RF and GBDT on 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!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`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`

Feature	Description
`description`	Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

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

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

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

Notes on the Essay Data

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

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

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

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

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

In [2]:
```
import warnings
warnings.filterwarnings("ignore")
%matplotlib inline


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

1.1 Reading Data (Considered 30K data)

In [219]:
```
project_data = pd.read_csv('train_data.csv',nrows=30000)
resource_data = pd.read_csv('resources.csv')
```

In [220]:
```
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 (30000, 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 [221]:
```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(project_data.columns)]


#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
project_data['Date'] = pd.to_datetime(project_data['project_submitted_datetime'])
project_data.drop('project_submitted_datetime', axis=1, inplace=True)
project_data.sort_values(by=['Date'], inplace=True)


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


project_data.head(2)
```

Out[221]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	proj
3287	159755	p147002	6ada7036aeb258d3653589d1f2a5b815	Mrs.	CA	2016-01-05 02:02:00	Grades 3-5	Liter Spec
19437	146532	p024903	55f60249d65840ee198285acdc455838	Mrs.	CA	2016-01-05 02:57:00	Grades 3-5	Math Lang

In [222]:
```
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[222]:

	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 [223]:
```
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"=> "Math","&", "S
cience"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [224]:
```
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"=> "Math","&", "S
cience"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

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

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

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

Preprocessing of `teacher_prefix`

In [225]:
```
#“Teacher prefix” data having the dots(.) and its has been observed the some rows are  empty in  this feature .
#the dot(.) and  empty row available in the data consider as float datatype and it does not
# accepted by the .Split() – Pandas function , so removing the same.
# cleaning has been done for the same following references are used
# 1.    Removing (.) from dataframe column - used ".str.replce" funtion (padas documentation)
# 2.    for  empty cell in datafram column - added the "Mrs." (in train data.cvs) which has me mostly occured in data
 set.

project_data["teacher_prefix_clean"] = project_data["teacher_prefix"].str.replace(".","")
project_data.head(2)
print(project_data.teacher_prefix_clean.shape)
```

```
(30000,)
```

1.4 Text preprocessing

In [226]:
```
# 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 [227]:
```
project_data.head(2)
```

Out[227]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	proj
3287	159755	p147002	6ada7036aeb258d3653589d1f2a5b815	Mrs.	CA	2016-01-05 02:02:00	Grades 3-5	Multi Apps Gam
19437	146532	p024903	55f60249d65840ee198285acdc455838	Mrs.	CA	2016-01-05 02:57:00	Grades 3-5	Colo Writi

In [228]:
```
# 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)
```

```
My students need new ways to learn. Research indicates technology and games help improve student engagement.My studen
ts are elementary students in kindergarten through sixth grade who have been identified with a disability, such as AD
HD, a learning disability, speech impairment, or autism. They attend a Title 1 school and about half are considered E
nglish learners. These students are able to learn but often in the less traditional way.My students are pulled from t
heir general education classrooms to work on their academic skills. It is my hope that these materials will help moti
vate my students to learn. They will learn how to comprehend the various forms of literacy, learn various academic sk
ills with educational apps, and improve their literacy skills.This donation will improve motivate my students to lear
n and increase student engagement. In addition, their academic skills and social skills will be enhanced through thes
e materials and better prepare them for life.
==================================================
A soft-spoken voice must say, \"Keep calm and cool down\" in order to see all of my students frowns turn upside down.
We are an underfunded, Title 1 school, in Philadelphia, with over 900 hundred students. Our school mission is to prov
ide a challenging education in a safe, caring environment where every student is challenged to reach his or her full
potential. We are an active bunch with active minds and emotions. At times we have our rough moments, but we have a
\"Cool Down Spot\" to think over our actions. My students express emotions in various ways. We play games, draw and u
se other various techniques, to express how we feel and cool down. My students absolutely love technology to learn an
d relax. Technology allows my students to learn and explore with apps, downloadable books and Lexia. My students love
Lexia and books. Technology allows my students to be hands on and engaged. We currently have two computers and the ta
blets would allow everyone a turn on Lexia and to download stories for us to share in small group.\r\n\r\nMy students
will be able to use the tablets for Lexia, take turns on a game and review literacy and mathematical skills through a
ctive learning games. All of my active techies will be able to learn, express and work towards success in various way
s and skill sets. At times, some of my students become angry or upset, but my students know what makes them happy and
calm. Technology allows my students to relax, speak and express they way they feel through picture apps. \r\n\r\nOver
all, we work to learn and we learn to work! My students will continue to learn various techniques to calm down when u
pset, angry or frustrated. The resources will provide an environment for my students to look forward to using every d
ay for literacy, math and games. My students can download games to bond together. The organization bin will allow my
students to respect the tablets. My students will learn to minimize anger and build positive relationships amongst on
e another with these new and innovative resources.nannan
==================================================
I work in the special ed. department of a junior high.  We have seen greatly increasing numbers of autistic students
in this region, we have also seen increasing numbers of autistic students who do not access the curriculum due to a c
oncomitant disability, such as ADHD.  Not only do these students struggle with understanding the social cues which te
achers give and having the social ability to ask questions for clarity to understand directions, but they also strugg
le with various aspects of their assignments due to the ADHD disability.   These aspects are typically related to exe
cutive functioning, such as working memory, organizational skills, ability to monitor time, and the physical act of w
riting.I am requesting an iPad 2 mini to help my students access any curriculum which requires writing.   Poor Transc
ription problems are often associated with ADHD.   I recently reviewed assignments, and found a dramatic difference b
etween grades which required writing and those that did not. \r\nDifficulty writing smoothly and easily, letters that
are reversed, rotated, and generally unrecognizable are common.\r\nI have seen this gap between what a student knows
and what a student can physically write many times.  I know my students would really benefit if they had more access
to keyboards to take notes and do projects within the junior high setting.nannan
==================================================
```

In [229]:
```
# 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 [230]:
```
sent = decontracted(project_data['essay'].values[2000])
print(sent)
print("="*50)
```

```
What would a Kindergarten classroom be without a dramatic play area? Currently, my classroom does not have any dramat
ic play supplies. In addition to learning to read, write, add, and subtract, kindergartners need to opportunity to le
arn and express themselves through dramatic play.\r\nMy students are fantastic!\r\nThey are a creative group of kids
who are eager to learn. I work in a   Title-1 school with 90% of the students with free  Breakfast and Lunch. My stud
ents deserve the best! Without a dramatic play area, my students miss out on an important piece of growing and learni
ng. These supplies (kitchen set, shop stand, and play food) will enhance the learning in my classroom by giving the s
tudents real life experiences which will provide them with an opportunity to learn through social interaction and dra
matic play. Please help support this project.\r\n\r\n\r\nDuring the Kindergarten day, there is a time for learning ce
nters. During this time, the students learn through self discovery and play. Currently, my classroom does not have dr
amatic play supplies. My classroom really needs dramatic play supplies to support the developmental needs of my stude
nts The students will use kitchen set, grocery store/restaurant stand, and play food to create a play house, grocery
store, restaurant, and anything else their imagination dreams up. Dramatic play is very important to the social skill
s, learning, and development of Kindergartners. I want to give my students these experiences!\r\nIf I am able to add
a dramatic play area to my classroom, I will be able to enhance the learning experience of my students for years to c
ome!\r\nCreative, dramatic play is a very important aspect to the social skills and development of Kindergarten stude
nts. This project will give my students the opportunity to learn important developmental skills through dramatic pla
y.\r\nnannan
==================================================
```

In [231]:
```
# \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)
```

```
What would a Kindergarten classroom be without a dramatic play area? Currently, my classroom does not have any dramat
ic play supplies. In addition to learning to read, write, add, and subtract, kindergartners need to opportunity to le
arn and express themselves through dramatic play.  My students are fantastic!  They are a creative group of kids who
are eager to learn. I work in a   Title-1 school with 90% of the students with free  Breakfast and Lunch. My students
deserve the best! Without a dramatic play area, my students miss out on an important piece of growing and learning. T
hese supplies (kitchen set, shop stand, and play food) will enhance the learning in my classroom by giving the studen
ts real life experiences which will provide them with an opportunity to learn through social interaction and dramatic
play. Please help support this project.      During the Kindergarten day, there is a time for learning centers. Durin
g this time, the students learn through self discovery and play. Currently, my classroom does not have dramatic play
supplies. My classroom really needs dramatic play supplies to support the developmental needs of my students The stud
ents will use kitchen set, grocery store/restaurant stand, and play food to create a play house, grocery store, resta
urant, and anything else their imagination dreams up. Dramatic play is very important to the social skills, learning,
and development of Kindergartners. I want to give my students these experiences!  If I am able to add a dramatic play
area to my classroom, I will be able to enhance the learning experience of my students for years to come!  Creative,
dramatic play is a very important aspect to the social skills and development of Kindergarten students. This project
will give my students the opportunity to learn important developmental skills through dramatic play.  nannan
```

In [232]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
What would a Kindergarten classroom be without a dramatic play area Currently my classroom does not have any dramatic
play supplies In addition to learning to read write add and subtract kindergartners need to opportunity to learn and
express themselves through dramatic play My students are fantastic They are a creative group of kids who are eager to
learn I work in a Title 1 school with 90 of the students with free Breakfast and Lunch My students deserve the best W
ithout a dramatic play area my students miss out on an important piece of growing and learning These supplies kitchen
set shop stand and play food will enhance the learning in my classroom by giving the students real life experiences w
hich will provide them with an opportunity to learn through social interaction and dramatic play Please help support
this project During the Kindergarten day there is a time for learning centers During this time the students learn thr
ough self discovery and play Currently my classroom does not have dramatic play supplies My classroom really needs dr
amatic play supplies to support the developmental needs of my students The students will use kitchen set grocery stor
e restaurant stand and play food to create a play house grocery store restaurant and anything else their imagination
dreams up Dramatic play is very important to the social skills learning and development of Kindergartners I want to g
ive my students these experiences If I am able to add a dramatic play area to my classroom I will be able to enhance
the learning experience of my students for years to come Creative dramatic play is a very important aspect to the soc
ial skills and development of Kindergarten students This project will give my students the opportunity to learn impor
tant developmental skills through dramatic play nannan
```

In [233]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'furthe
r',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'mor
e',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now', 'd', 'll', 'm', 'o', 're',
 \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'weren', "were
n't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

1.4.1 Data Pracessing (Essay)

In [234]:
```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████| 30000/30000 [00:15<00:00, 1894.67it/s]
```

In [235]:
```
project_data["preprocessed_essays"] = preprocessed_essays
```

In [236]:
```
project_data.shape
```

Out[236]: (30000, 20)

1.4.2 Words in the Essay

In [237]:
```
# https://stackoverflow.com/questions/49984905/count-number-of-words-per-row/49984998
project_data['essay_word_count'] = [len(x.split()) for x in project_data['preprocessed_essays'].tolist()]
```

In [238]:
```
project_data.shape
```

Out[238]: (30000, 21)

In [239]:
```
project_data.head(2)
```

Out[239]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	proj
3287	159755	p147002	6ada7036aeb258d3653589d1f2a5b815	Mrs.	CA	2016-01-05 02:02:00	Grades 3-5	Multi Apps Gam
19437	146532	p024903	55f60249d65840ee198285acdc455838	Mrs.	CA	2016-01-05 02:57:00	Grades 3-5	Colo Writi

2 rows × 21 columns

1.5 Preprocessing of `project_title`

In [240]:
```
# Data processing for project titles
Title_clean = project_data.project_title
Title_clean.head(2)
```

Out[240]:
```
3287     Multimedia, Apps, and a Game
19437                Colorful Writing
Name: project_title, dtype: object
```

In [241]:
```
P = decontracted(project_data['project_title'].values[1])
print(P)
```

```
Colorful Writing
```

In [242]:
```
# \r \n \t  and -- remove from string python: http://texthandler.com/info/remove-line-breaks-python/
P = P.replace('\\r', ' ')
P = P.replace('\\"', ' ')
P = P.replace('\\n', ' ')
P = P.replace('--', ' ')
print(P)
```

```
Colorful Writing
```

1.5.1 Data Pracessing (Project Title)

In [243]:
```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_Titles = []
# tqdm is for printing the status bar
for Pance in tqdm(project_data['project_title'].values):
    P = decontracted(Pance)
    P = P.replace('\\r', ' ')
    P = P.replace('\\"', ' ')
    P = P.replace('\\n', ' ')
    P = re.sub('[^A-Za-z0-9]+', ' ', P)
    # https://gist.github.com/sebleier/554280
    P = ' '.join(e for e in P.split() if e not in stopwords)
    preprocessed_Titles.append(P.lower().strip())
```

```
100%|██████████| 30000/30000 [00:00<00:00, 41647.62it/s]
```

In [244]:
```
project_data["preprocessed_Titles"] = preprocessed_Titles
```

1.5.2 Words in the Project Title

In [245]:
```
project_data['title_word_count'] = [len(x.split()) for x in project_data['preprocessed_Titles'].tolist()]
```

In [246]:
```
project_data.head(2)
```

Out[246]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	proj
3287	159755	p147002	6ada7036aeb258d3653589d1f2a5b815	Mrs.	CA	2016-01-05 02:02:00	Grades 3-5	Multi Apps Gam
19437	146532	p024903	55f60249d65840ee198285acdc455838	Mrs.	CA	2016-01-05 02:57:00	Grades 3-5	Colo Writi

2 rows × 23 columns

Train , Cross Validation and Test Data Split

In [247]:
```
#As recommended in the Lecture video, splitting the Data in Train, Test and Cross validation data set
#before applying Vectorization to avoid the data leakage issues.
# As suggested to use stratify sampling, Referred following site for code
# https://stackoverflow.com/questions/29438265/stratified-train-test-split-in-scikit-learn



# split the data set into train and test
X_train, X_test, y_train, y_test = cross_validation.train_test_split(project_data, project_data['project_is_approved'
], test_size=0.33,stratify = project_data['project_is_approved'
])

# split the train data set into cross validation train and cross validation test
X_train, X_cv, y_train, y_cv = cross_validation.train_test_split(X_train, y_train, test_size=0.33,stratify=y_train)
```

1.6 Preparing data for models

In [248]:
```
project_data.columns
```

Out[248]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'teacher_prefix_clean',
       'essay', 'preprocessed_essays', 'essay_word_count',
       'preprocessed_Titles', 'title_word_count'],
      dtype='object')
```

1.6.1 Vectorizing Text data

1.6.1.1 Bag of words

Train Data Vectorization - BOW (essays)

In [249]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_bow_essay = CountVectorizer(min_df=10)

bow_essays_train = vectorizer_bow_essay.fit_transform(X_train["preprocessed_essays"])
print("Shape of matrix after one hot encodig ",bow_essays_train.shape)
```

```
Shape of matrix after one hot encodig  (13467, 7111)
```

CV Data Vectorization - BOW (essays)

In [250]:
```
bow_essays_cv = vectorizer_bow_essay.transform(X_cv["preprocessed_essays"])
print("Shape of matrix after one hot encodig ",bow_essays_cv.shape)
```

```
Shape of matrix after one hot encodig  (6633, 7111)
```

Test Data Vectorization - BOW (essays)

In [251]:
```
bow_essays_test = vectorizer_bow_essay.transform(X_test["preprocessed_essays"])
print("Shape of matrix after one hot encoding ",bow_essays_test.shape)
```

```
Shape of matrix after one hot encoding  (9900, 7111)
```

Train Data Vectorization - BOW (Project Titles)

In [252]:
```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_bow_title = CountVectorizer(min_df=10)
bow_title_train = vectorizer_bow_title.fit_transform(X_train["preprocessed_Titles"])
print("Shape of matrix after one hot encodig ",bow_title_train.shape)
```

```
Shape of matrix after one hot encodig  (13467, 832)
```

CV Data Vectorization - BOW (Project Titles)

In [253]:
```
bow_title_cv = vectorizer_bow_title.transform(X_cv["preprocessed_Titles"])
print("Shape of matrix after one hot encodig ",bow_title_cv.shape)
```

```
Shape of matrix after one hot encodig  (6633, 832)
```

Test Data Vectorization - BOW (Project Titles)

In [254]:
```
bow_title_test = vectorizer_bow_title.transform(X_test["preprocessed_Titles"])
print("Shape of matrix after one hot encodig ",bow_title_test.shape)
```

```
Shape of matrix after one hot encodig  (9900, 832)
```

1.6.1.2 TFIDF vectorizer

Train Data Vectorization - TFIDF (essays)

In [255]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
tfidf_essays_train = vectorizer_tfidf_essay.fit_transform(X_train["preprocessed_essays"])
print("Shape of matrix after one hot encodig ",tfidf_essays_train.shape)
```

```
Shape of matrix after one hot encodig  (13467, 7111)
```

CV Data Vectorization - TFIDF (essays)

In [256]:
```
tfidf_essays_cv = vectorizer_tfidf_essay.transform(X_cv["preprocessed_essays"])
print("Shape of matrix after one hot encodig ",tfidf_essays_cv.shape)
```

```
Shape of matrix after one hot encodig  (6633, 7111)
```

Test Data Vectorization - TFIDF (essays)

In [257]:
```
tfidf_essays_test = vectorizer_tfidf_essay.transform(X_test["preprocessed_essays"])
print("Shape of matrix after one hot encodig ",tfidf_essays_test.shape)
```

```
Shape of matrix after one hot encodig  (9900, 7111)
```

Train Data Vectorization - TFIDF (Project Titles)

In [258]:
```
vectorizer_tfidf_title = CountVectorizer(min_df=10)
tfidf_title_train = vectorizer_tfidf_title.fit_transform(X_train["preprocessed_Titles"])
print("Shape of matrix after one hot encodig ",bow_title_train.shape)
```

```
Shape of matrix after one hot encodig  (13467, 832)
```

CV Data Vectorization - TFIDF (Project Titles)

In [259]:
```
tfidf_title_cv = vectorizer_tfidf_title.transform(X_cv["preprocessed_Titles"])
print("Shape of matrix after one hot encodig ",bow_title_cv.shape)
```

```
Shape of matrix after one hot encodig  (6633, 832)
```

Test Data Vectorization - TFIDF (Project Titles)

In [260]:
```
tfidf_title_test = vectorizer_tfidf_title.transform(X_test["preprocessed_Titles"])
print("Shape of matrix after one hot encodig ",bow_title_test.shape)
```

```
Shape of matrix after one hot encodig  (9900, 832)
```

1.6.1.3 Using Pretrained Models: Avg W2V

In [45]:
```
# 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')
```

```
Loading Glove Model

1917495it [03:41, 8676.37it/s]

Done. 1917495  words loaded!
```

In [46]:
```
words = []
for i in X_train["preprocessed_essays"]:
    words.extend(i.split(' '))

for i in X_train["preprocessed_essays"]:
    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))
```

```
all the words in the coupus 4435736
the unique words in the coupus 26080
The number of words that are present in both glove vectors and our coupus 24910 ( 95.514 %)
word 2 vec length 24910
```

In [47]:
```
words = []
for i in X_train["preprocessed_Titles"]:
    words.extend(i.split(' '))

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

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

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

```
all the words in the coupus 127156
the unique words in the coupus 6609
The number of words that are present in both glove vectors and our coupus 6454 ( 97.655 %)
word 2 vec length 6454
```

In [48]:
```
import pickle
with open('glove_vectors', 'wb') as f:
    pickle.dump(words_courpus, f)
```

In [49]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

Train Data Vectorization - AGV_W2V (essays)

In [261]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_essays_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["preprocessed_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essays_train.append(vector)

print(len(avg_w2v_essays_train))
print(len(avg_w2v_essays_train[0]))
```

```
100%|████████████████████████████████████████████████████████████| 13467/13467 [00:03<00:00, 4238.13it/s]
13467
300
```

CV Data Vectorization - AGV_W2V (essays)

In [262]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_essays_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["preprocessed_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_essays_cv.append(vector)

print(len(avg_w2v_essays_cv))
print(len(avg_w2v_essays_cv[0]))
```

```
100%|████████████████████████████████████████████████████████████| 6633/6633 [00:01<00:00, 3985.20it/s]

6633
300
```

Test Data Vectorization - AGV_W2V (essays)

In [263]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_essays_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["preprocessed_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    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_essays_test.append(vector)

print(len(avg_w2v_essays_test))
print(len(avg_w2v_essays_test[0]))
```

```
100%|██████████████████████████████████████████████████████████| 9900/9900 [00:02<00:00, 4047.59it/s]

9900
300
```

Train Data Vectorization - AGV_W2V (Project Titles)

In [264]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["preprocessed_Titles"]): # 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_title_train.append(vector)

print(len(avg_w2v_title_train))
print(len(avg_w2v_title_train[0]))
```

```
100%|██████████████████████████████████████████████████████████| 13467/13467 [00:00<00:00, 70343.40it/s]

13467
300
```

CV Data Vectorization - AGV_W2V (Project Titles)

In [265]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_title_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["preprocessed_Titles"]): # 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_title_cv.append(vector)

print(len(avg_w2v_title_cv))
print(len(avg_w2v_title_cv[0]))
```

```
100%|██████████████████████████████████████████████████████████| 6633/6633 [00:00<00:00, 75478.63it/s]

6633
300
```

Test Data Vectorization - AGV_W2V (Project Titles)

In [266]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_title_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["preprocessed_Titles"]): # 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_title_test.append(vector)

print(len(avg_w2v_title_test))
print(len(avg_w2v_title_test[0]))
```

```
100%|██████████████████████████████████████████████████████████| 9900/9900 [00:00<00:00, 65218.55it/s]

9900
300
```

1.6.1.3 Using Pretrained Models: TFIDF weighted W2V

In [267]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train["preprocessed_essays"])
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

Train Data Vectorization - TFIDF_W2V (essays)

In [268]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_essays_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["preprocessed_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.
split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each
 word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_essays_train.append(vector)

print(len(tfidf_w2v_essays_train))
print(len(tfidf_w2v_essays_train[0]))
```

```
100%|██████████████████████████████████████████████████████████| 13467/13467 [00:22<00:00, 590.96it/s]

13467
300
```

CV Data Vectorization - TFIDF_W2V (essays)

In [269]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_essays_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["preprocessed_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.
split()))) 
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each
 word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_essays_cv.append(vector)

print(len(tfidf_w2v_essays_cv))
print(len(tfidf_w2v_essays_cv[0]))
```

```
100%|██████████| 6633/6633 [00:11<00:00, 588.78it/s]

6633
300
```

Test Data Vectorization - TFIDF_W2V (essays)

In [270]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_essays_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["preprocessed_essays"]): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.
split()))) 
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each
 word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_essays_test.append(vector)

print(len(tfidf_w2v_essays_test))
print(len(tfidf_w2v_essays_test[0]))
```

```
100%|██████████| 9900/9900 [00:16<00:00, 595.19it/s]

9900
300
```

In [271]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train["preprocessed_Titles"])
# 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_titles = set(tfidf_model.get_feature_names())
```

Train Data Vectorization - TFIDF_W2V (Project Titles)

In [272]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_title_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train["preprocessed_Titles"]): # 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_titles):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.
split()))) 
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each
 word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_title_train.append(vector)

print(len(tfidf_w2v_title_train))
print(len(tfidf_w2v_title_train[0]))
```

```
100%|████████████████████████████████████████████████████████████| 13467/13467 [00:00<00:00, 34868.41it/s]

13467
300
```

CV Data Vectorization - TFIDF_W2V (Project Titles)

In [273]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_title_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv["preprocessed_Titles"]): # 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_titles ):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.
split()))) 
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each
 word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_title_cv.append(vector)

print(len(tfidf_w2v_title_cv))
print(len(tfidf_w2v_title_cv[0]))
```

```
100%|████████████████████████████████████████████████████████████| 6633/6633 [00:00<00:00, 33833.46it/s]

6633
300
```

Test Data Vectorization - TFIDF_W2V (Project Titles)

In [274]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_title_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test["preprocessed_Titles"]): # 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_titles):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.
split()))) 
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each
 word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_title_test.append(vector)

print(len(tfidf_w2v_title_test))
print(len(tfidf_w2v_title_test[0]))
```

```
100%|████████████████████████████████████████████████████████████| 9900/9900 [00:00<00:00, 36781.58it/s]

9900
300
```

1.6.2 Vectorizing Numerical features

1.6.2.1 Vectorizing Numerical features - Price

In [275]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()

# Merging the project data train , Cv , test with price from resource data
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
```

In [276]:
```
X_train.head(2)
```

Out[276]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_ti
0	169306	p221374	cdd537a38dd777ab82bde350ef0bca81	Mrs.	IN	2016-07-08 11:15:00	Grades PreK-2	Movemen At Your Se
1	10913	p176797	676a4235f7e8ecb6eae1d144314a9c0a	Ms.	IL	2016-06-30 14:08:00	Grades 6-8	Need Translatio No Problemo!

2 rows × 25 columns

In [277]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.normalize.html

from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['price'].values.reshape(-1,1))

price_train = normalizer.transform(X_train['price'].values.reshape(-1,1))
price_cv = normalizer.transform(X_cv['price'].values.reshape(-1,1))
price_test = normalizer.transform(X_test['price'].values.reshape(-1,1))

print(price_train.shape)
print(price_cv.shape)
print(price_test.shape)
```

```
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.2.2 Vectorizing Numerical features - teacher_number_of_previously_posted_projects

In [278]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

prev_post_train = normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_post_cv = normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_post_test = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

print(prev_post_train.shape)
print(prev_post_cv.shape)
print(prev_post_test.shape)
```

```
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.2.3 Vectorizing Numerical features - Quantity

In [279]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['quantity'].values.reshape(-1,1))

Quantity_train = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
Quantity_cv = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
Quantity_test = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

print(Quantity_train.shape)
print(Quantity_cv.shape)
print(Quantity_test.shape)
```

```
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.2.4 Vectorizing Numerical features - Project Title word count

In [280]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['title_word_count'].values.reshape(-1,1))

title_word_count_train = normalizer.transform(X_train['title_word_count'].values.reshape(-1,1))
title_word_count_cv = normalizer.transform(X_cv['title_word_count'].values.reshape(-1,1))
title_word_count_test = normalizer.transform(X_test['title_word_count'].values.reshape(-1,1))

print(title_word_count_train.shape)
print(title_word_count_cv.shape)
print(title_word_count_test.shape)
```

```
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.2.5 Vectorizing Numerical features - Essay word count

In [281]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
normalizer.fit(X_train['essay_word_count'].values.reshape(-1,1))

essay_word_count_train = normalizer.transform(X_train['essay_word_count'].values.reshape(-1,1))
essay_word_count_cv = normalizer.transform(X_cv['essay_word_count'].values.reshape(-1,1))
essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.reshape(-1,1))

print(essay_word_count_train.shape)
print(essay_word_count_cv.shape)
print(essay_word_count_test.shape)
```

```
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.3 Categorical features - Response Coding

In [282]:
```
#Followed the Implementation Steps provided by Applied AI Team

#1.Consider each categorical feature separately from the train dataset

#2.Find the probability of each category based on the class_labels('0' and '1')

#3.Generate "Class_0" and "Class_1" values for each type of category.

#4.Append those class_0 and class_1 values for a particular category of categorical feature
#which is present in the train data and test data and Cv data.

#5. If there is a new category in your test data, consider 0.5, 0.5 as it's value
```

1.6.3.1 Project_categories - Response Coding

Finding the positive and negative classes

In [283]:
```
X_train.columns
```

Out[283]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'teacher_prefix_clean',
       'essay', 'preprocessed_essays', 'essay_word_count',
       'preprocessed_Titles', 'title_word_count', 'price', 'quantity'],
      dtype='object')
```

In [284]:
```
X_train_PC = X_train.loc[X_train['project_is_approved'] == 1]
```

In [285]:
```
clean_category_PC = {}

for a in X_train_PC['clean_categories'] :
    for b in a.split():
        if b not in clean_category_PC :
            clean_category_PC[b] = 1
        else :
            clean_category_PC[b] += 1
```

In [286]:
```
X_train_NC = X_train.loc[X_train['project_is_approved'] == 0]
```

In [287]:
```
clean_category_NC = {}

for a in X_train_NC['clean_categories'] :
    for b in a.split():
        if b not in clean_category_NC :
            clean_category_NC[b] = 1
        else :
            clean_category_NC[b] += 1
```

In [288]:
```
clean_category_total = {}

for a in X_train['clean_categories'] :
    for b in a.split():
        if b not in clean_category_total :
            clean_category_total[b] = 1
        else :
            clean_category_total[b] += 1
```

Finding Probability for positive and negative class

In [289]:
```
PC_prob_category = {}

for pc in clean_category_total.keys():
    PC_prob_category[pc] = (clean_category_PC[pc])/float(clean_category_total[pc])
```

In [290]:
```
NC_prob_category = {}

for nc in clean_category_total.keys():
    NC_prob_category[nc] = (clean_category_NC[nc])/float(clean_category_total[nc])
```

Train data- Applying Probability

In [291]:
```
cat_nc_train = []
cat_pc_train = []

for a in X_train["clean_categories"] :
    b = a.split()
    if len(b) == 1 :
        cat_nc_train.append(NC_prob_category[a])
        cat_pc_train.append(PC_prob_category[a])
    else :
        c = NC_prob_category[b[0]]
        d = NC_prob_category[b[1]]
        e = PC_prob_category[b[0]]
        f = PC_prob_category[b[1]]

        cat_nc_train.append(c*d)
        cat_pc_train.append(e*f)
```

In [292]:
```
X_train["cat_nc_train"] = cat_nc_train
X_train["cat_pc_train"] = cat_pc_train
```

cv data- Applying Probability

In [293]:
```
cat_nc_cv = []
cat_pc_cv = []

for a in X_cv["clean_categories"] :
    b = a.split()
    if len(b) == 1 :
        cat_nc_cv.append(NC_prob_category[a])
        cat_pc_cv.append(PC_prob_category[a])
    else :
        c = NC_prob_category[b[0]]
        d = NC_prob_category[b[1]]
        e = PC_prob_category[b[0]]
        f = PC_prob_category[b[1]]

        cat_nc_cv.append(c*d)
        cat_pc_cv.append(e*f)
```

In [294]:
```
X_cv["cat_nc_cv"] = cat_nc_cv
X_cv["cat_pc_cv"] = cat_pc_cv
```

Test data- Applying Probability

In [295]:
```
cat_nc_test = []
cat_pc_test = []

for a in X_test["clean_categories"] :
    b = a.split()
    if len(b) == 1 :
        cat_nc_test.append(NC_prob_category[a])
        cat_pc_test.append(PC_prob_category[a])
    else :
        c = NC_prob_category[b[0]]
        d = NC_prob_category[b[1]]
        e = PC_prob_category[b[0]]
        f = PC_prob_category[b[1]]

        cat_nc_test.append(c*d)
        cat_pc_test.append(e*f)
```

In [296]:
```
X_test["cat_nc_test"] = cat_nc_test
X_test["cat_pc_test"] = cat_pc_test
```

Negative Class - Normalization

In [297]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["cat_nc_train"].values.reshape(-1,1))

cat_nc_train = normalizer.transform(X_train["cat_nc_train"].values.reshape(-1,1))
cat_nc_cv= normalizer.transform(X_cv["cat_nc_cv"].values.reshape(-1,1))
cat_nc_test = normalizer.transform(X_test["cat_nc_test"].values.reshape(-1,1))


print("After vectorizations")
print(cat_nc_train.shape)
print(cat_nc_cv.shape)
print(cat_nc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

Positive Class - Normalization

In [298]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["cat_pc_train"].values.reshape(-1,1))

cat_pc_train = normalizer.transform(X_train["cat_pc_train"].values.reshape(-1,1))
cat_pc_cv= normalizer.transform(X_cv["cat_pc_cv"].values.reshape(-1,1))
cat_pc_test = normalizer.transform(X_test["cat_pc_test"].values.reshape(-1,1))


print("After vectorizations")
print(cat_pc_train.shape)
print(cat_pc_cv.shape)
print(cat_pc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.3.2 Project_sub_categories - Response Coding

In [299]:
```
clean_subcategory_PC = {}

for a in X_train_PC['clean_subcategories'] :
    for b in a.split():
        if b not in clean_subcategory_PC :
            clean_subcategory_PC[b] = 1
        else :
            clean_subcategory_PC[b] += 1
```

In [300]:
```
clean_subcategory_NC = {}

for a in X_train_NC['clean_subcategories'] :
    for b in a.split():
        if b not in clean_subcategory_NC :
            clean_subcategory_NC[b] = 1
        else :
            clean_subcategory_NC[b] += 1
```

In [301]:
```
clean_subcategory_total = {}

for a in X_train['clean_subcategories'] :
    for b in a.split():
        if b not in clean_subcategory_total :
            clean_subcategory_total[b] = 1
        else :
            clean_subcategory_total[b] += 1
```

Finding Probability for positive and negative class

In [302]:
```
PC_prob_subcategory = {}

for pc in clean_subcategory_total.keys():
    PC_prob_subcategory[pc] = (clean_subcategory_PC[pc])/float(clean_subcategory_total[pc])
```

In [303]:
```
NC_prob_subcategory = {}

for nc in clean_subcategory_total.keys():
    NC_prob_subcategory[nc] = (clean_subcategory_NC[nc])/float(clean_subcategory_total[nc])
```

Train data- Applying Probability

In [304]:
```
subcat_nc_train = []
subcat_pc_train = []

for a in X_train["clean_subcategories"] :
    b = a.split()
    if len(b) == 1 :
        subcat_nc_train.append(NC_prob_subcategory[a])
        subcat_pc_train.append(PC_prob_subcategory[a])
    else :
        c = NC_prob_subcategory[b[0]]
        d = NC_prob_subcategory[b[1]]
        e = PC_prob_subcategory[b[0]]
        f = PC_prob_subcategory[b[1]]

        subcat_nc_train.append(c*d)
        subcat_pc_train.append(e*f)
```

In [305]:
```
X_train["subcat_nc_train"] = subcat_nc_train
X_train["subcat_pc_train"] = subcat_pc_train
```

cv data- Applying Probability

In [306]:
```
subcat_nc_cv = []
subcat_pc_cv = []

for a in X_cv["clean_subcategories"] :
    b = a.split()
    if len(b) == 1 :
        subcat_nc_cv.append(NC_prob_subcategory[a])
        subcat_pc_cv.append(PC_prob_subcategory[a])
    else :
        c = NC_prob_subcategory[b[0]]
        d = NC_prob_subcategory[b[1]]
        e = PC_prob_subcategory[b[0]]
        f = PC_prob_subcategory[b[1]]

        subcat_nc_cv.append(c*d)
        subcat_pc_cv.append(e*f)
```

In [307]:
```
X_cv["subcat_nc_cv"] = subcat_nc_cv
X_cv["subcat_pc_cv"] = subcat_pc_cv
```

test data- Applying Probability

In [308]:
```
subcat_nc_test = []
subcat_pc_test = []

for a in X_test["clean_subcategories"] :
    b = a.split()
    if len(b) == 1 :
        subcat_nc_test.append(NC_prob_subcategory[a])
        subcat_pc_test.append(PC_prob_subcategory[a])
    else :
        c = NC_prob_subcategory[b[0]]
        d = NC_prob_subcategory[b[1]]
        e = PC_prob_subcategory[b[0]]
        f = PC_prob_subcategory[b[1]]

        subcat_nc_test.append(c*d)
        subcat_pc_test.append(e*f)
```

In [309]:
```
X_test["subcat_nc_test"] = subcat_nc_test
X_test["subcat_pc_test"] = subcat_pc_test
```

Negative Class - Normalization

In [310]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["subcat_nc_train"].values.reshape(-1,1))

subcat_nc_train = normalizer.transform(X_train["subcat_nc_train"].values.reshape(-1,1))
subcat_nc_cv= normalizer.transform(X_cv["subcat_nc_cv"].values.reshape(-1,1))
subcat_nc_test = normalizer.transform(X_test["subcat_nc_test"].values.reshape(-1,1))


print("After vectorizations")
print(subcat_nc_train.shape)
print(subcat_nc_cv.shape)
print(subcat_nc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

Positive Class - Normalization

In [311]:
```
normalizer.fit(X_train["subcat_pc_train"].values.reshape(-1,1))

subcat_pc_train = normalizer.transform(X_train["subcat_pc_train"].values.reshape(-1,1))
subcat_pc_cv= normalizer.transform(X_cv["subcat_pc_cv"].values.reshape(-1,1))
subcat_pc_test = normalizer.transform(X_test["subcat_pc_test"].values.reshape(-1,1))


print("After vectorizations")
print(subcat_pc_train.shape)
print(subcat_pc_cv.shape)
print(subcat_pc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.3.3 School_State - Response Coding

In [312]:
```
school_state_PC = {}

for a in X_train_PC['school_state'] :

        if a not in school_state_PC :
            school_state_PC[a] = 1
        else :
            school_state_PC[a] += 1
```

In [313]:
```
school_state_NC = {}

for a in X_train_NC['school_state'] :

        if a not in school_state_NC :
            school_state_NC[a] = 1
        else :
            school_state_NC[a] += 1
```

In [314]:
```
school_state_total = {}

for a in X_train['school_state'] :

        if a not in school_state_total :
            school_state_total[a] = 1
        else :
            school_state_total[a] += 1
```

Finding Probability for positive and negative class

In [315]:
```
PC_prob_school_state = {}

for pc in school_state_total.keys():
    PC_prob_school_state[pc] = (school_state_PC[pc])/float(school_state_total[pc])
```

In [316]:
```
NC_prob_school_state = {}

for nc in school_state_total.keys():
    NC_prob_school_state[nc] = (school_state_NC[nc])/float(school_state_total[nc])
```

Train data- Applying Probability

In [317]:
```
school_state_nc_train = []
school_state_pc_train = []

for a in X_train["school_state"] :

        school_state_nc_train.append(NC_prob_school_state[a])
        school_state_pc_train.append(PC_prob_school_state[a])
```

In [318]:
```
X_train["school_state_nc_train"] = school_state_nc_train
X_train["school_state_pc_train"] = school_state_pc_train
```

cv data- Applying Probability

In [319]:
```
school_state_nc_cv = []
school_state_pc_cv = []

for a in X_cv["school_state"] :

        school_state_nc_cv.append(NC_prob_school_state[a])
        school_state_pc_cv.append(PC_prob_school_state[a])
```

In [320]:
```
X_cv["school_state_nc_cv"] = school_state_nc_cv
X_cv["school_state_pc_cv"] = school_state_pc_cv
```

test data- Applying Probability

In [321]:
```
school_state_nc_test = []
school_state_pc_test = []

for a in X_test["school_state"] :

        school_state_nc_test.append(NC_prob_school_state[a])
        school_state_pc_test.append(PC_prob_school_state[a])
```

In [322]:
```
X_test["school_state_nc_test"] = school_state_nc_test
X_test["school_state_pc_test"] = school_state_pc_test
```

Negative Class - Normalization

In [323]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["school_state_nc_train"].values.reshape(-1,1))

school_state_nc_train = normalizer.transform(X_train["school_state_nc_train"].values.reshape(-1,1))
school_state_nc_cv= normalizer.transform(X_cv["school_state_nc_cv"].values.reshape(-1,1))
school_state_nc_test = normalizer.transform(X_test["school_state_nc_test"].values.reshape(-1,1))


print("After vectorizations")
print(school_state_nc_train.shape)
print(school_state_nc_cv.shape)
print(school_state_nc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

Positive Class - Normalization

In [324]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["school_state_pc_train"].values.reshape(-1,1))

school_state_pc_train = normalizer.transform(X_train["school_state_pc_train"].values.reshape(-1,1))
school_state_pc_cv= normalizer.transform(X_cv["school_state_pc_cv"].values.reshape(-1,1))
school_state_pc_test = normalizer.transform(X_test["school_state_pc_test"].values.reshape(-1,1))


print("After vectorizations")
print(school_state_pc_train.shape)
print(school_state_pc_cv.shape)
print(school_state_pc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.3.4 teacher_prefix - Response Coding

In [325]:
```
#“Teacher prefix” data having the dots(.) and its has been observed the some rows are  empty in  this feature .
#the dot(.) and  empty row available in the data consider as float datatype and it does not
# accepted by the .Split() – Pandas function , so removing the same.
# cleaning has been done for the same following references are used
# 1.    Removing (.) from dataframe column - used ".str.replce" funtion (padas documentation)
# 2.    for  empty cell in datafram column - added the "Mrs." (in train data.cvs) which has me mostly occured in data
 set.

project_data["teacher_prefix_clean"] = project_data["teacher_prefix"].str.replace(".","")
project_data.head(2)
print(project_data.teacher_prefix_clean.shape)
```

```
(30000,)
```

In [326]:
```
teacher_prefix_clean_PC = {}

for a in X_train_PC['teacher_prefix_clean'] :

        if a not in teacher_prefix_clean_PC :
            teacher_prefix_clean_PC[a] = 1
        else :
            teacher_prefix_clean_PC[a] += 1
```

In [327]:
```
teacher_prefix_clean_NC = {}

for a in X_train_NC['teacher_prefix_clean'] :

        if a not in teacher_prefix_clean_NC :
            teacher_prefix_clean_NC[a] = 1
        else :
            teacher_prefix_clean_NC[a] += 1
```

In [328]:
```
teacher_prefix_clean_total = {}

for a in X_train['teacher_prefix_clean'] :

        if a not in teacher_prefix_clean_total :
            teacher_prefix_clean_total[a] = 1
        else :
            teacher_prefix_clean_total[a] += 1
```

Finding Probability for positive and negative class

In [329]:
```
PC_prob_teacher_prefix_clean = {}

for pc in teacher_prefix_clean_total.keys():
    PC_prob_teacher_prefix_clean[pc] = (teacher_prefix_clean_PC[pc])/float(teacher_prefix_clean_total[pc])
```

In [330]:
```
NC_prob_teacher_prefix_clean = {}

for nc in teacher_prefix_clean_total.keys():
    NC_prob_teacher_prefix_clean[nc] = (teacher_prefix_clean_NC[nc])/float(teacher_prefix_clean_total[nc])
```

Train data- Applying Probability

In [331]:
```
teacher_prefix_clean_nc_train = []
teacher_prefix_clean_pc_train = []

for a in X_train["teacher_prefix_clean"] :

        teacher_prefix_clean_nc_train.append(NC_prob_teacher_prefix_clean[a])
        teacher_prefix_clean_pc_train.append(PC_prob_teacher_prefix_clean[a])
```

In [332]:
```
X_train["teacher_prefix_clean_nc_train"] = teacher_prefix_clean_nc_train
X_train["teacher_prefix_clean_pc_train"] = teacher_prefix_clean_pc_train
```

cv data- Applying Probability

In [333]:
```
teacher_prefix_clean_nc_cv = []
teacher_prefix_clean_pc_cv = []

for a in X_cv["teacher_prefix_clean"] :

        teacher_prefix_clean_nc_cv.append(NC_prob_teacher_prefix_clean[a])
        teacher_prefix_clean_pc_cv.append(PC_prob_teacher_prefix_clean[a])
```

In [334]:
```
X_cv["teacher_prefix_clean_nc_cv"] = teacher_prefix_clean_nc_cv
X_cv["teacher_prefix_clean_pc_cv"] = teacher_prefix_clean_pc_cv
```

test data- Applying Probability

In [335]:
```
teacher_prefix_clean_nc_test = []
teacher_prefix_clean_pc_test = []

for a in X_test["teacher_prefix_clean"] :

        teacher_prefix_clean_nc_test.append(NC_prob_teacher_prefix_clean[a])
        teacher_prefix_clean_pc_test.append(PC_prob_teacher_prefix_clean[a])
```

In [336]:
```
X_test["teacher_prefix_clean_nc_test"] = teacher_prefix_clean_nc_test
X_test["teacher_prefix_clean_pc_test"] = teacher_prefix_clean_pc_test
```

Negative Class - Normalization

In [337]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["teacher_prefix_clean_nc_train"].values.reshape(-1,1))

teacher_prefix_clean_nc_train = normalizer.transform(X_train["teacher_prefix_clean_nc_train"].values.reshape(-1,1))
teacher_prefix_clean_nc_cv= normalizer.transform(X_cv["teacher_prefix_clean_nc_cv"].values.reshape(-1,1))
teacher_prefix_clean_nc_test = normalizer.transform(X_test["teacher_prefix_clean_nc_test"].values.reshape(-1,1))


print("After vectorizations")
print(teacher_prefix_clean_nc_train.shape)
print(teacher_prefix_clean_nc_cv.shape)
print(teacher_prefix_clean_nc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

Positive Class - Normalization

In [338]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["teacher_prefix_clean_pc_train"].values.reshape(-1,1))

teacher_prefix_clean_pc_train = normalizer.transform(X_train["teacher_prefix_clean_pc_train"].values.reshape(-1,1))
teacher_prefix_clean_pc_cv= normalizer.transform(X_cv["teacher_prefix_clean_pc_cv"].values.reshape(-1,1))
teacher_prefix_clean_pc_test = normalizer.transform(X_test["teacher_prefix_clean_pc_test"].values.reshape(-1,1))


print("After vectorizations")
print(teacher_prefix_clean_pc_train.shape)
print(teacher_prefix_clean_pc_cv.shape)
print(teacher_prefix_clean_pc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

1.6.3.5 project_grade_category - Response Coding

In [339]:
```
project_grade_category_PC = {}

for a in X_train_PC['project_grade_category'] :

        if a not in project_grade_category_PC :
            project_grade_category_PC[a] = 1
        else :
            project_grade_category_PC[a] += 1
```

In [340]:
```
project_grade_category_NC = {}

for a in X_train_NC['project_grade_category'] :

        if a not in project_grade_category_NC :
            project_grade_category_NC[a] = 1
        else :
            project_grade_category_NC[a] += 1
```

In [341]:
```
project_grade_category_total = {}

for a in X_train['project_grade_category'] :

        if a not in project_grade_category_total :
            project_grade_category_total[a] = 1
        else :
            project_grade_category_total[a] += 1
```

Finding Probability for positive and negative class

In [342]:
```
PC_prob_project_grade_category = {}

for pc in project_grade_category_total.keys():
    PC_prob_project_grade_category[pc] = (project_grade_category_PC[pc])/float(project_grade_category_total[pc])
```

In [343]:
```
NC_prob_project_grade_category = {}

for nc in project_grade_category_total.keys():
    NC_prob_project_grade_category[nc] = (project_grade_category_NC[nc])/float(project_grade_category_total[nc])
```

Train data- Applying Probability

In [344]:
```
project_grade_category_nc_train = []
project_grade_category_pc_train = []

for a in X_train["project_grade_category"] :

        project_grade_category_nc_train.append(NC_prob_project_grade_category[a])
        project_grade_category_pc_train.append(PC_prob_project_grade_category[a])
```

In [345]:
```
X_train["project_grade_category_nc_train"] = project_grade_category_nc_train
X_train["project_grade_category_pc_train"] = project_grade_category_pc_train
```

cv data- Applying Probability

In [346]:
```
project_grade_category_nc_cv = []
project_grade_category_pc_cv = []

for a in X_cv["project_grade_category"] :

        project_grade_category_nc_cv.append(NC_prob_project_grade_category[a])
        project_grade_category_pc_cv.append(PC_prob_project_grade_category[a])
```

In [347]:
```
X_cv["project_grade_category_nc_cv"] = project_grade_category_nc_cv
X_cv["project_grade_category_pc_cv"] = project_grade_category_pc_cv
```

test data- Applying Probability

In [348]:
```
project_grade_category_nc_test = []
project_grade_category_pc_test = []

for a in X_test["project_grade_category"] :

        project_grade_category_nc_test.append(NC_prob_project_grade_category[a])
        project_grade_category_pc_test.append(PC_prob_project_grade_category[a])
```

In [349]:
```
X_test["project_grade_category_nc_test"] = project_grade_category_nc_test
X_test["project_grade_category_pc_test"] = project_grade_category_pc_test
```

Negative Class - Normalization

In [350]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["project_grade_category_nc_train"].values.reshape(-1,1))

project_grade_category_nc_train = normalizer.transform(X_train["project_grade_category_nc_train"].values.reshape(-1,1
))
project_grade_category_nc_cv= normalizer.transform(X_cv["project_grade_category_nc_cv"].values.reshape(-1,1))
project_grade_category_nc_test = normalizer.transform(X_test["project_grade_category_nc_test"].values.reshape(-1,1))


print("After vectorizations")
print(project_grade_category_nc_train.shape)
print(project_grade_category_nc_cv.shape)
print(project_grade_category_nc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

Positive Class - Normalization

In [351]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train["project_grade_category_pc_train"].values.reshape(-1,1))

project_grade_category_pc_train = normalizer.transform(X_train["project_grade_category_pc_train"].values.reshape(-1,1
))
project_grade_category_pc_cv= normalizer.transform(X_cv["project_grade_category_pc_cv"].values.reshape(-1,1))
project_grade_category_pc_test = normalizer.transform(X_test["project_grade_category_pc_test"].values.reshape(-1,1))


print("After vectorizations")
print(project_grade_category_pc_train.shape)
print(project_grade_category_pc_cv.shape)
print(project_grade_category_pc_test.shape)
```

```
After vectorizations
(13467, 1)
(6633, 1)
(9900, 1)
```

In [352]:
```
X_train.columns
```

Out[352]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'teacher_prefix_clean',
       'essay', 'preprocessed_essays', 'essay_word_count',
       'preprocessed_Titles', 'title_word_count', 'price', 'quantity',
       'cat_nc_train', 'cat_pc_train', 'subcat_nc_train', 'subcat_pc_train',
       'school_state_nc_train', 'school_state_pc_train',
       'teacher_prefix_clean_nc_train', 'teacher_prefix_clean_pc_train',
       'project_grade_category_nc_train', 'project_grade_category_pc_train'],
      dtype='object')
```

In [353]:
```
X_cv.columns
```

Out[353]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'teacher_prefix_clean',
       'essay', 'preprocessed_essays', 'essay_word_count',
       'preprocessed_Titles', 'title_word_count', 'price', 'quantity',
       'cat_nc_cv', 'cat_pc_cv', 'subcat_nc_cv', 'subcat_pc_cv',
       'school_state_nc_cv', 'school_state_pc_cv',
       'teacher_prefix_clean_nc_cv', 'teacher_prefix_clean_pc_cv',
       'project_grade_category_nc_cv', 'project_grade_category_pc_cv'],
      dtype='object')
```

In [354]:
```
X_test.columns
```

Out[354]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_title', 'project_essay_1',
       'project_essay_2', 'project_essay_3', 'project_essay_4',
       'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'clean_categories', 'clean_subcategories', 'teacher_prefix_clean',
       'essay', 'preprocessed_essays', 'essay_word_count',
       'preprocessed_Titles', 'title_word_count', 'price', 'quantity',
       'cat_nc_test', 'cat_pc_test', 'subcat_nc_test', 'subcat_pc_test',
       'school_state_nc_test', 'school_state_pc_test',
       'teacher_prefix_clean_nc_test', 'teacher_prefix_clean_pc_test',
       'project_grade_category_nc_test', 'project_grade_category_pc_test'],
      dtype='object')
```

Assignment 9: RF and GBDT

Response Coding: Example

The response tabel is built only on train dataset. For a category which is not there in train data and present in test data, we will encode them with default values Ex: in our test data if have State: D then we encode it as [0.5, 0.05]

1. **Apply both Random Forrest and GBDT on these feature sets**

    - Set 1: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical(instead of one hot encoding, try response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **The hyper paramter tuning (Consider any two hyper parameters preferably n_estimators, max_depth)**

    - 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/simple cross validation data
    - use gridsearch cv or randomsearch cv or you can write your own for loops to do this task

3. **Representation of results**

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

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

    or

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

    seaborn heat maps (https://seaborn.pydata.org/generated/seaborn.heatmap.html) with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**
    - You can choose either of the plotting techniques: 3d plot or heat map
    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.

    - Along with plotting ROC curve, you need to print the confusion matrix (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

4. **Conclusion**

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

Note: Data Leakage

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

2. Random Forest and GBDT

2.4 Appling Randon Forest on different kind of featurization as mentioned in the instructions

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

2.4.1 Applying Random Forest on BOW, SET 1

In [355]:
```
from scipy.sparse import hstack
X_train_bow = hstack((cat_nc_train, cat_pc_train,subcat_nc_train,subcat_pc_train,school_state_nc_train,school_state_pc
_train,teacher_prefix_clean_nc_train,teacher_prefix_clean_pc_train,project_grade_category_nc_train,project_grade_categ
ory_pc_train,bow_essays_train,bow_title_train,price_train,prev_post_train,title_word_count_train,essay_word_count_trai
n)).tocsr()
X_train_bow.shape
```

Out[355]: (13467, 7957)

In [356]:
```
X_cv_bow = hstack((cat_nc_cv, cat_pc_cv,subcat_nc_cv,subcat_pc_cv,school_state_nc_cv,school_state_pc_cv,teacher_prefix
_clean_nc_cv,teacher_prefix_clean_pc_cv,project_grade_category_nc_cv,project_grade_category_pc_cv,bow_essays_cv,bow_ti
tle_cv,price_cv,prev_post_cv,title_word_count_cv,essay_word_count_cv)).tocsr()
X_cv_bow.shape
```

Out[356]: (6633, 7957)

In [357]:
```
X_test_bow = hstack((cat_nc_test, cat_pc_test,subcat_nc_test,subcat_pc_test,school_state_nc_test,school_state_pc_test,
teacher_prefix_clean_nc_test,teacher_prefix_clean_pc_test,project_grade_category_nc_test,project_grade_category_pc_tes
t,bow_essays_test,bow_title_test,price_test,prev_post_test,title_word_count_test,essay_word_count_test)).tocsr()
X_test_bow.shape
```

Out[357]: (9900, 7957)

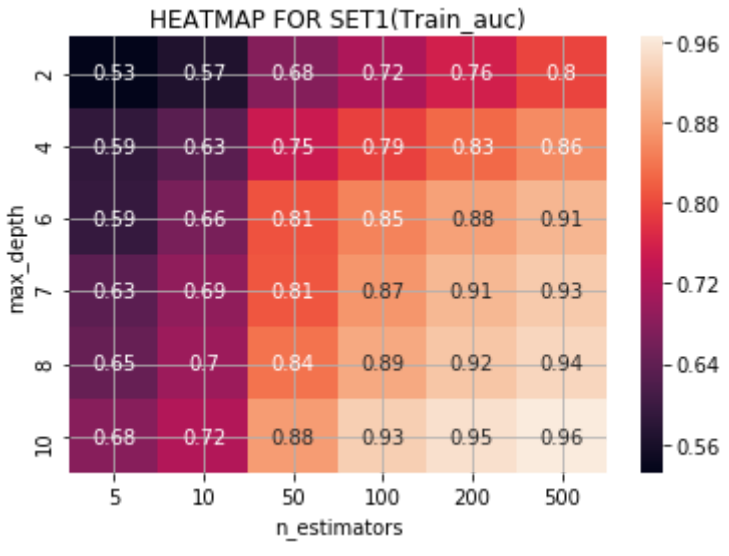
GridSearchCV - Finding the best hyper parameter That maximum AUC value

In [358]:
```
from sklearn.ensemble import RandomForestClassifier
```

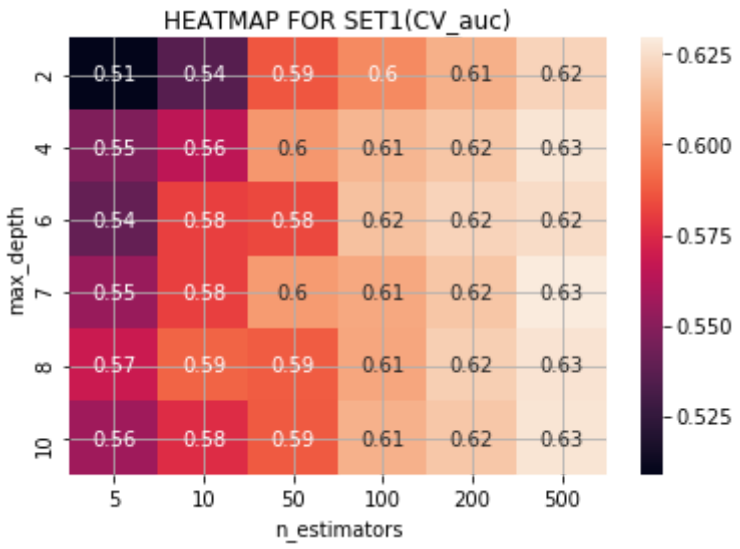
CV_With max_depth andn_estimators

In [359]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV

RF = RandomForestClassifier()

n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]

tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(RF,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_bow, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [360]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [361]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
plt.show()
```



In [362]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

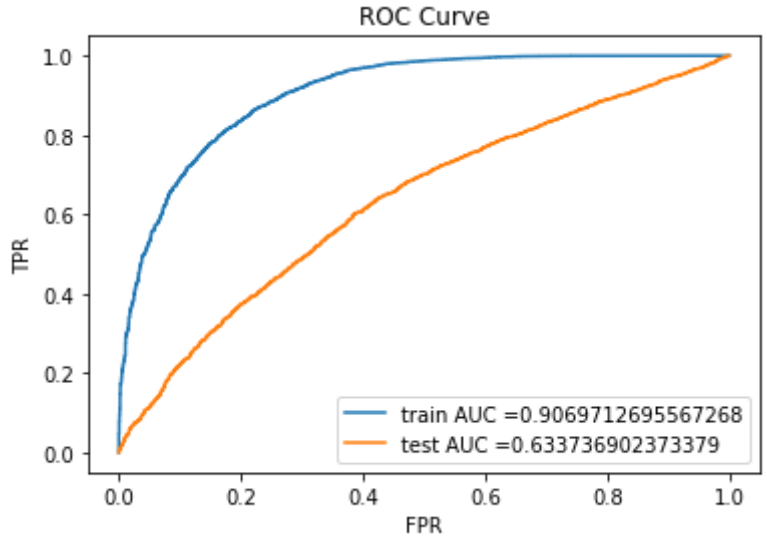
```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.5318565768956652 | 0.5087754951465097 |
|     5     |   4   | 0.568519555925557  | 0.5357827859223596 |
|     5     |   6   | 0.676420744279511  | 0.5867481872457928 |
|     5     |   7   |  0.71711293461911  | 0.6001863661564286 |
|     5     |   8   | 0.7562569004774243 | 0.6107390920918461 |
|     5     |   10  | 0.7963227477291518 | 0.6214526735681232 |
|     10    |   2   | 0.5887564877444441 | 0.5475425091956857 |
|     10    |   4   | 0.6331183334553135 | 0.5648613200223344 |
|     10    |   6   | 0.7478246844679318 | 0.6036123216613023 |
|     10    |   7   | 0.7930071544163969 | 0.6126267263648965 |
|     10    |   8   | 0.8281435125624824 | 0.6173833909900561 |
|     10    |   10  | 0.8601845652222965 | 0.6272454245240194 |
|     50    |   2   | 0.5931815786688533 | 0.5398985746817473 |
|     50    |   4   | 0.6648370606932709 | 0.5812269137474131 |
|     50    |   6   | 0.8090474130734909 | 0.5835468422218969 |
|     50    |   7   | 0.8528342165181169 | 0.6160513470783788 |
|     50    |   8   | 0.8836146384510067 | 0.6215667133912803 |
|     50    |   10  | 0.9054419794934576 | 0.6246104652945104 |
|    100    |   2   | 0.6345337250706216 | 0.5547768163928829 |
|    100    |   4   | 0.6880904967577042 | 0.5811601686721559 |
|    100    |   6   | 0.8118896726973525 | 0.6044924264802796 |
|    100    |   7   | 0.8706504669602616 | 0.6083686107177159 |
|    100    |   8   | 0.9068066370137285 | 0.617430565923927  |
|    100    |   10  | 0.9265652420470737 | 0.6294016504890596 |
|    200    |   2   | 0.6463743546802887 | 0.569048968363906  |
|    200    |   4   | 0.699409515927199  | 0.5900116513906222 |
|    200    |   6   | 0.8366956374404074 | 0.5883829647406547 |
|    200    |   7   | 0.8904967962404537 | 0.6080383244094877 |
|    200    |   8   | 0.9209832256127036 | 0.6200671945343876 |
|    200    |   10  | 0.9410671636950804 | 0.6266146895981536 |
|    500    |   2   | 0.6790019449194666 | 0.5563865499137784 |
|    500    |   4   | 0.722402761440391  | 0.5757544140451917 |
|    500    |   6   | 0.8778754160539566 | 0.5878108914256197 |
|    500    |   7   | 0.9326623857662683 | 0.6111893468191081 |
|    500    |   8   | 0.9519939596942573 | 0.6178538493259679 |
|    500    |   10  | 0.9648356418042902 | 0.6274886780232405 |
+-----------+-------+--------------------+--------------------+
```

Using Best hyperparameters Value – Training the Model

In [363]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 100
max_depth = 10
```

In [364]:
```
from sklearn.metrics import roc_auc_score
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your 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 [365]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


RF = RandomForestClassifier(n_estimators = 100, max_depth = 10)
RF.fit(X_train_bow, y_train)

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

y_train_pred_bow = batch_predict(RF, X_train_bow)
y_test_pred_bow = batch_predict(RF, X_test_bow)

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.rcParams["figure.figsize"] = [5,5]
plt.show()
```



Confusion Matrix

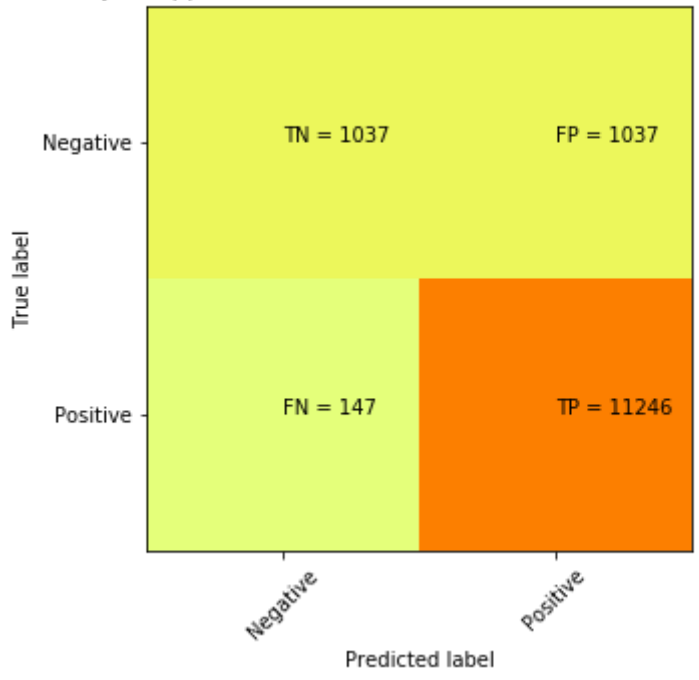
Train confusion matrix

In [366]:
```
#https://stackoverflow.com/questions/28719067/roc-curve-and-cut-off-point-python

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

In [367]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
bow_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_bow, tr_thresholds, train_fpr, train_fpr))
print(bow_train_confusion_matrix)
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.25 for threshold 0.829
[[ 1037  1037]
 [  147 11246]]
```

In [368]:
```
#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(bow_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Bow Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(bow_train_confusion_matrix[i][j]))
plt.show()
```

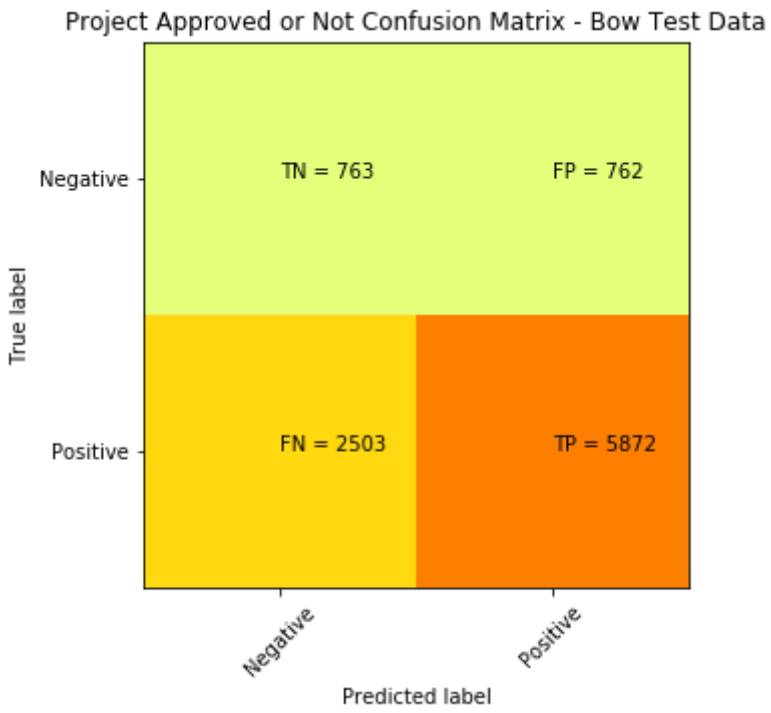


Test confusion matrix

In [369]:
```
print("Train confusion matrix")
bow_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_bow, te_thresholds, test_fpr, test_fpr))
print(bow_test_confusion_matrix)
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.844
[[ 763  762]
 [2503 5872]]
```

In [370]:
```
##http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(bow_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Bow Test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(bow_test_confusion_matrix[i][j]))
plt.show()
```



2.4.2 Applying Random Forest on TFIDF, SET 2

In [371]:
```
X_train_tfidf = hstack((cat_nc_train, cat_pc_train,subcat_nc_train,subcat_pc_train,school_state_nc_train,school_state_pc_train,teacher_prefix_clean_nc_train,teacher_prefix_clean_pc_train,project_grade_category_nc_train,project_grade_category_pc_train,tfidf_essays_train,tfidf_title_train,price_train,prev_post_train,title_word_count_train,essay_word_count_train)).tocsr()
X_train_tfidf.shape
```

Out[371]: (13467, 7957)

In [372]:
```
X_cv_tfidf = hstack((cat_nc_cv, cat_pc_cv,subcat_nc_cv,subcat_pc_cv,school_state_nc_cv,school_state_pc_cv,teacher_prefix_clean_nc_cv,teacher_prefix_clean_pc_cv,project_grade_category_nc_cv,project_grade_category_pc_cv,tfidf_essays_cv,tfidf_title_cv,price_cv,prev_post_cv,title_word_count_cv,essay_word_count_cv)).tocsr()
X_cv_tfidf.shape
```

Out[372]: (6633, 7957)

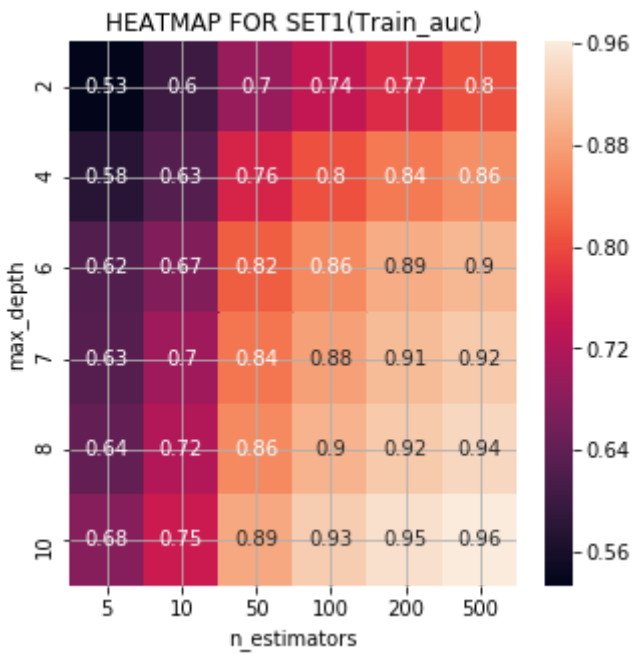
In [373]:
```
X_test_tfidf = hstack((cat_nc_test, cat_pc_test,subcat_nc_test,subcat_pc_test,school_state_nc_test,school_state_pc_test,teacher_prefix_clean_nc_test,teacher_prefix_clean_pc_test,project_grade_category_nc_test,project_grade_category_pc_test,tfidf_essays_test,tfidf_title_test,price_test,prev_post_test,title_word_count_test,essay_word_count_test)).tocsr()
X_test_tfidf.shape
```

Out[373]: (9900, 7957)

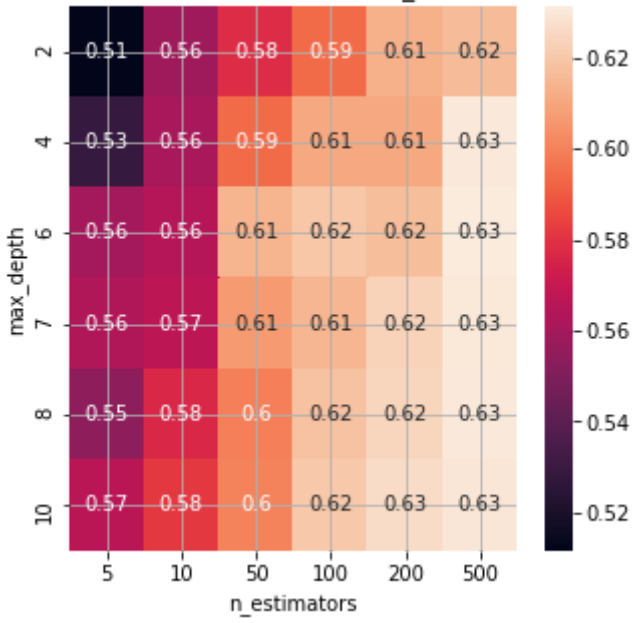
GridSearchCV - Finding the best hyper parameter That maximum AUC value

In [375]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV

RF = RandomForestClassifier()
n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]

tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(RF,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_tfidf, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [376]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [378]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
plt.show()
```



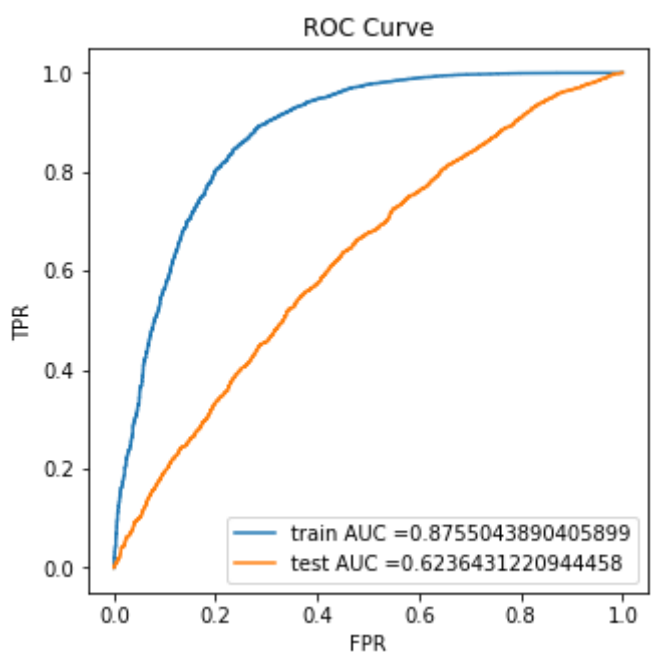
In [379]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.5336854133907104 | 0.5115859379385037 |
|     5     |   4   | 0.6029872032636211 | 0.5585076249438626 |
|     5     |   6   | 0.695848756192324  | 0.5782430108000386 |
|     5     |   7   | 0.7376796049160327 | 0.5941995300205333 |
|     5     |   8   | 0.7703367503500423 | 0.6133071508306305 |
|     5     |   10  | 0.8043736428039764 | 0.6164919241176694 |
|     10    |   2   | 0.5798608422764221 | 0.5284866867702054 |
|     10    |   4   | 0.6282154879133269 | 0.5615631614440417 |
|     10    |   6   | 0.7621815441183668 | 0.5941625323382056 |
|     10    |   7   | 0.8047754075669525 | 0.6110214340175727 |
|     10    |   8   | 0.8417651113740868 | 0.6110774486381443 |
|     10    |   10  | 0.8611951337736757 | 0.6307115501379074 |
|     50    |   2   | 0.6249485505317912 | 0.5599605504971926 |
|     50    |   4   | 0.6738168889390307 | 0.5648129411539139 |
|     50    |   6   | 0.8166407925222533 | 0.6145133399902359 |
|     50    |   7   | 0.8567183472249343 | 0.6199615161157238 |
|     50    |   8   | 0.8921741092700444 | 0.6169196690084363 |
|     50    |   10  | 0.9044068013375844 | 0.6313879478095251 |
|    100    |   2   | 0.6296345162597139 | 0.5635763222365887 |
|    100    |   4   | 0.7028647930605167 | 0.5676358580615085 |
|    100    |   6   | 0.8389101768198591 | 0.606807859846521  |
|    100    |   7   | 0.8792470357286328 | 0.6145819339802076 |
|    100    |   8   | 0.906325419177694  | 0.6237448982486672 |
|    100    |   10  | 0.9243971404964189 | 0.6302865154257374 |
|    200    |   2   | 0.6430935550288779 | 0.5544441340447053 |
|    200    |   4   | 0.7217573950633359 | 0.5766455399366955 |
|    200    |   6   | 0.8571349587403955 | 0.5993534074745333 |
|    200    |   7   | 0.8990819744498305 | 0.6183230500470878 |
|    200    |   8   | 0.9236989849250752 | 0.624745562577167  |
|    200    |   10  | 0.9389646861255185 | 0.6308637070036809 |
|    500    |   2   | 0.6782801316899999 | 0.5664830982802529 |
|    500    |   4   | 0.7464693846401754 | 0.5816338278534954 |
|    500    |   6   | 0.8878930322580921 | 0.6003171883258513 |
|    500    |   7   | 0.9265515629767235 | 0.6202475276447508 |
|    500    |   8   | 0.9481285216205784 | 0.6262419979574473 |
|    500    |   10  | 0.9613938572767186 | 0.6299501455757983 |
+-----------+-------+--------------------+--------------------+
```

Using Best Hyperparameters Value – Training the Model

In [380]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 50
max_depth = 10
```

In [381]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

RF = RandomForestClassifier(n_estimators = 50, max_depth = 10)
RF.fit(X_train_tfidf, y_train)

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

y_train_pred_tfidf = batch_predict(RF, X_train_tfidf)
y_test_pred_tfidf = batch_predict(RF, X_test_tfidf)

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.rcParams["figure.figsize"] = [5,5]
plt.show()
```



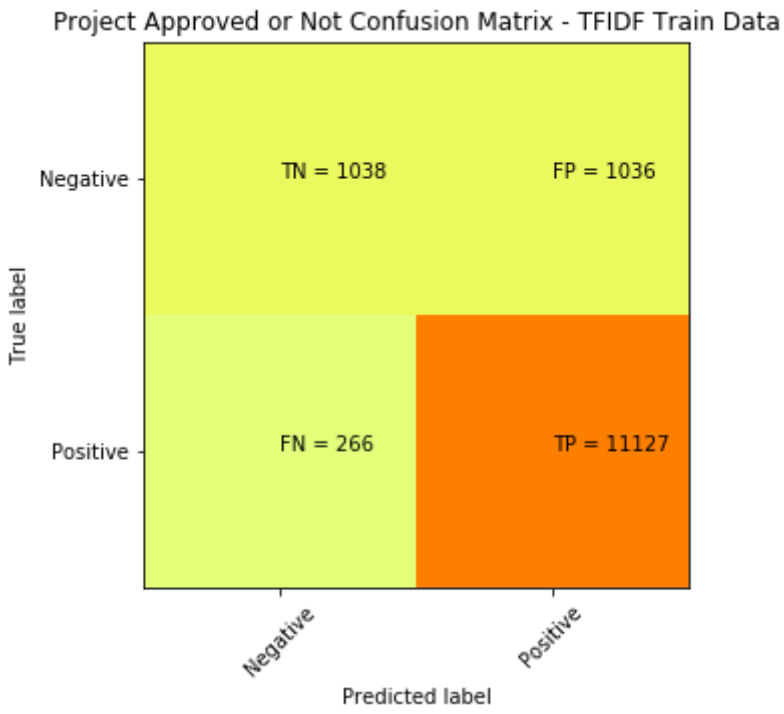
Confusion Matrix

Train confusion matrix

In [382]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tfidf_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_tfidf, tr_thresholds, train_fpr, train_f
pr))
print(tfidf_train_confusion_matrix)
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999976752166 for threshold 0.823
[[ 1038  1036]
 [  266 11127]]
```

In [383]:
```
#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(tfidf_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - TFIDF Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_train_confusion_matrix[i][j]))
plt.show()
```

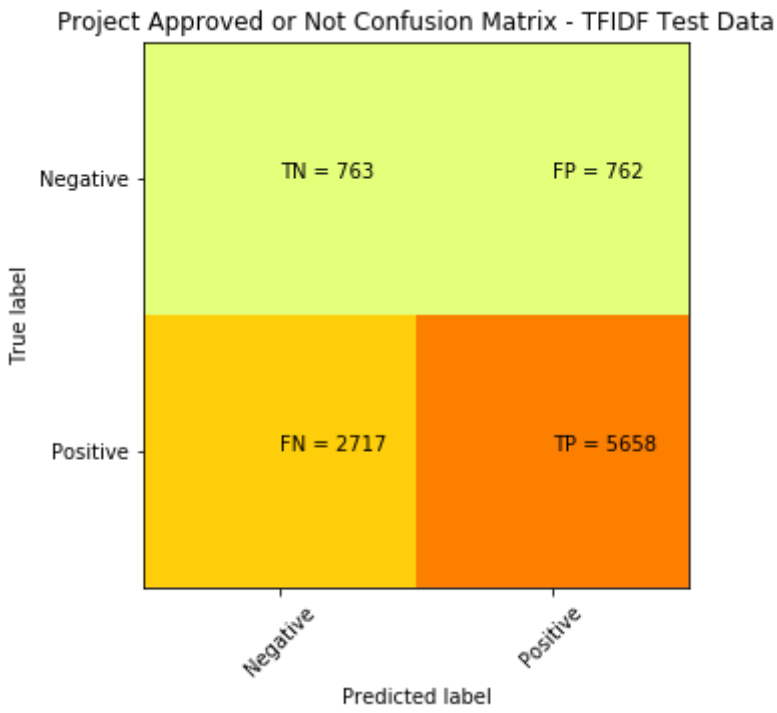


Test confusion matrix

In [384]:
```
print("Test confusion matrix")
tfidf_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_tfidf, te_thresholds, test_fpr, test_fpr))
print(tfidf_test_confusion_matrix)
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.846
[[ 763  762]
 [2717 5658]]
```

In [385]:
```
##http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(tfidf_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - TFIDF Test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_test_confusion_matrix[i][j]))
plt.show()
```



2.4.3 Applying Random Forest on AVG W2V, SET 3

In [386]:
```
X_train_avg_w2v = np.hstack((cat_nc_train, cat_pc_train,subcat_nc_train,subcat_pc_train,school_state_nc_train,school_state_pc_train,teacher_prefix_clean_nc_train,teacher_prefix_clean_pc_train,project_grade_category_nc_train,project_grade_category_pc_train,avg_w2v_essays_train,avg_w2v_title_train,price_train,prev_post_train,title_word_count_train,essay_word_count_train))
X_train_avg_w2v.shape
```

Out[386]: (13467, 614)

In [387]:
```
X_cv_avg_w2v = np.hstack((cat_nc_cv, cat_pc_cv,subcat_nc_cv,subcat_pc_cv,school_state_nc_cv,school_state_pc_cv,teacher_prefix_clean_nc_cv,teacher_prefix_clean_pc_cv,project_grade_category_nc_cv,project_grade_category_pc_cv,avg_w2v_essays_cv,avg_w2v_title_cv,price_cv,prev_post_cv,title_word_count_cv,essay_word_count_cv))
X_cv_avg_w2v.shape
```

Out[387]: (6633, 614)

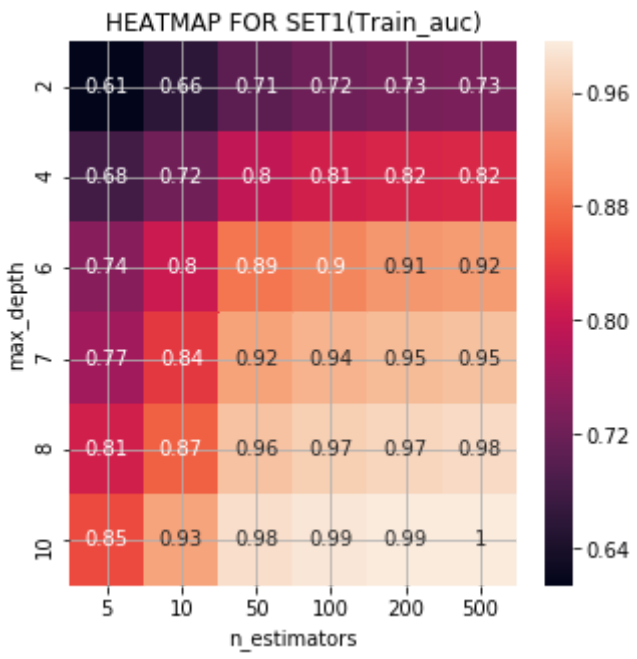
In [388]:
```
X_test_avg_w2v = np.hstack((cat_nc_test, cat_pc_test,subcat_nc_test,subcat_pc_test,school_state_nc_test,school_state_pc_test,teacher_prefix_clean_nc_test,teacher_prefix_clean_pc_test,project_grade_category_nc_test,project_grade_category_pc_test,avg_w2v_essays_test,avg_w2v_title_test,price_test,prev_post_test,title_word_count_test,essay_word_count_test))
X_test_avg_w2v.shape
```

Out[388]: (9900, 614)

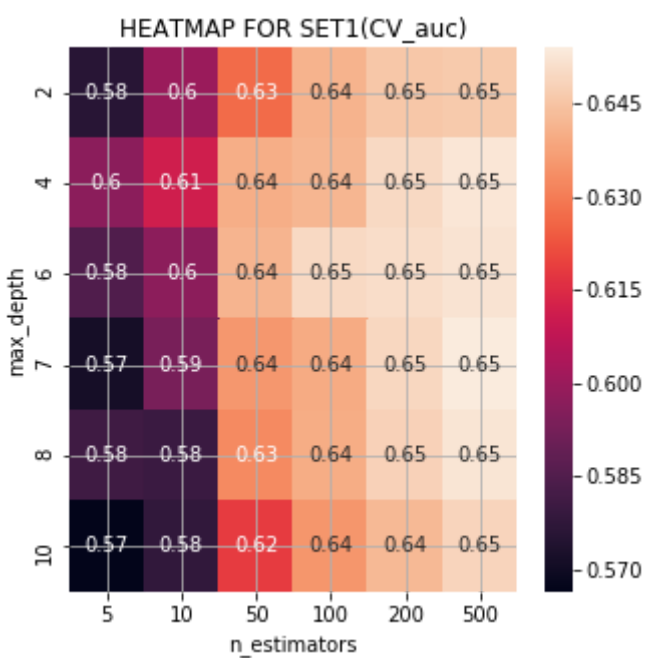
GridSearchCV - Finding the best hyper parameter That maximum AUC value

In [389]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV


RF = RandomForestClassifier()
n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]

tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(RF,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_avg_w2v, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [391]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [392]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
```



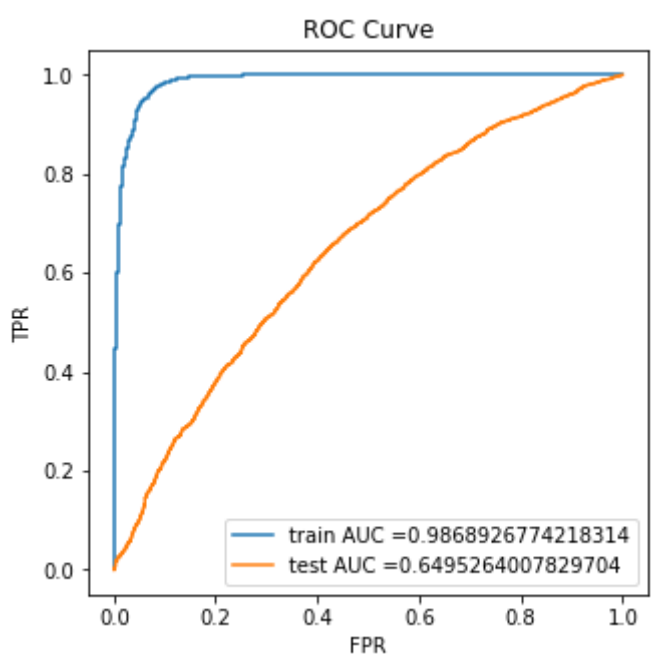
In [393]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.6140498025575623 | 0.5758473331637584 |
|     5     |   4   | 0.6589803415997196 | 0.6002132067226466 |
|     5     |   6   | 0.7052450375944321 | 0.6268837542991728 |
|     5     |   7   | 0.7219076868030223 | 0.6413574708645524 |
|     5     |   8   | 0.7290862518586579 | 0.6457793897748885 |
|     5     |   10  | 0.7327496419827148 | 0.6463106160630236 |
|     10    |   2   | 0.6819579468688035 | 0.5969417548215057 |
|     10    |   4   | 0.7229567628964068 | 0.6113153133892752 |
|     10    |   6   |  0.79584705196743  | 0.6400954374888248 |
|     10    |   7   | 0.8118794963697876 | 0.6418137431871942 |
|     10    |   8   | 0.8197364496893144 | 0.6497907460852735 |
|     10    |   10  | 0.8223282831948672 | 0.6529267711200621 |
|     50    |   2   | 0.7439352316016087 | 0.5846186510361758 |
|     50    |   4   | 0.8043519152330288 | 0.5975153600411427 |
|     50    |   6   | 0.8865508002948607 | 0.6415262209266482 |
|     50    |   7   | 0.899847003135173  | 0.6496194460812209 |
|     50    |   8   | 0.9145417469300797 | 0.6509493411624272 |
|     50    |   10  | 0.9187746885382008 | 0.652192705866691  |
|    100    |   2   | 0.7670006400216703 | 0.5715479972597284 |
|    100    |   4   | 0.8365548943878743 | 0.593441066337234  |
|    100    |   6   | 0.9245730854213532 | 0.6353488703163909 |
|    100    |   7   | 0.9393337810468417 | 0.6396403871449705 |
|    100    |   8   | 0.9475404688167033 | 0.6492925951512849 |
|    100    |   10  | 0.952638151144673  | 0.6540452513059459 |
|    200    |   2   | 0.8113271376350916 | 0.5811266270292482 |
|    200    |   4   | 0.868431876087273  | 0.5799822793164893 |
|    200    |   6   | 0.9551776546875207 | 0.6327424680613307 |
|    200    |   7   | 0.9669486106181644 | 0.6397539430613326 |
|    200    |   8   | 0.9734961993895132 | 0.6480744945307914 |
|    200    |   10  | 0.9779769963841547 | 0.6525537977897049 |
|    500    |   2   | 0.8518146949221618 | 0.566442832701507  |
|    500    |   4   | 0.9269489358186228 | 0.5777951904580018 |
|    500    |   6   | 0.983377703274618  | 0.6182031741457923 |
|    500    |   7   | 0.9909370577627215 | 0.635120351030892  |
|    500    |   8   | 0.9943321144599077 | 0.6426655802533016 |
|    500    |   10  | 0.9957034321330105 | 0.6486589073586514 |
+-----------+-------+--------------------+--------------------+
```

Using Best Hyper parameters Value – Training the Model

In [394]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 200
max_depth = 10
```

In [395]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


RF = RandomForestClassifier(n_estimators = 200, max_depth = 10)
RF.fit(X_train_avg_w2v, 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_avg_w2v = batch_predict(RF,X_train_avg_w2v)
y_test_pred_avg_w2v = batch_predict(RF,X_test_avg_w2v)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_avg_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_avg_w2v)

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("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")

plt.show()
```

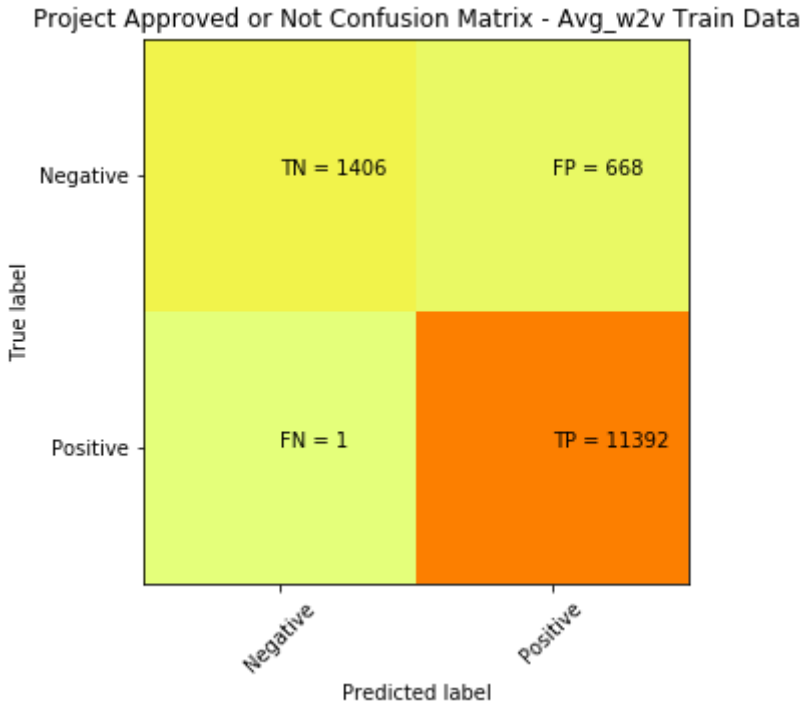


Confusion Matrix

Train confusion matrix

In [396]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
avg_w2v_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_avg_w2v, tr_thresholds, train_fpr, tra
in_fpr))
print(avg_w2v_train_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(avg_w2v_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Avg_w2v Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(avg_w2v_train_confusion_matrix[i][j]))
plt.show()
```

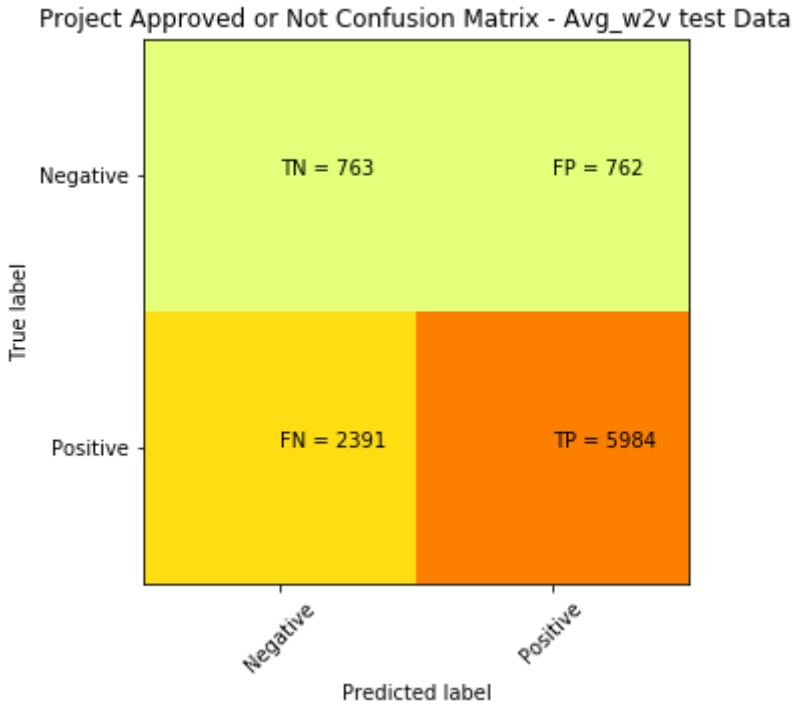
```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.21834551674820457 for threshold 0.759
[[ 1406   668]
 [    1 11392]]
```



Test confusion matrix

In [397]:
```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
avg_w2v_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_avg_w2v, te_thresholds, test_fpr, test_fp
r))
print(avg_w2v_test_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(avg_w2v_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Avg_w2v test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(avg_w2v_test_confusion_matrix[i][j]))
plt.show()
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.837
[[ 763  762]
 [2391 5984]]
```



2.4.4 Applying Random Forest on TFIDF W2V, SET 4

In [402]:
```
X_train_tfidf_w2v = np.hstack((cat_nc_train, cat_pc_train,subcat_nc_train,subcat_pc_train,school_state_nc_train,school
_state_pc_train,teacher_prefix_clean_nc_train,teacher_prefix_clean_pc_train,project_grade_category_nc_train,project_gr
ade_category_pc_train,tfidf_w2v_essays_train,tfidf_w2v_title_train,price_train,prev_post_train,title_word_count_train,
essay_word_count_train))
X_train_tfidf_w2v.shape
```

Out[402]: (13467, 614)

In [403]:
```
X_cv_tfidf_w2v = np.hstack((cat_nc_cv, cat_pc_cv,subcat_nc_cv,subcat_pc_cv,school_state_nc_cv,school_state_pc_cv,teach
er_prefix_clean_nc_cv,teacher_prefix_clean_pc_cv,project_grade_category_nc_cv,project_grade_category_pc_cv,tfidf_w2v_e
ssays_cv,tfidf_w2v_title_cv,price_cv,prev_post_cv,title_word_count_cv,essay_word_count_cv))
X_cv_tfidf_w2v.shape
```

Out[403]: (6633, 614)

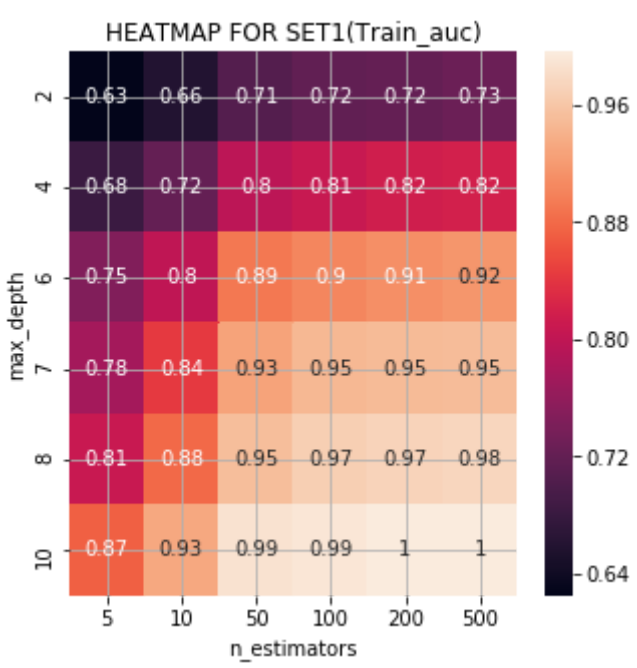
In [404]:
```
X_test_tfidf_w2v = np.hstack((cat_nc_test, cat_pc_test,subcat_nc_test,subcat_pc_test,school_state_nc_test,school_state
_pc_test,teacher_prefix_clean_nc_test,teacher_prefix_clean_pc_test,project_grade_category_nc_test,project_grade_catego
ry_pc_test,tfidf_w2v_essays_test,tfidf_w2v_title_test,price_test,prev_post_test,title_word_count_test,essay_word_count
_test))
X_test_tfidf_w2v.shape
```

Out[404]: (9900, 614)

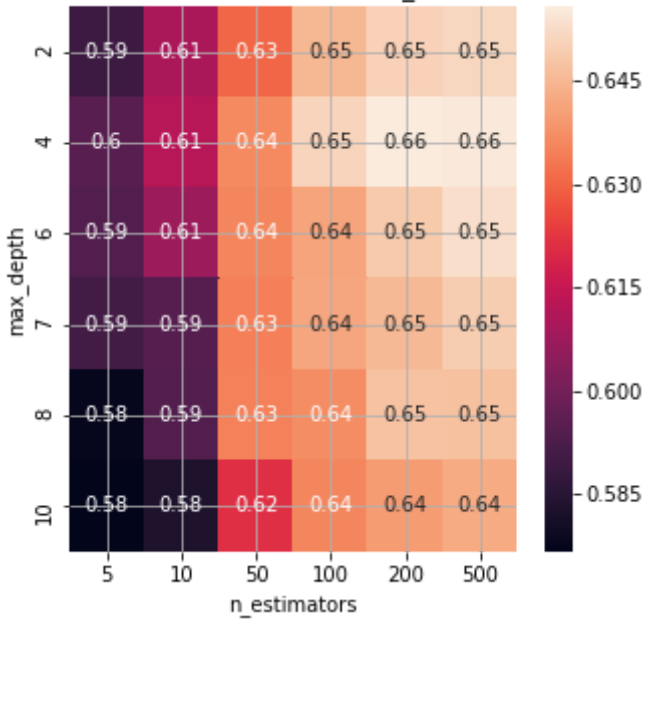
GridSearchCV - Finding the best hyper parameter That maximum AUC value

In [405]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV

RF = RandomForestClassifier()
n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]

tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(RF,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_tfidf_w2v, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [406]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [407]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
plt.show()
```



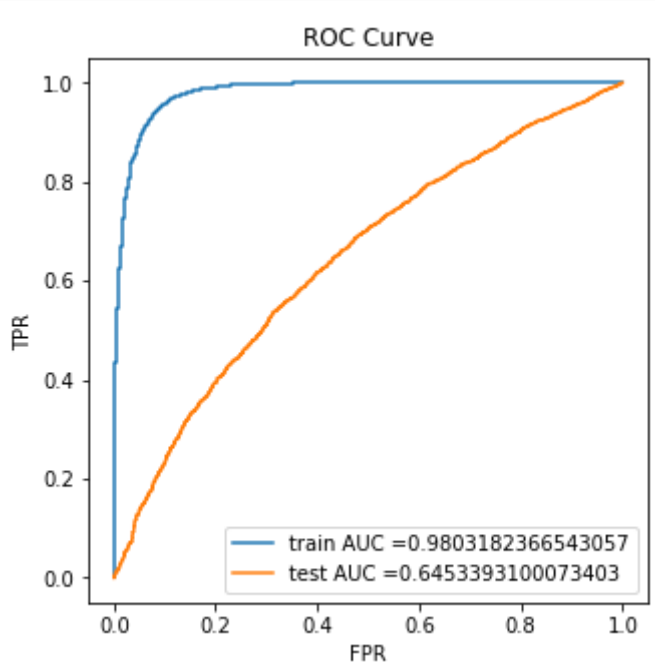
In [408]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.6250932472605791 | 0.589349993450807  |
|     5     |   4   | 0.658817469315851  | 0.6098286280527782 |
|     5     |   6   | 0.7069916516057976 | 0.6301480621032602 |
|     5     |   7   | 0.7181054703891122 | 0.6450902891558499 |
|     5     |   8   | 0.7217390406034467 | 0.6503411317734926 |
|     5     |   10  | 0.7275513626106115 | 0.6517494110467489 |
|     10    |   2   | 0.6830836861360453 | 0.595145240168593  |
|     10    |   4   | 0.7219304313273446 | 0.6122965410210867 |
|     10    |   6   | 0.7971596757198319 | 0.6364996830528195 |
|     10    |   7   | 0.8066598156475626 | 0.6510472498740327 |
|     10    |   8   | 0.8160675363720417 | 0.6557678825265192 |
|     10    |   10  | 0.8185326252779069 | 0.6551517727663048 |
|     50    |   2   | 0.7464099633733953 | 0.5934535511199431 |
|     50    |   4   | 0.8005408648187685 | 0.6072608112880215 |
|     50    |   6   | 0.8916123041035254 | 0.6359112010260976 |
|     50    |   7   | 0.9030911444671793 | 0.6412974610844887 |
|     50    |   8   | 0.9103724477486862 | 0.6489097692848941 |
|     50    |   10  | 0.915408068676355  | 0.653081405432699  |
|    100    |   2   | 0.7761657548785438 | 0.5907123664917515 |
|    100    |   4   | 0.8433603273318449 | 0.5943738247856848 |
|    100    |   6   | 0.9275521903136542 | 0.6345760998441998 |
|    100    |   7   | 0.9464731929540943 | 0.6417557038438411 |
|    100    |   8   | 0.9496398023165481 | 0.6454844085580476 |
|    100    |   10  | 0.9511907337207598 |  0.64936659220135  |
|    200    |   2   | 0.8086003490529202 | 0.5778162144415601 |
|    200    |   4   | 0.8795987021967718 | 0.5934794702003768 |
|    200    |   6   | 0.9530204731909723 | 0.6348293623101977 |
|    200    |   7   | 0.9684986744004543 | 0.6369589560359079 |
|    200    |   8   | 0.9731398902441479 | 0.647318567318837  |
|    200    |   10  | 0.9761849603490296 | 0.6468764097338523 |
|    500    |   2   | 0.8731739333518561 | 0.5766511553653527 |
|    500    |   4   | 0.9324987429699406 | 0.5829163466488031 |
|    500    |   6   | 0.9870159726457025 | 0.6211581718574907 |
|    500    |   7   | 0.9914786461243263 | 0.6357620655302265 |
|    500    |   8   | 0.9957126341477959 | 0.6399626682390244 |
|    500    |   10  | 0.9966856378056083 | 0.642764269743002  |
+-----------+-------+--------------------+--------------------+
```

Using Best Hyper parameters Value – Training the Model

In [409]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 50
max_depth = 10
```

In [410]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

RF = RandomForestClassifier(n_estimators = 50, max_depth = 10)
RF.fit(X_train_tfidf_w2v, y_train)

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

y_train_pred_tfidf_w2v = batch_predict(RF,X_train_tfidf_w2v)
y_test_pred_tfidf_w2v = batch_predict(RF,X_test_tfidf_w2v)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf_w2v)

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("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")

plt.show()
```

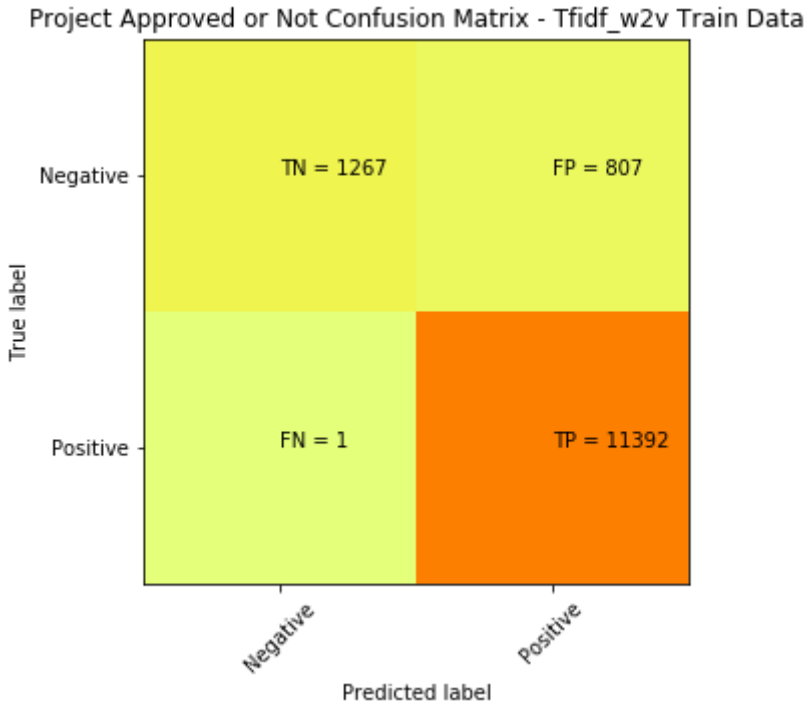


Confusion Matrix

Train confusion matrix

In [411]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tfidf_w2v_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_tfidf_w2v, tr_thresholds, train_fpr,
train_fpr))
print(tfidf_w2v_train_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(tfidf_w2v_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Tfidf_w2v Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_w2v_train_confusion_matrix[i][j]))
plt.show()
```

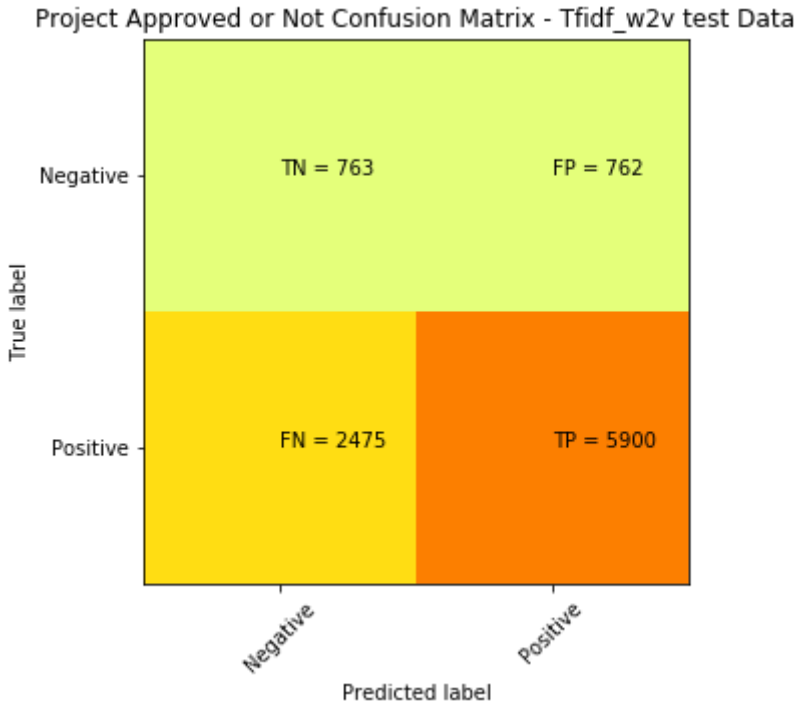
```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.23770189581436696 for threshold 0.736
[[ 1267   807]
 [    1 11392]]
```



Test confusion matrix

In [412]:
```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
tfidf_w2v_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_tfidf_w2v, te_thresholds, test_fpr, tes
t_fpr))
print(tfidf_w2v_test_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(avg_w2v_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Tfidf_w2v test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_w2v_test_confusion_matrix[i][j]))
plt.show()
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.834
[[ 763  762]
 [2475 5900]]
```



2.5 Appling GBDT on different kind of featurization as mentioned in the instructions

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

2.5.1 Applying GBDT on BOW, SET 1

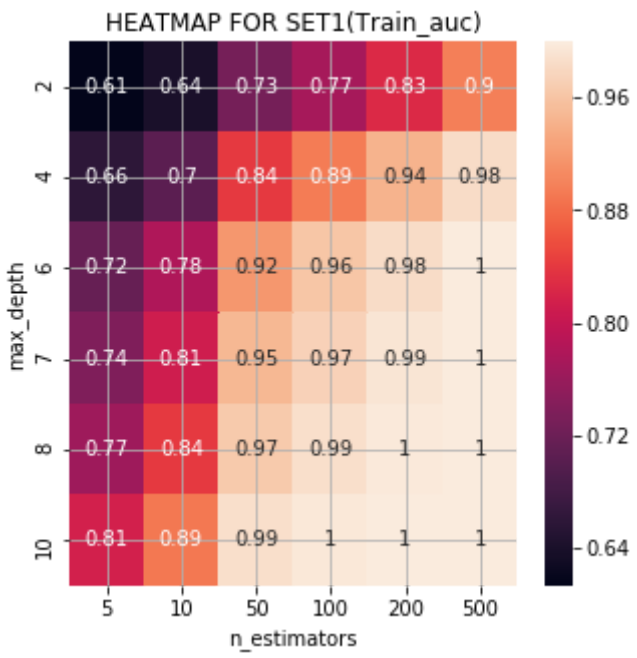
GridSearchCV - Finding the best hyper parameter That maximum AUC value

In [413]:
```
from sklearn.ensemble import GradientBoostingClassifier
```

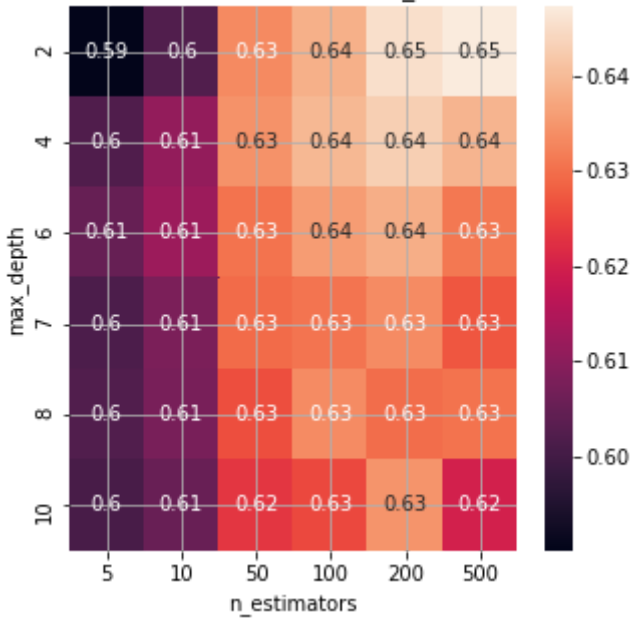
CV_With max_depth andn_estimators

In [414]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV

GBDT =  GradientBoostingClassifier()

n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]

tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(GBDT,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_bow, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [415]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [416]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
plt.show()
```



In [417]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

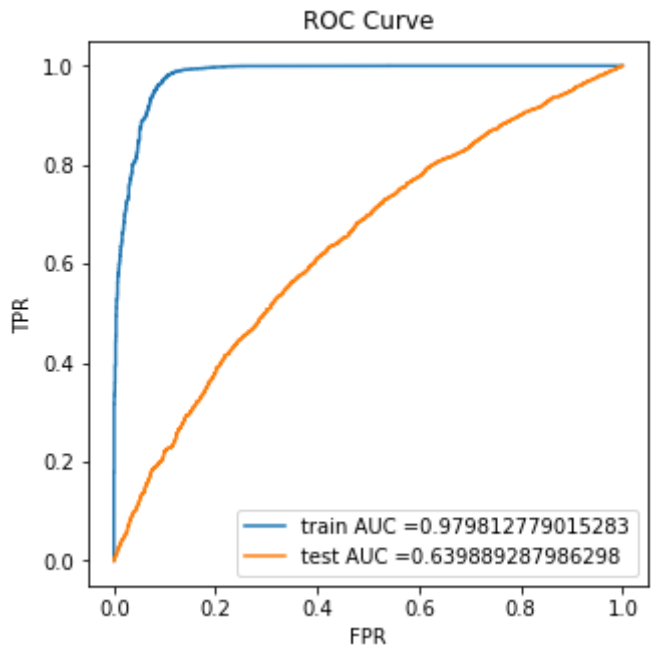
```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.6135798993487369 | 0.5900810586215375 |
|     5     |   4   | 0.6396814052438499 | 0.6022426804148265 |
|     5     |   6   | 0.7283602148749947 | 0.6333848872627319 |
|     5     |   7   | 0.7731841244004197 | 0.6384530531011717 |
|     5     |   8   | 0.8251532527914116 | 0.6454399151310238 |
|     5     |   10  | 0.896799317450692  | 0.6472452879456427 |
|     10    |   2   | 0.6600770758174382 | 0.6020706761707133 |
|     10    |   4   | 0.7043154399845122 | 0.6112773089762483 |
|     10    |   6   | 0.8401820433671201 | 0.6344005384476638 |
|     10    |   7   | 0.8942736368661212 | 0.6395195584776616 |
|     10    |   8   | 0.9428390864960493 | 0.6429394330878129 |
|     10    |   10  | 0.9848322673378914 | 0.6389892237062716 |
|     50    |   2   | 0.716107690414637  | 0.6050557780410959 |
|     50    |   4   | 0.7797267585727855 | 0.6123103447802629 |
|     50    |   6   | 0.9170936283133129 | 0.6304736576301891 |
|     50    |   7   | 0.9611220729153024 | 0.6356963381764336 |
|     50    |   8   | 0.984865880316128  | 0.6381014570062726 |
|     50    |   10  | 0.9989927290509727 | 0.6310348072373239 |
|    100    |   2   | 0.7382916087241677 | 0.6015817425563589 |
|    100    |   4   | 0.8103330733104991 | 0.6081467492397733 |
|    100    |   6   | 0.9483887440611586 |  0.62939552362812  |
|    100    |   7   | 0.9736697476301983 | 0.6305654083444066 |
|    100    |   8   | 0.9924890074976757 | 0.6334324094788217 |
|    100    |   10  | 0.9998040883388715 | 0.6269608712227149 |
|    200    |   2   | 0.7651817425544077 | 0.6022397108875925 |
|    200    |   4   | 0.8413444835775629 | 0.6076368177221229 |
|    200    |   6   | 0.9666411990076917 | 0.6261901313395574 |
|    200    |   7   | 0.9868776968344052 | 0.6334059497028123 |
|    200    |   8   | 0.9976251168915198 | 0.6298241825846026 |
|    200    |   10  | 0.9999494277245605 | 0.6303349229924732 |
|    500    |   2   | 0.8143683456415144 | 0.6008718427870542 |
|    500    |   4   | 0.8911376205732447 | 0.6053331006566213 |
|    500    |   6   | 0.9865202107291752 | 0.623189015209712  |
|    500    |   7   | 0.9962155544506045 | 0.6255021949627229 |
|    500    |   8   | 0.9993384618537801 | 0.6345776208733932 |
|    500    |   10  |        1.0         | 0.6198250265325616 |
+-----------+-------+--------------------+--------------------+
```

Using Best hyperparameters Value – Training the Model

In [418]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 50
max_depth = 10
```

In [419]:
```
from sklearn.metrics import roc_auc_score
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your 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 [421]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


GBDT =  GradientBoostingClassifier(n_estimators = 50, max_depth = 10)
GBDT.fit(X_train_bow, y_train)

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

y_train_pred_bow = batch_predict(GBDT, X_train_bow)
y_test_pred_bow = batch_predict(GBDT, X_test_bow)

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.rcParams["figure.figsize"] = [5,5]
plt.show()
```



Confusion Matrix

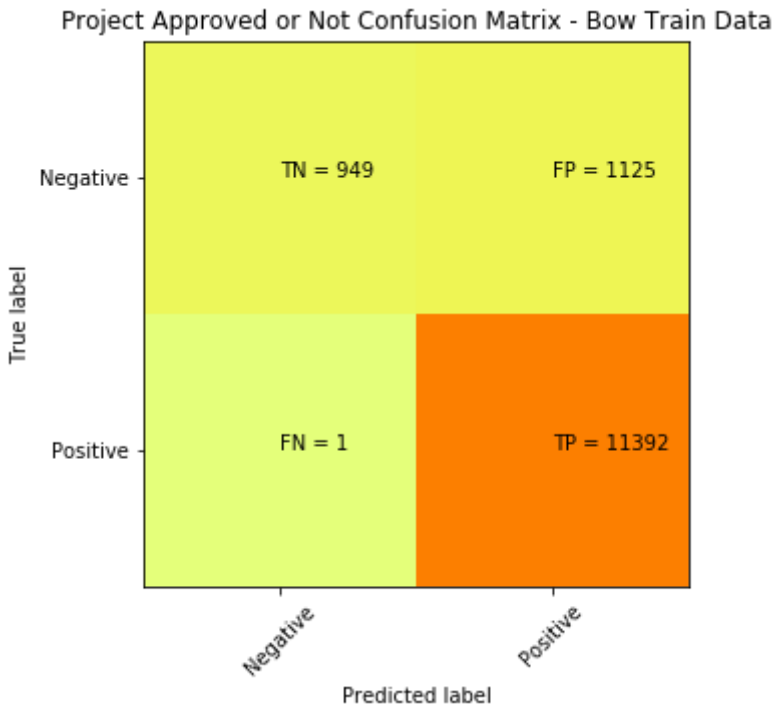
Train confusion matrix

In [422]:
```
#https://stackoverflow.com/questions/28719067/roc-curve-and-cut-off-point-python

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

In [423]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
bow_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_bow, tr_thresholds, train_fpr, train_fpr))
print(bow_train_confusion_matrix)
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2481996877350937 for threshold 0.608
[[  949  1125]
 [    1 11392]]
```

In [424]:
```
#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(bow_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Bow Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(bow_train_confusion_matrix[i][j]))
plt.show()
```

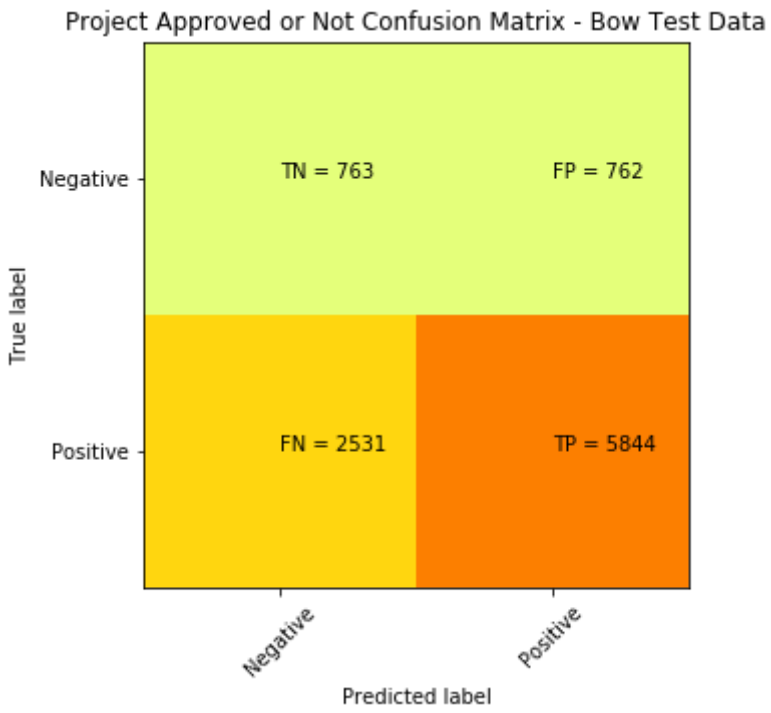


Test confusion matrix

In [425]:
```
print("Train confusion matrix")
bow_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_bow, te_thresholds, test_fpr, test_fpr))
print(bow_test_confusion_matrix)
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.848
[[ 763  762]
 [2531 5844]]
```

In [426]:
```
##http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(bow_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Bow Test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(bow_test_confusion_matrix[i][j]))
plt.show()
```



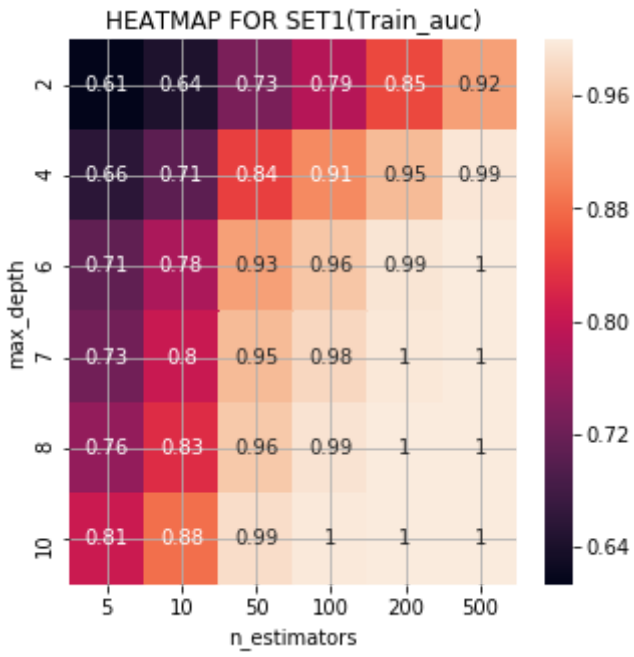
2.5.2 Applying GBDT on TFIDF, SET 2

GridSearchCV - Finding the best hyper parameter That maximum AUC value

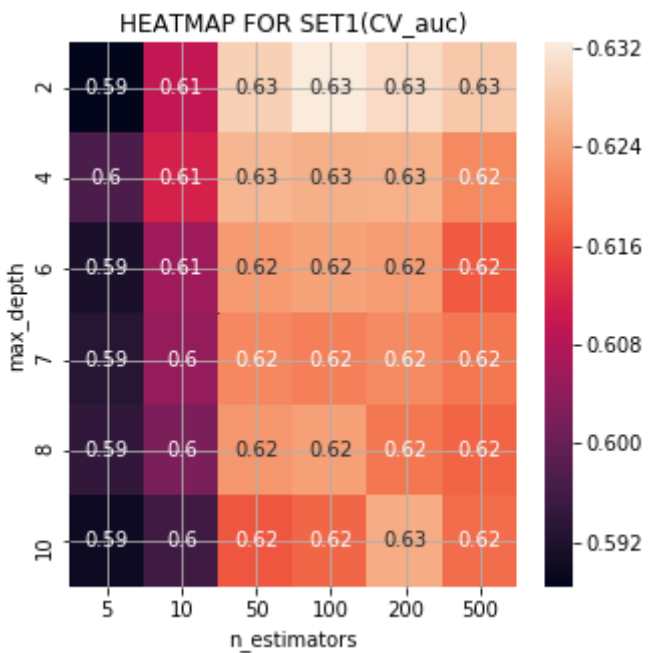
CV_With max_depth andn_estimators

In [427]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV

GBDT =  GradientBoostingClassifier()

n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]


tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(GBDT,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_tfidf, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [428]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [429]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
plt.show()
```



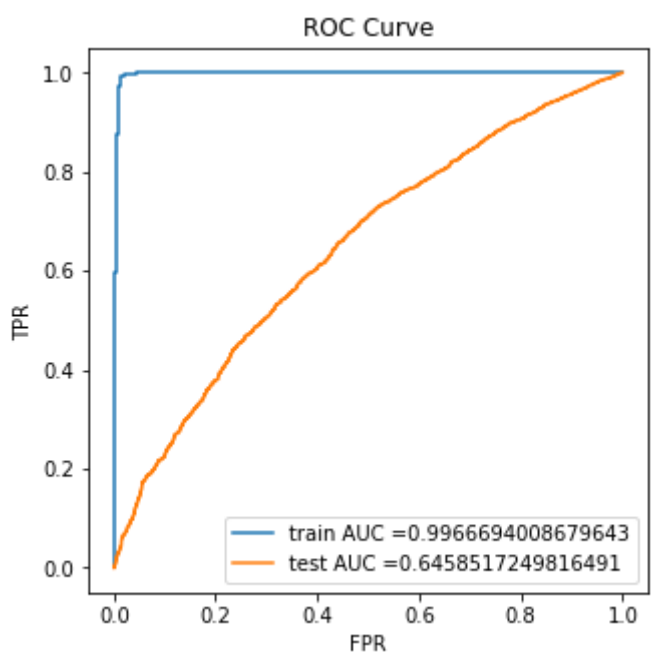
In [430]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.6134739201267729 | 0.5884054292913363 |
|     5     |   4   | 0.643796051935985  | 0.6095372345704158 |
|     5     |   6   | 0.7332511938787784 | 0.6292147456818298 |
|     5     |   7   | 0.7858767736109225 | 0.6324610671303218 |
|     5     |   8   | 0.8529338364854452 | 0.6304247643866667 |
|     5     |   10  | 0.9245295155296706 | 0.6284961089590181 |
|     10    |   2   | 0.6584392548633636 | 0.5971283049386252 |
|     10    |   4   | 0.7056632101393774 | 0.6115025734848871 |
|     10    |   6   | 0.8447445125819436 | 0.6263271808247584 |
|     10    |   7   | 0.9063132829054347 | 0.6256861423367419 |
|     10    |   8   | 0.9515420690180488 | 0.6258751527353809 |
|     10    |   10  | 0.9949546440382132 | 0.6217272867585176 |
|     50    |   2   | 0.7095646657063089 | 0.5913476470444883 |
|     50    |   4   | 0.7774248103743394 | 0.6056797488412407 |
|     50    |   6   | 0.9250322781543993 | 0.6234449922343325 |
|     50    |   7   | 0.9622292558379538 | 0.6243634391300714 |
|     50    |   8   | 0.9937950374737726 | 0.6235722798838431 |
|     50    |   10  | 0.9997661194225881 | 0.6172565963786724 |
|    100    |   2   | 0.7266164850897093 | 0.5929078563582119 |
|    100    |   4   | 0.8043045600564164 | 0.6047551370573396 |
|    100    |   6   | 0.9505117476008533 | 0.6215075546409896 |
|    100    |   7   | 0.9792089939861479 | 0.6206714749142707 |
|    100    |   8   | 0.9965078254575778 | 0.6219163465772451 |
|    100    |   10  | 0.9999962239223859 | 0.6199581404455035 |
|    200    |   2   | 0.7564927853359622 | 0.5941509679589544 |
|    200    |   4   | 0.8292943337199183 | 0.6020685795047709 |
|    200    |   6   | 0.9643406141088263 | 0.6231278536183108 |
|    200    |   7   | 0.9920799743103134 | 0.6238925376029237 |
|    200    |   8   | 0.9989315176351621 | 0.6199587453595695 |
|    200    |   10  |        1.0         | 0.6181231448168827 |
|    500    |   2   | 0.806175200298641  | 0.5898538501808478 |
|    500    |   4   | 0.8832117687417651 | 0.595773362737318  |
|    500    |   6   | 0.9852195072469406 | 0.6168888727949672 |
|    500    |   7   | 0.9982167517879262 | 0.6182438017052486 |
|    500    |   8   | 0.9999088726992457 | 0.6253112667458394 |
|    500    |   10  |        1.0         | 0.6190148865147584 |
+-----------+-------+--------------------+--------------------+
```

Using Best hyperparameters Value – Training the Model

In [439]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 100
max_depth = 10
```

In [440]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

GBDT =  GradientBoostingClassifier(n_estimators = 100, max_depth = 10)
GBDT.fit(X_train_tfidf, y_train)

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

y_train_pred_tfidf = batch_predict(GBDT, X_train_tfidf)
y_test_pred_tfidf = batch_predict(GBDT, X_test_tfidf)

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

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")
plt.rcParams["figure.figsize"] = [5,5]
plt.show()
```



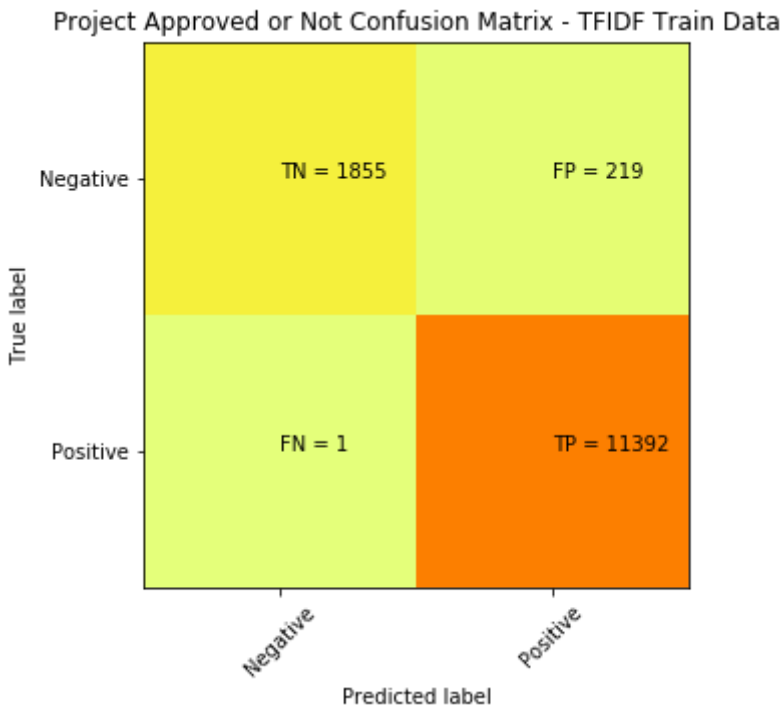
Confusion Matrix

Train confusion matrix

In [441]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tfidf_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_tfidf, tr_thresholds, train_fpr, train_f
pr))
print(tfidf_train_confusion_matrix)
```

```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.09444316323048181 for threshold 0.728
[[ 1855   219]
 [    1 11392]]
```

In [442]:
```
#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(tfidf_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - TFIDF Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_train_confusion_matrix[i][j]))
plt.show()
```

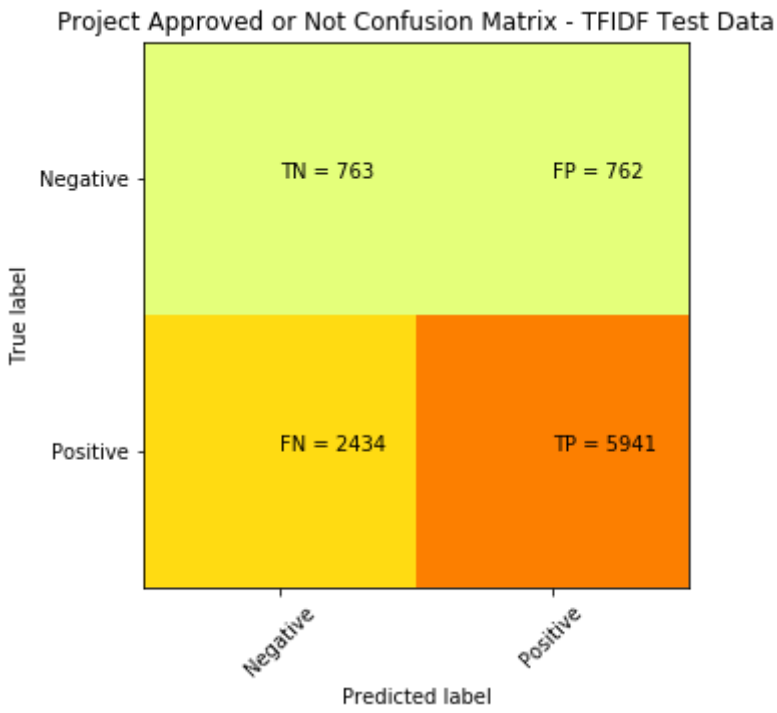


Test confusion matrix

In [443]:
```
print("Test confusion matrix")
tfidf_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_tfidf, te_thresholds, test_fpr, test_fpr))
print(tfidf_test_confusion_matrix)
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.859
[[ 763  762]
 [2434 5941]]
```

In [444]:
```
##http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(tfidf_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - TFIDF Test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_test_confusion_matrix[i][j]))
plt.show()
```



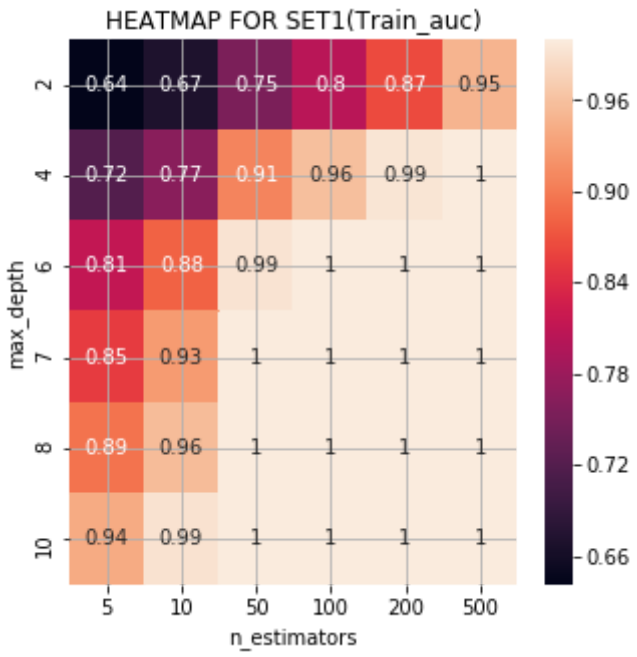
2.5.3 Applying GBDT on AVG W2V, SET 3

GridSearchCV - Finding the best hyper parameter That maximum AUC value

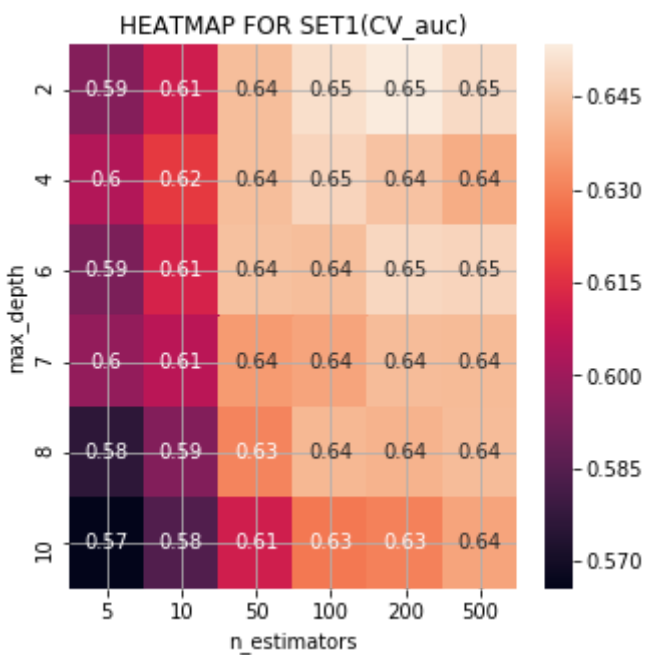
CV_With max_depth and n_estimators

In [431]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV


GBDT =  GradientBoostingClassifier()

n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]

tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(GBDT,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_avg_w2v, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [432]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [433]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
```



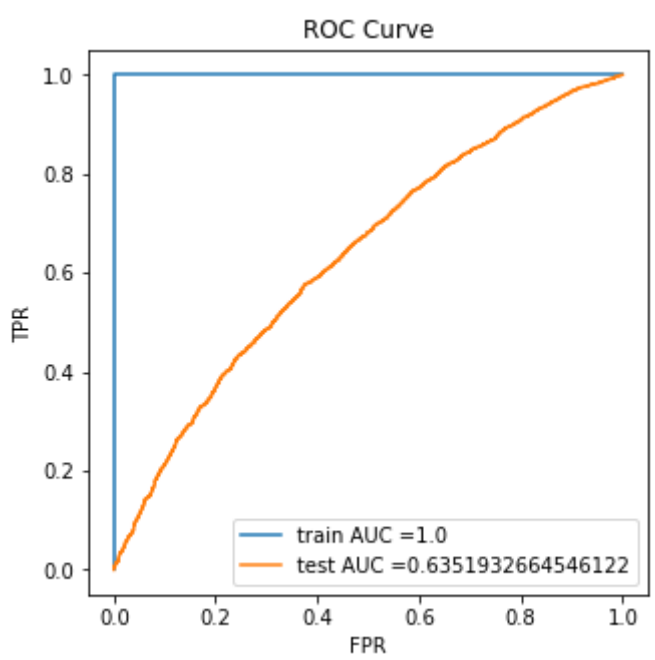
In [434]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.6412070205581458 | 0.5949313541033646 |
|     5     |   4   | 0.6703783812072679 | 0.6105457785162287 |
|     5     |   6   | 0.7539662496625361 | 0.6429590540672157 |
|     5     |   7   | 0.8048944424018845 | 0.6506274031144375 |
|     5     |   8   | 0.8652844508009215 | 0.6534805196639738 |
|     5     |   10  | 0.9483516356668966 | 0.6494351173431445 |
|     10    |   2   | 0.7189190304502255 | 0.6042277995269233 |
|     10    |   4   | 0.7657530159973785 | 0.6172260219663711 |
|     10    |   6   | 0.907837316014047  | 0.6429170293971257 |
|     10    |   7   | 0.9591453950061247 | 0.6480740075159254 |
|     10    |   8   | 0.9930179266856153 |  0.64414638267793  |
|     10    |   10  | 0.9999932410517752 | 0.6393808834685978 |
|     50    |   2   | 0.812421695788756  | 0.5932862867049963 |
|     50    |   4   | 0.8808718901856838 | 0.6119600524245287 |
|     50    |   6   | 0.9919098653709316 | 0.6436127087044726 |
|     50    |   7   | 0.999691325251423  | 0.6431533079333998 |
|     50    |   8   |        1.0         | 0.6487270849002713 |
|     50    |   10  |        1.0         | 0.6481129157680798 |
|    100    |   2   | 0.8536637079447672 | 0.5978909463113227 |
|    100    |   4   | 0.9262762932958809 | 0.6057535309634919 |
|    100    |   6   | 0.9988093486835296 | 0.6353996149291502 |
|    100    |   7   | 0.9999987619973904 | 0.6374085095297258 |
|    100    |   8   |        1.0         | 0.6426199917919343 |
|    100    |   10  |        1.0         | 0.642236579110184  |
|    200    |   2   | 0.8942711448451984 | 0.5758828637513189 |
|    200    |   4   | 0.955423210645909  | 0.594429258266803  |
|    200    |   6   | 0.9999600271555241 | 0.6310500497865514 |
|    200    |   7   |        1.0         | 0.6415667397305846 |
|    200    |   8   |        1.0         | 0.6405883078464292 |
|    200    |   10  |        1.0         | 0.6428077975678321 |
|    500    |   2   | 0.9401458512252598 | 0.5655628803594733 |
|    500    |   4   | 0.9907204828496562 | 0.584364451768257  |
|    500    |   6   |        1.0         | 0.6107836387689128 |
|    500    |   7   |        1.0         | 0.6284461055559225 |
|    500    |   8   |        1.0         | 0.6304089973967768 |
|    500    |   10  |        1.0         | 0.6375288341848692 |
+-----------+-------+--------------------+--------------------+
```

Using Best hyperparameters Value – Training the Model

In [454]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 10
max_depth = 50
```

In [455]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


GBDT =  GradientBoostingClassifier(n_estimators = 50, max_depth = 10)
GBDT.fit(X_train_avg_w2v, 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_avg_w2v = batch_predict(GBDT,X_train_avg_w2v)
y_test_pred_avg_w2v = batch_predict(GBDT,X_test_avg_w2v)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_avg_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_avg_w2v)

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("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")

plt.show()
```

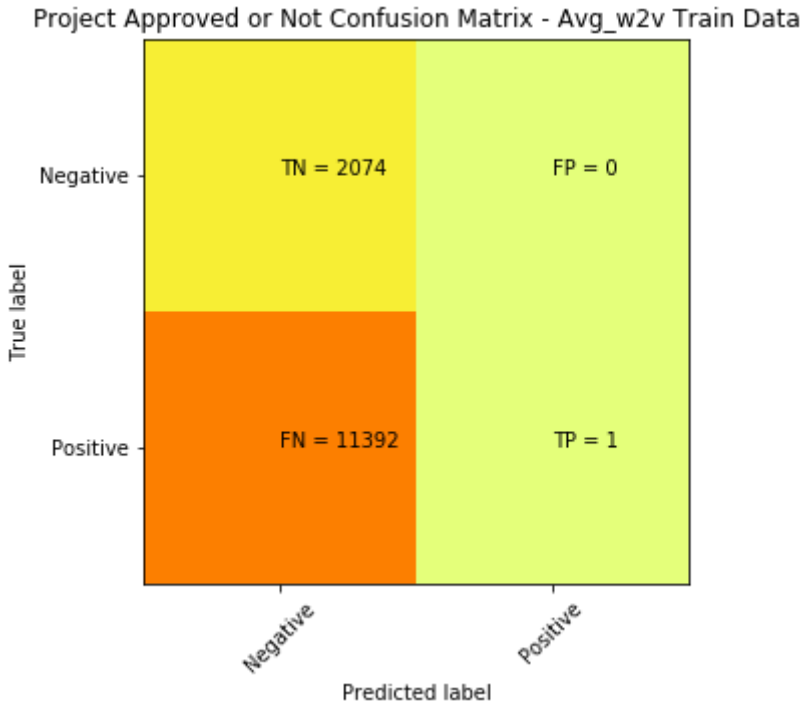


Confusion Matrix

Train confusion matrix

In [456]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
avg_w2v_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_avg_w2v, tr_thresholds, train_fpr, tra
in_fpr))
print(avg_w2v_train_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(avg_w2v_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Avg_w2v Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(avg_w2v_train_confusion_matrix[i][j]))
plt.show()
```

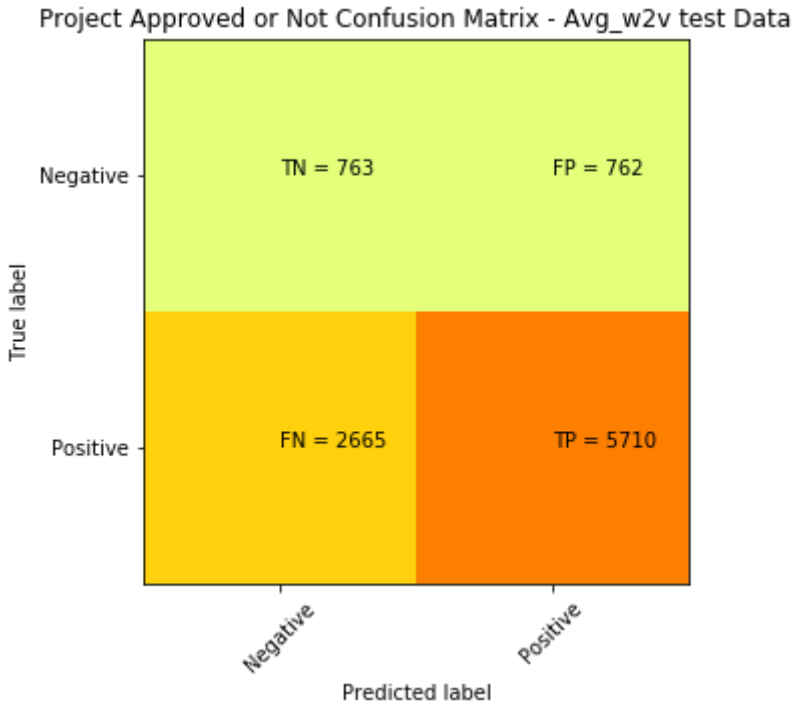
```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.0 for threshold 0.987
[[ 2074     0]
 [11392     1]]
```



Test confusion matrix

In [457]:
```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
avg_w2v_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_avg_w2v, te_thresholds, test_fpr, test_fp
r))
print(avg_w2v_test_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(avg_w2v_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Avg_w2v test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(avg_w2v_test_confusion_matrix[i][j]))
plt.show()
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.9
[[ 763  762]
 [2665 5710]]
```



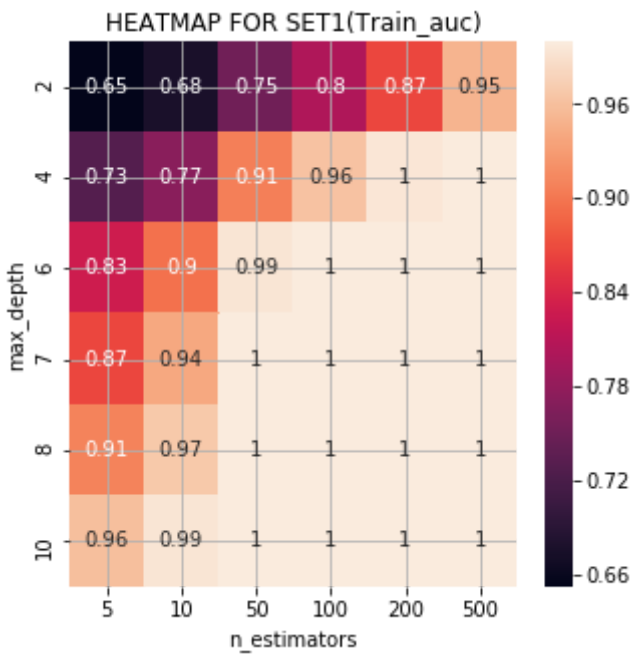
2.5.4 Applying GBDT on TFIDF W2V, SET 4

GridSearchCV - Finding the best hyper parameter That maximum AUC value

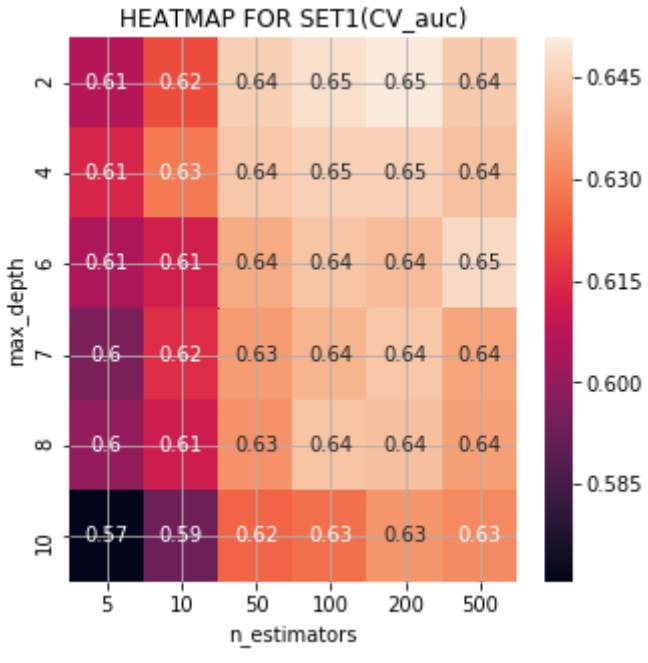
CV_With max_depth andn_estimators

In [435]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV

GBDT =  GradientBoostingClassifier()

n_estimators = [5, 10, 50, 100, 200, 500]
max_depth = [2, 4,6, 7, 8, 10]

tuned_parameters = [{'n_estimators':n_estimators,'max_depth': max_depth}]

clf = GridSearchCV(GBDT,tuned_parameters, cv=3, scoring='roc_auc')
clf.fit(X_train_tfidf_w2v, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
Train_auc = train_auc.reshape(len(n_estimators),len(max_depth))
Cv_auc = cv_auc.reshape(len(n_estimators),len(max_depth))
```

In [436]:
```
sns.heatmap(Train_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(Train_auc)")
plt.grid()
plt.show()
```



In [437]:
```
sns.heatmap(Cv_auc,annot=True,xticklabels=[5, 10, 50, 100, 200, 500], yticklabels=[2, 4,6, 7, 8, 10],)
plt.xlabel("n_estimators")
plt.ylabel("max_depth")
plt.title("HEATMAP FOR SET1(CV_auc)")
plt.grid()
plt.show()
```



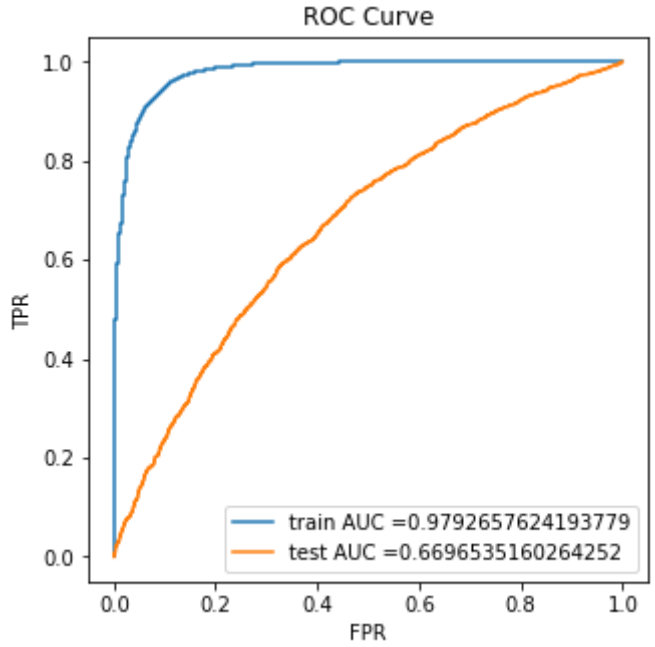
In [438]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable
Estimator = [5,5,5,5,5,5, 10,10,10,10,10,10,50,50,50,50,50,50,100,100,100,100,100,100,200,200,200,200,200, 200,500,500
,500,500,500,500]
Depth = [2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10,2, 4,6, 7, 8, 10]
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
column_names = ['Estimator','Depth','train_auc','cv_auc']
x.add_column(column_names[0],Estimator)
x.add_column(column_names[1],Depth)
x.add_column(column_names[2],train_auc)
x.add_column(column_names[3],cv_auc)
print(x)
```

```
+-----------+-------+--------------------+--------------------+
| Estimator | Depth |     train_auc      |       cv_auc       |
+-----------+-------+--------------------+--------------------+
|     5     |   2   | 0.6528482265545911 | 0.6066735653957752 |
|     5     |   4   | 0.6765503649134647 | 0.6209208357427772 |
|     5     |   6   | 0.7531322161025793 | 0.6447019835190594 |
|     5     |   7   | 0.8027175645234842 | 0.648583076284414  |
|     5     |   8   | 0.8658407284161705 | 0.6509814465125322 |
|     5     |   10  | 0.9510875885143367 | 0.6438653141871776 |
|     10    |   2   | 0.7294624632934236 | 0.6136236427823012 |
|     10    |   4   | 0.7722829363254022 | 0.6286018230001974 |
|     10    |   6   | 0.9074701169175153 | 0.6432489106811676 |
|     10    |   7   | 0.9633270443078729 | 0.6452112347392871 |
|     10    |   8   | 0.9954817183810775 | 0.6451788493124422 |
|     10    |   10  |        1.0         | 0.6420856882793449 |
|     50    |   2   | 0.8286951704062201 | 0.6050002629048402 |
|     50    |   4   | 0.8961456251439209 | 0.6122512565892805 |
|     50    |   6   | 0.9935525525176656 | 0.637779197459607  |
|     50    |   7   | 0.999940159226186  | 0.6425379353739193 |
|     50    |   8   |        1.0         | 0.6409679125122595 |
|     50    |   10  |        1.0         | 0.6469852859864955 |
|    100    |   2   | 0.8659418588826971 | 0.596001920790965  |
|    100    |   4   | 0.939764496235385  | 0.615309739316646  |
|    100    |   6   | 0.9997865313207198 | 0.6348295097137516 |
|    100    |   7   |        1.0         | 0.6394965052345623 |
|    100    |   8   |        1.0         | 0.6433139074910142 |
|    100    |   10  |        1.0         | 0.6363218883344781 |
|    200    |   2   | 0.909512856785927  | 0.6000182061096876 |
|    200    |   4   | 0.9687899481941633 | 0.611297529045106  |
|    200    |   6   | 0.9999985719549341 | 0.6330080103179286 |
|    200    |   7   |        1.0         | 0.6427630028849779 |
|    200    |   8   |        1.0         | 0.6416132894016685 |
|    200    |   10  |        1.0         |  0.63544998265455  |
|    500    |   2   | 0.9603202494909094 | 0.5705597956326323 |
|    500    |   4   | 0.9934309798048006 | 0.5933945641387669 |
|    500    |   6   |        1.0         | 0.6246680032098979 |
|    500    |   7   |        1.0         | 0.6267433601405517 |
|    500    |   8   |        1.0         | 0.6335224124095497 |
|    500    |   10  |        1.0         | 0.6313246530817795 |
+-----------+-------+--------------------+--------------------+
```

Using Best hyperparameters Value – Training the Model

In [449]:
```
#Taking the Optimal hyperparameter from heatmap and Pretty table of Max depth , Max Split , Train and CV AUC
n_estimators = 100
max_depth = 5
```

In [451]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


GBDT =  GradientBoostingClassifier(n_estimators = 100, max_depth = 5 )
GBDT.fit(X_train_tfidf_w2v, y_train)

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

y_train_pred_tfidf_w2v = batch_predict(GBDT,X_train_tfidf_w2v)
y_test_pred_tfidf_w2v = batch_predict(GBDT,X_test_tfidf_w2v)

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred_tfidf_w2v)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred_tfidf_w2v)

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("FPR")
plt.ylabel("TPR")
plt.title("ROC Curve")

plt.show()
```

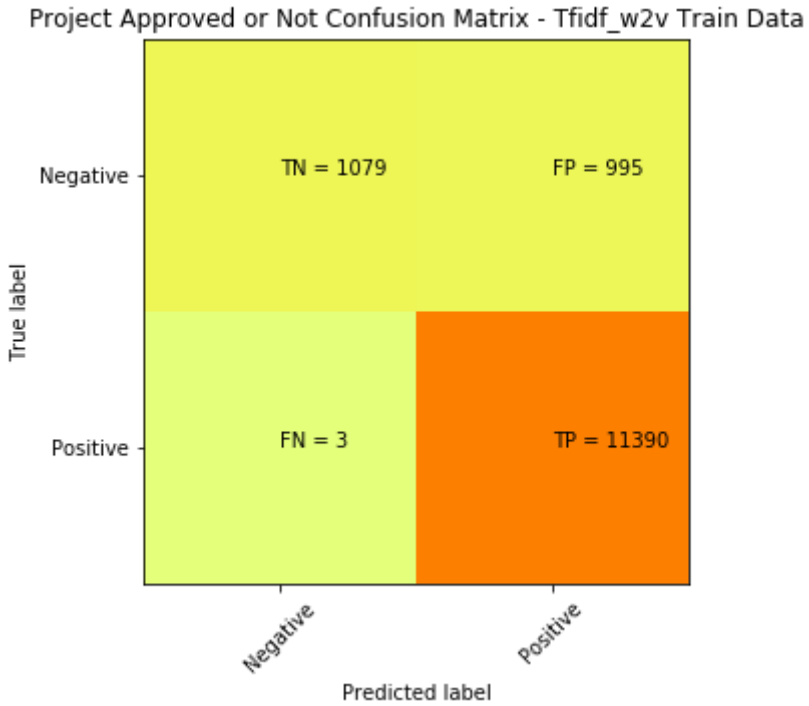


Confusion Matrix

Train confusion matrix

In [452]:
```
from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
tfidf_w2v_train_confusion_matrix = confusion_matrix(y_train, predict(y_train_pred_tfidf_w2v, tr_thresholds, train_fpr,
train_fpr))
print(tfidf_w2v_train_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(tfidf_w2v_train_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Tfidf_w2v Train Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_w2v_train_confusion_matrix[i][j]))
plt.show()
```

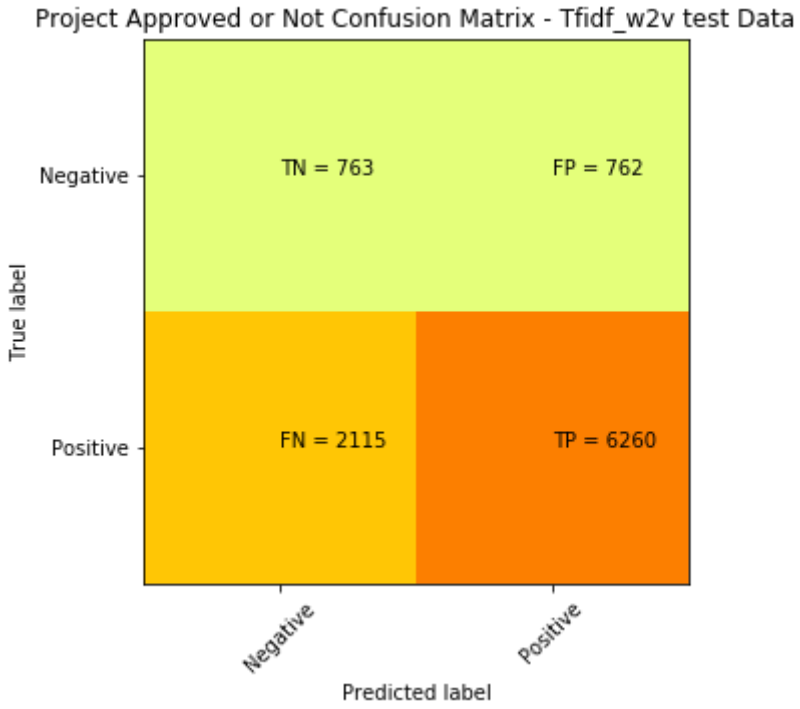
```
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.24958990820825222 for threshold 0.57
[[ 1079   995]
 [    3 11390]]
```



Test confusion matrix

In [453]:
```
from sklearn.metrics import confusion_matrix
print("Test confusion matrix")
tfidf_w2v_test_confusion_matrix = confusion_matrix(y_test, predict(y_test_pred_tfidf_w2v, te_thresholds, test_fpr, tes
t_fpr))
print(tfidf_w2v_test_confusion_matrix)

#http://www.tarekatwan.com/index.php/2017/12/how-to-plot-a-confusion-matrix-in-python/

plt.clf()
plt.imshow(avg_w2v_test_confusion_matrix, interpolation='nearest', cmap=plt.cm.Wistia)
classNames = ['Negative','Positive']
plt.title('Project Approved or Not Confusion Matrix - Tfidf_w2v test Data')
plt.ylabel('True label')
plt.xlabel('Predicted label')
tick_marks = np.arange(len(classNames))
plt.xticks(tick_marks, classNames, rotation=45)
plt.yticks(tick_marks, classNames)
s = [['TN','FP'], ['FN', 'TP']]
for i in range(2):
    for j in range(2):
        plt.text(j,i, str(s[i][j])+" = "+str(tfidf_w2v_test_confusion_matrix[i][j]))
plt.show()
```

```
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999989250201562 for threshold 0.833
[[ 763  762]
 [2115 6260]]
```



3. Conclusions

In [460]:
```
from prettytable import PrettyTable
#If you get a ModuleNotFoundError error , install prettytable using: pip3 install prettytable
x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyper Parameter(Max depth & n_estimators )", "AUC"]
x.add_row(["BOW",  "Randon Forest  " , (10 , 100), 0.64])
x.add_row(["TFIDF", "Randon Forest  " , (10 ,  50), 0.63])
x.add_row(["AVG W2V", "Randon Forest  " , (10 , 200), 0.65])
x.add_row(["TFIDF W2V", "Randon Forest   " , (10 , 50), 0.65])
x.add_row(["BOW",  "GBDT  " , (10 , 50), 0.64])
x.add_row(["TFIDF", "GBDT  " , (10 ,  100), 0.65])
x.add_row(["AVG W2V", "GBDT  " , (10 , 50), 0.64])
x.add_row(["TFIDF W2V","GBDT   " , (5 , 100), 0.67])


print(x)
```

```
+------------+-----------------+-------------------------------------------+------+
| Vectorizer |      Model      | Hyper Parameter(Max depth & n_estimators ) | AUC  |
+------------+-----------------+-------------------------------------------+------+
|    BOW     | Randon Forest   |                (10, 100)                  | 0.64 |
|   TFIDF    | Randon Forest   |                 (10, 50)                  | 0.63 |
|  AVG W2V   | Randon Forest   |                (10, 200)                  | 0.65 |
| TFIDF W2V  | Randon Forest   |                 (10, 50)                  | 0.65 |
|    BOW     |      GBDT       |                 (10, 50)                  | 0.64 |
|   TFIDF    |      GBDT       |                (10, 100)                  | 0.65 |
|  AVG W2V   |      GBDT       |                 (10, 50)                  | 0.64 |
| TFIDF W2V  |     GBDT        |                 (5, 100)                  | 0.67 |
+------------+-----------------+-------------------------------------------+------+
```