
```
conf_mat_set1_train=pd.DataFrame(confusion_matrix(y_train,predict(y_train_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_train,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 4 Train')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.39981246015190813 for threshold 0.857
```

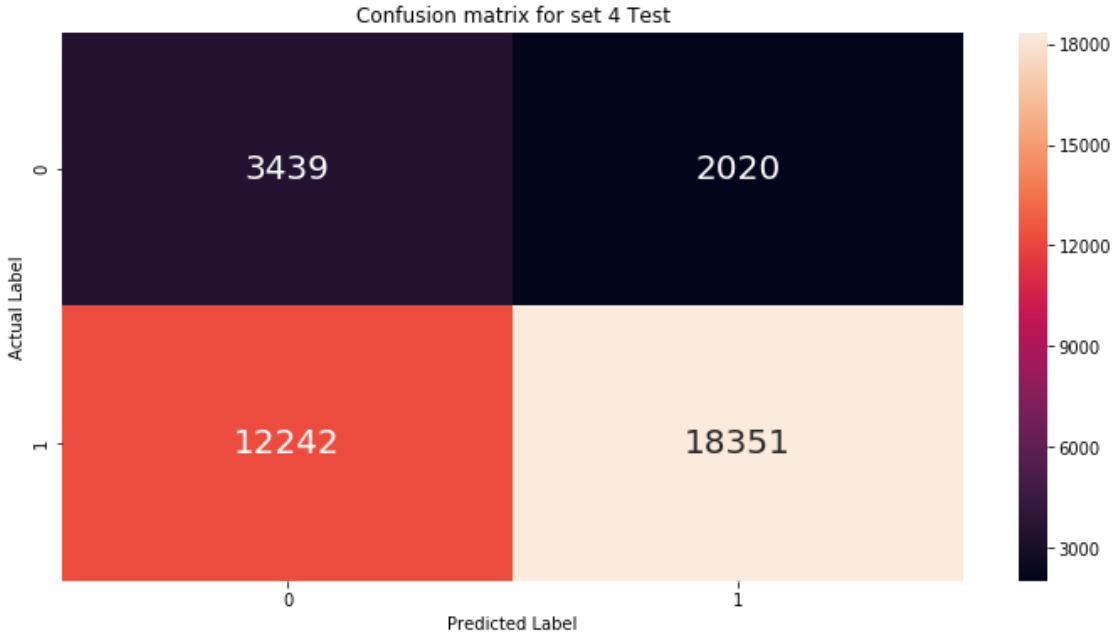
Out[278]:
```
Text(87.0, 0.5, 'Actual Label')
```



In [279]:
```
conf_mat_set1_test=pd.DataFrame(confusion_matrix(y_test,predict(y_test_pred,tr_thresholds,
train_fpr,train_tpr)),range(2),range(2))
sns.heatmap(conf_mat_set1_test,annot=True,annot_kws={"size":20},fmt='g')
plt.title('Confusion matrix for set 4 Test')
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
```

```
the maximum value of tpr*(1-fpr) 0.39981246015190813 for threshold 0.857
```

Out[279]:
```
Text(87.0, 0.5, 'Actual Label')
```



2.5 [Task-2]Getting top 5k features using `feature_importances_`

In [291]:
```
# please write all the code with proper documentation, and proper titles for each subsection
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
from sklearn.tree import DecisionTreeClassifier
dt = DecisionTreeClassifier(max_depth = 10)
```

In [292]:
```
model = dt.fit(X_tr_set2, y_train)
```

In [293]:
```
ft_imp = dt.feature_importances_
```

In [294]:
```
# Removing features which have 0 importance
ft_imp = list(ft_imp)
final_ft_imp = []
for z in range(len(ft_imp)):
    if ft_imp[z] > 0:
        final_ft_imp.append(z)
print(len(final_ft_imp))
```

```
185
```

In [295]:
```
print(final_ft_imp)
```

```
[17, 89, 162, 241, 343, 559, 571, 572, 653, 701, 723, 734, 815, 916, 1037, 1070, 1140, 1149, 1246, 1330,
1504, 1598, 1805, 1810, 1913, 1949, 1973, 1995, 2008, 2153, 2155, 2163, 2177, 2187, 2524, 2575, 2708, 27
11, 2809, 3034, 3091, 3452, 3482, 3729, 3746, 3749, 3810, 3914, 3923, 4040, 4084, 4175, 4207, 4401, 449
4, 4512, 4547, 4570, 4605, 4610, 4744, 4760, 4793, 4795, 4811, 4842, 4892, 5008, 5015, 5125, 5154, 5216,
5251, 5284, 5409, 5457, 5470, 5673, 5748, 5858, 6109, 6142, 6216, 6220, 6285, 6291, 6363, 6390, 6419, 64
51, 6495, 6584, 6600, 6627, 6641, 6683, 6806, 6903, 6917, 6981, 7011, 7087, 7133, 7188, 7220, 7254, 741
1, 7501, 7643, 7678, 7703, 7822, 7985, 8167, 8215, 8289, 8383, 8417, 8540, 8564, 8621, 8680, 8687, 8751,
9144, 9284, 9437, 9559, 9604, 9778, 9831, 9847, 9880, 9942, 9989, 10080, 10081, 10397, 10400, 10415, 104
70, 10537, 10540, 10546, 10634, 10640, 10656, 10740, 10852, 10853, 10892, 10968, 10995, 11194, 11276, 11
315, 11439, 11442, 11457, 11532, 11582, 11628, 11634, 11690, 11738, 11753, 11786, 11901, 11937, 11952, 1
2007, 12014, 12399, 13214, 13237, 13308, 13666, 13809, 13873, 14033, 14123, 14176, 14217, 14257, 14258]
```

Selecting all the datapoints having the above important features from set 2

In [296]:
```
p = pd.DataFrame(X_tr_set2.todense())
```

In [297]:
```
X_tr_set2_fts = p.iloc[:,final_ft_imp]
```

In [298]:
```
print(X_tr_set2_fts.shape)
```

```
(49041, 185)
```

In [299]:
```
#xtr_ft_imp = pd.DataFrame(final_ft_imp.todense())
```

Selecting best Feature from the test set as well

In [300]:
```
q = pd.DataFrame(X_te_set2.todense())
```

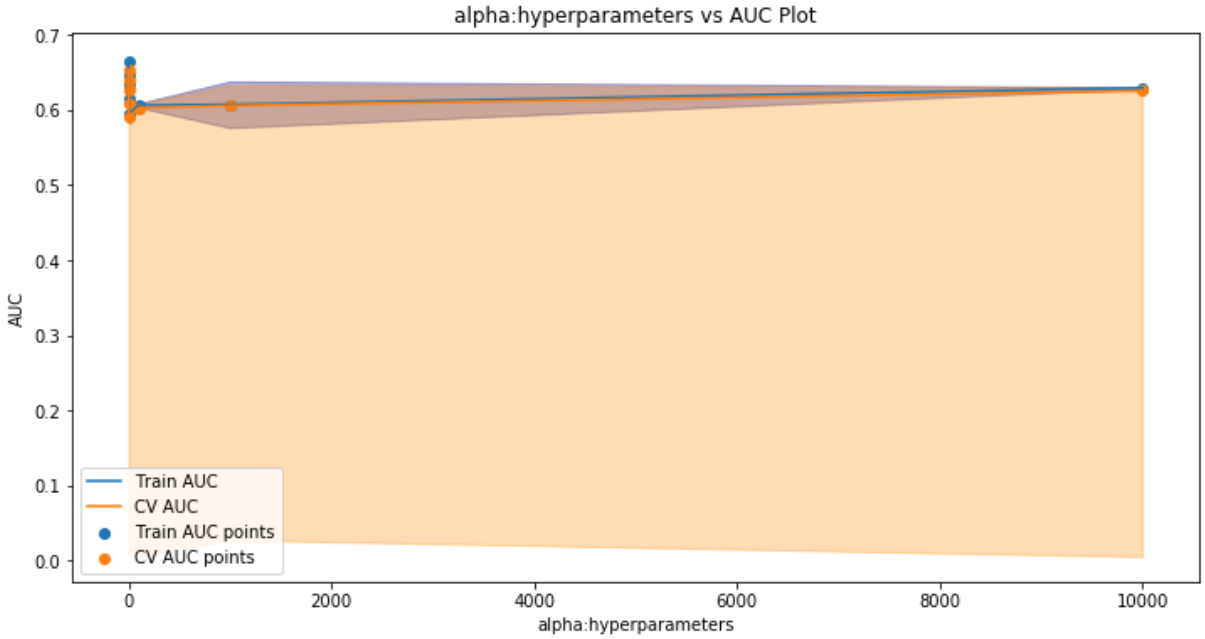
In [301]:
```
xte_ft_imp = q.iloc[:,final_ft_imp]
```

In [302]:
```
print(xte_ft_imp.shape)
```

```
(36052, 185)
```

Using Logistic Regression for modelling with top 5k Featuers

In [303]:
```
#code source: http://occam.olin.edu/sites/default/files/DataScienceMaterials/machine_learning_lecture_2/Mo
from sklearn.model_selection import learning_curve, GridSearchCV
from sklearn.datasets import *
from sklearn.linear_model import LogisticRegression,SGDClassifier
import matplotlib.pyplot as plt
data = data #refer: http://scikit-learn.org/stable/modules/generated/sklearn.datasets.load_breast_cancer.h
tuned_parameters = {'alpha': [10**(-4), 10**(-3), 10**(-2), 10**(-1), 1, 10, 10**2, 10**3, 10**4]}
#Using SGDClassifier
model = GridSearchCV(SGDClassifier(loss='log', class_weight='balanced'), tuned_parameters, cv=5, scoring=
model.fit(X_tr_set2_fts, y_train)

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

plt.figure()
plt.plot(tuned_parameters['alpha'],train_auc,label="Train AUC")
plt.gca().fill_between(tuned_parameters['alpha'],train_auc - train_auc_std,train_auc + train_auc_std, alph
plt.plot(tuned_parameters['alpha'],cv_auc,label="CV AUC")
plt.gca().fill_between(tuned_parameters['alpha'],cv_auc_std,cv_auc + cv_auc_std,alpha=0.3,color='darkorang
plt.scatter(tuned_parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(tuned_parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend(loc='best')
plt.xlabel("alpha:hyperparameters")
plt.ylabel("AUC")
plt.title("alpha:hyperparameters vs AUC Plot")
plt.show()
```

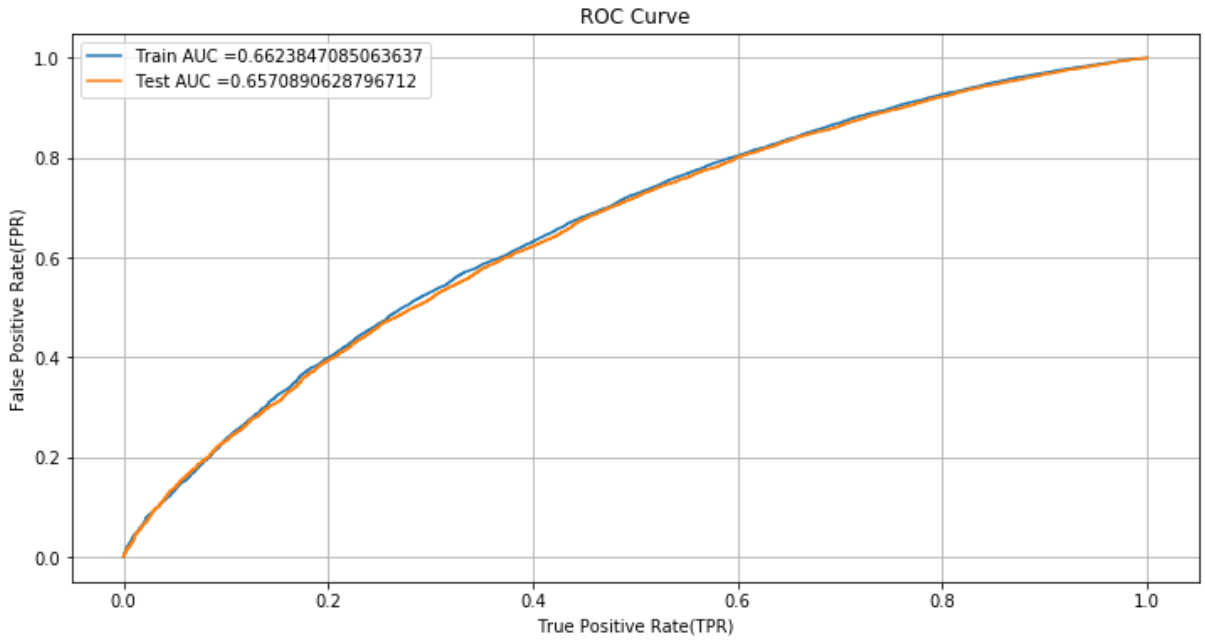


In [304]:
```
best_a = model.best_params_

best_a = list(best_a.values())[0]
print("Best a :{0}".format(best_a))
print(model.best_score_)
```

```
Best a :0.0001
0.6529949071498455
```

In [305]:
```
def batch_predict(clf, data):

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

    return y_data_pred
```

In [306]:
```
# https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curv
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import LogisticRegression,SGDClassifier

model = SGDClassifier(loss='log', alpha= best_a, class_weight='balanced')

model.fit(X_tr_set2_fts, 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(model, X_tr_set2_fts)
y_test_pred = batch_predict(model, xte_ft_imp)
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC Curve")
plt.grid(True)
plt.show()
```



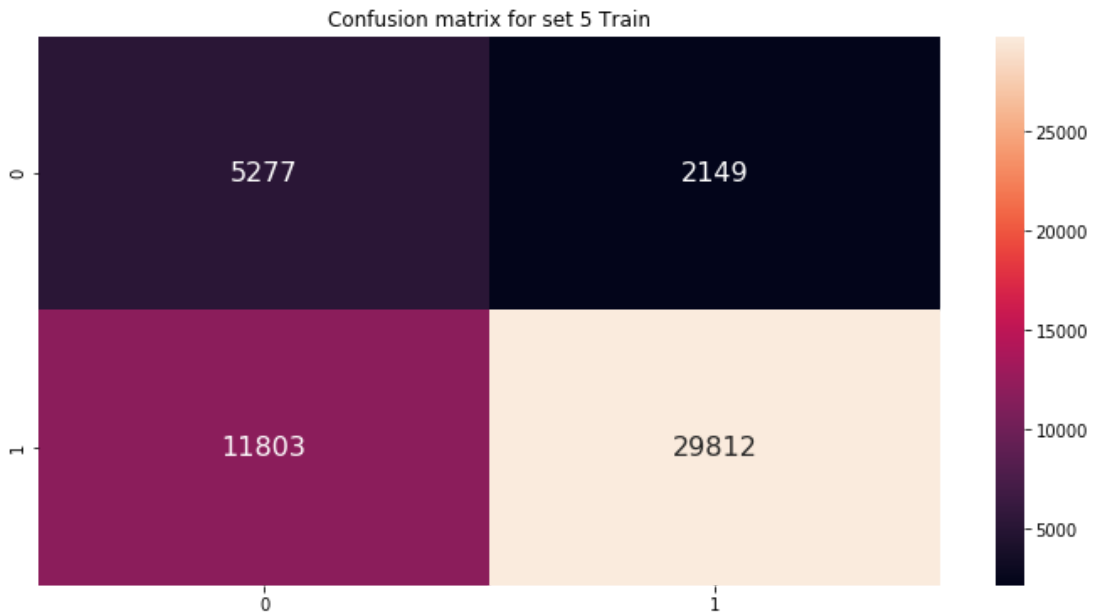
In [307]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshould, fpr, tpr):

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

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

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

In [308]:
```
print("="*100)
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, train_fpr, train_tpr)))
```

```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.38109469477676156 for threshold 0.507
[[ 4817  2609]
 [17166 24449]]
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.38109469477676156 for threshold 0.507
[[ 3522  1937]
 [12793 17800]]
```

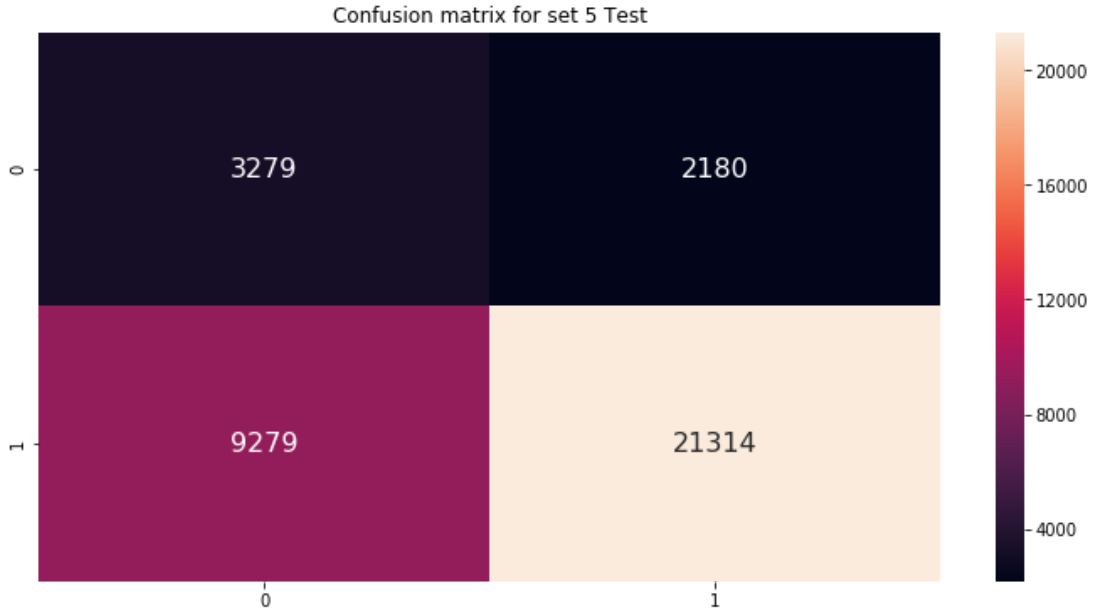
In [309]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[5277,2149],
        [11803,29812]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 5 Train')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[309]: <matplotlib.axes._subplots.AxesSubplot at 0x7ff015b995c0>



In [310]:
```
#How to plot confusion matrix using heat map - https://stackoverflow.com/questions/35572000/how-can-i-plot
import seaborn as sn
import pandas as pd
import matplotlib.pyplot as plt
array = [[3279,2180],
        [9279,21314]]
df_cm = pd.DataFrame(array, index = [i for i in "01"],
                  columns = [i for i in "01"])
plt.figure
plt.title('Confusion matrix for set 5 Test')
sn.heatmap(df_cm, annot=True, annot_kws={"size":16}, fmt='g')
```

Out[310]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff015939f98>
```



3. Conclusion

In [4]:
```
# Please compare all your models using Prettytable library
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Alpha",  "Max Depth", "Min Sample Split", "Test AUC"]
x.add_row(["BOW", "Decision Tree", "NA", "10", "500", "0.68"])
x.add_row(["TFIDF", "Decision Tree", "NA", "5", "500", "0.67"])
x.add_row(["AVG W2V", "Decision Tree", "NA", "5", "500", "0.66"])
x.add_row(["TFIDF W2V", "Decision Tree", "NA", "5", "500", "0.66"])
x.add_row(["TFIDF", "Logistic Regression", 0.0001, "NA", "NA", "0.65"])
print(x)
```

```
+------------+---------------------+--------+-----------+------------------+----------+
| Vectorizer |        Model        | Alpha  | Max Depth | Min Sample Split | Test AUC |
+------------+---------------------+--------+-----------+------------------+----------+
|    BOW     |    Decision Tree    |   NA   |     10    |       500        |   0.68   |
|   TFIDF    |    Decision Tree    |   NA   |     5     |       500        |   0.67   |
|  AVG W2V   |    Decision Tree    |   NA   |     5     |       500        |   0.66   |
| TFIDF W2V  |    Decision Tree    |   NA   |     5     |       500        |   0.66   |
|   TFIDF    | Logistic Regression | 0.0001 |     NA    |        NA        |   0.65   |
+------------+---------------------+--------+-----------+------------------+----------+
```

In [ ]: