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

Feature	Description
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
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."

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]:

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

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

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

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

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

from tqdm import tqdm
import os

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

1.1 Reading Data

In [3]:

```
train_data= pd.read_csv('C:/Users/User/Downloads/train_data.csv', na_values=' ')
resource_data = pd.read_csv('C:/Users/User/Downloads/resources.csv', na_values=' ')
```

In [4]:

```
df=pd.DataFrame(train_data)
```

In [5]:

```
project_data=df
```

In [6]:

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

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

In [7]:

```
# 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[7]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

In [8]:

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

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

Out[8]:

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

In [9]:

```
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[9]:

Out[9]:

	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 [10]:

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

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

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

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

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

1.3 preprocessing of `project_subject_subcategories`

In [11]:

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

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

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

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

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

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

1.3 Text preprocessing

In [12]:

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

In [13]:

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

Out[13]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5

In [14]:

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

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom as well as the STEM j
ournals, which my students really enjoyed.  I would love to implement more of the Lakeshore STEM k
its in my classroom for the next school year as they provide excellent and engaging STEM
lessons.My students come from a variety of backgrounds, including language and socioeconomic statu
s.  Many of them don't have a lot of experience in science and engineering and these kits give me
the materials to provide these exciting opportunities for my students.Each month I try to do
several science or STEM/STEAM projects.  I would use the kits and robot to help guide my science i
nstruction in engaging and meaningful ways.  I can adapt the kits to my current language arts paci
ng guide where we already teach some of the material in the kits like tall tales (Paul Bunyan) or
Johnny Appleseed.  The following units will be taught in the next school year where I will
implement these kits: magnets, motion, sink vs. float, robots.  I often get to these units and don
't know If I am teaching the right way or using the right materials.    The kits will give me
additional ideas, strategies, and lessons to prepare my students in science.It is challenging to d
```

```
evelop high quality science activities.  These kits give me the materials I need to provide my
students with science activities that will go along with the curriculum in my classroom.  Although
I have some things (like magnets) in my classroom, I don't know how to use them effectively.  The
kits will provide me with the right amount of materials and show me how to use them in an
appropriate way.
==================================================
I teach high school English to students with learning and behavioral disabilities. My students all
vary in their ability level. However, the ultimate goal is to increase all students literacy level
s. This includes their reading, writing, and communication levels.I teach a really dynamic group o
f students. However, my students face a lot of challenges. My students all live in poverty and in
a dangerous neighborhood. Despite these challenges, I have students who have the the desire to def
eat these challenges. My students all have learning disabilities and currently all are performing
below grade level. My students are visual learners and will benefit from a classroom that fulfills
their preferred learning style.The materials I am requesting will allow my students to be prepared
for the classroom with the necessary supplies.  Too often I am challenged with students who come t
o school unprepared for class due to economic challenges.  I want my students to be able to focus
on learning and not how they will be able to get school supplies.  The supplies will last all year
.  Students will be able to complete written assignments and maintain a classroom journal.  The ch
art paper will be used to make learning more visual in class and to create posters to aid students
in their learning.  The students have access to a classroom printer.  The toner will be used to pr
int student work that is completed on the classroom Chromebooks.I want to try and remove all barri
ers for the students learning and create opportunities for learning. One of the biggest barriers i
s the students not having the resources to get pens, paper, and folders. My students will be able
to increase their literacy skills because of this project.
==================================================
```

In [15]:

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

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

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

In [16]:

```python
sent = decontracted(project_data['essay'].values[20000])
```

In [17]:

```python
# \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', ' ')
```

In [18]:

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

In [19]:

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

In [20]:

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

```
100%|█████████████████████████████████| 109248/109248 [03:49<00:00, 475.05it/s]
```

In [21]:

```
# after preprocesing
project_data.head(3)
```

Out[21]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016- 04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016- 04-27 00:31:25	Grades 3-5
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016- 04-27	Grades PreK-2

00:46:53

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate

1.4 Preprocessing of `project_title`

In [22]:

```
# printing some random essays.
print(project_data['project_title'].values[0])
print("="*50)
print(project_data['project_title'].values[150])
print("="*50)
print(project_data['project_title'].values[1000])
```

```
Engineering STEAM into the Primary Classroom
==================================================
Building Blocks for Learning
==================================================
Empowering Students Through Art:Learning About Then and Now
```

In [23]:

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

```
100%|██████████████████████████████| 109248/109248 [00:10<00:00, 10040.60it/s]
```

In [24]:

```
project_data.head(3)
```

Out[24]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_cate
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grades PreK-2
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	Grades 3-5
51140	74477	p189804	4a97f3a390bfe21b99cf5e2b81981c73	Mrs.	CA	2016-04-27	Grades PreK-2

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	00:46:53 Date	project_grade_cate

1.4.1 Project_grade preprocessing

In [25]:

```
project_data['project_grade_category'][:4]
```

Out[25]:

```
55660    Grades PreK-2
76127       Grades 3-5
51140    Grades PreK-2
473      Grades PreK-2
Name: project_grade_category, dtype: object
```

In [26]:

```
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(" ", "_
")
project_data['project_grade_category'].value_counts()
```

Out[26]:

```
Grades_PreK-2    44225
Grades_3-5       37137
Grades_6-8       16923
Grades_9-12      10963
Name: project_grade_category, dtype: int64
```

Preprocessing teacher_prefix

In [27]:

```
project_data['teacher_prefix'][:4]
```

Out[27]:

```
55660    Mrs.
76127     Ms.
51140    Mrs.
473      Mrs.
Name: teacher_prefix, dtype: object
```

In [28]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace(".","")
project_data['teacher_prefix'].value_counts()
```

Out[28]:

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

1.5 Preparing data for models

In [29]:

```
project_data.columns
```

Out[29]:

```
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', 'essay',
       'preprocessed_essays', 'preprocessed_titles'],
      dtype='object')
```

we are going to consider

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

   - preprocessed_titles: text data
   - preprocessed_essays : text data


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

Split data into train,test and Cross validate

In [30]:

```
Y = project_data['project_is_approved'].values
project_data.drop(['project_is_approved'], axis=1, inplace=True)
```

In [31]:

```
X = project_data
X.head(1)
```

Out[31]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_categ
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs	CA	2016-04-27 00:27:36	Grades_PreK-2

In [32]:

```
# train test split
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, stratify=Y)
```

1.5.1 Vectorizing Categorical data

One Hot Encode - Clean_Categories

In [33]:

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


categories_one_hot_train = vectorizer.transform(X_train['clean_categories'].values)
categories_one_hot_test = vectorizer.transform(X_test['clean_categories'].values)


print("Shape of Train data - one hot encoding ",categories_one_hot_train.shape)
print("Shape of Test data - one hot encoding ",categories_one_hot_test.shape)
print(vectorizer.get_feature_names())
```

```
Shape of Train data - one hot encoding  (81936, 9)
Shape of Test data - one hot encoding  (27312, 9)
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
```

One Hot Encode - Clean_Sub-Categories

In [34]:

```
# we use count vectorizer to convert the values into one
from sklearn.feature_extraction.text import CountVectorizer

vectorizer= CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=T
rue)

vectorizer.fit(X_train['clean_subcategories'].values)
vectorizer_sub_proj=vectorizer
sub_cat_one_hot_train = vectorizer.transform(X_train['clean_subcategories'].values)
sub_cat_one_hot_test = vectorizer.transform(X_test['clean_subcategories'].values)


print("Shape of Train data - one hot encoding ",sub_cat_one_hot_train.shape)
print("Shape of Test data - one hot encoding",sub_cat_one_hot_test.shape)
print(vectorizer.get_feature_names())
```

```
Shape of Train data - one hot encoding  (81936, 30)
Shape of Test data - one hot encoding (27312, 30)
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
```

One Hot Encode - School_States

In [35]:

```
my_counter = Counter()
for state in project_data['school_state'].values:
    my_counter.update(state.split())
```

In [36]:

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

In [37]:

```
## we use count vectorizer to convert the values into one hot encoded features

vectorizer= CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys()), lowercase=False,
binary=True)
```

```
binary=True)
vectorizer.fit(X_train['school_state'].values)
vectorizer_states=vectorizer
school_state_one_hot_train = vectorizer.transform(X_train['school_state'].values)
school_state_one_hot_test = vectorizer.transform(X_test['school_state'].values)

print("Shape of Train data - one hot encoding",school_state_one_hot_train.shape)
print("Shape of Test data - one hot encoding",school_state_one_hot_test.shape)
print(vectorizer.get_feature_names())
```

```
Shape of Train data - one hot encoding (81936, 51)
Shape of Test data - one hot encoding (27312, 51)
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME', 'HI', 'DC', 'NM', 'KS', 'I
A', 'ID', 'AR', 'CO', 'MN', 'OR', 'KY', 'MS', 'NV', 'MD', 'CT', 'TN', 'UT', 'AL', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'WA', 'MA', 'LA', 'OH', 'MO', 'IN', 'PA', 'MI', 'SC', 'GA', 'IL', 'NC', 'FL', 'NY', 'TX
', 'CA']
```

One Hot Encode - Project_Grade_Category

In [38]:

```
my_counter = Counter()
for project_grade in project_data['project_grade_category'].values:
    my_counter.update(project_grade.split())
```

In [39]:

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

In [40]:

```
## we use count vectorizer to convert the values into one hot encoded features

vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_cat_dict.keys()), lowercase=Fals
e, binary=True)
vectorizer.fit(X_train['project_grade_category'].values)
vectorizer_grade=vectorizer
project_grade_cat_one_hot_train = vectorizer.transform(X_train['project_grade_category'].values)
project_grade_cat_one_hot_test = vectorizer.transform(X_test['project_grade_category'].values)


print("Shape of Train data - one hot encoding",project_grade_cat_one_hot_train.shape)
print("Shape of Test data - one hot encoding",project_grade_cat_one_hot_test.shape)
print(vectorizer.get_feature_names())
```

```
Shape of Train data - one hot encoding (81936, 4)
Shape of Test data - one hot encoding (27312, 4)
['Grades_9-12', 'Grades_6-8', 'Grades_3-5', 'Grades_PreK-2']
```

One Hot Encode - Teacher_Prefix

In [41]:

```
my_counter = Counter()
for teacher_prefix in project_data['teacher_prefix'].values:
    teacher_prefix = str(teacher_prefix)
    my_counter.update(teacher_prefix.split())
```

In [42]:

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

In [43]:

```
vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()), lowercase=Fal
vectorizer = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.keys()), lowercase=Fal
se, binary=True)
vectorizer.fit(X_train['teacher_prefix'].values.astype("U"))
vectorizer_teacher=vectorizer
teacher_prefix_cat_one_hot_train =
vectorizer.transform(X_train['teacher_prefix'].values.astype("U"))
teacher_prefix_cat_one_hot_test = vectorizer.transform(X_test['teacher_prefix'].values.astype("U"))

print("Shape of Train data - one hot encoding",teacher_prefix_cat_one_hot_train.shape)
print("Shape of Test data - one hot encoding ",teacher_prefix_cat_one_hot_test.shape)

print(vectorizer.get_feature_names())
```

```
Shape of Train data - one hot encoding (81936, 6)
Shape of Test data - one hot encoding  (27312, 6)
['nan', 'Dr', 'Teacher', 'Mr', 'Ms', 'Mrs']
```

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

BOW of eassys - FOr Train/Test/CV Datasets

In [44]:

```
vectorizer = CountVectorizer(min_df=10)# its a countvectors used for convert text to vectors
vectorizer.fit(X_train['preprocessed_essays'])

vectorizer_bow_essay =vectorizer
# BOW for essays Train Data
essay_bow_train = vectorizer.transform(X_train['preprocessed_essays'])
print(essay_bow_train.shape,Y_train.shape)


# BOW for essays Test Data
essay_bow_test = vectorizer.transform(X_test['preprocessed_essays'])
print(essay_bow_test.shape,Y_test.shape)
```

```
(81936, 14768) (81936,)
(27312, 14768) (27312,)
```

BOW of Project Titles - Train/Test/CV Data¶

In [45]:

```
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(X_train['preprocessed_titles'])
vectorizer_bow_title = vectorizer


# BOW for title Train Data
title_bow_train = vectorizer.transform(X_train['preprocessed_titles'])
print(title_bow_train.shape,Y_train.shape)


# BOW for title Test Data
title_bow_test = vectorizer.transform(X_test['preprocessed_titles'])
print(title_bow_test.shape,Y_test.shape)
```

```
(81936, 2799) (81936,)
(27312, 2799) (27312,)
```

1.5.2.2 TFIDF vectorizer for essay

In [46]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)# its a countvectors used for convert text to vectors

vectorizer.fit(X_train['preprocessed_essays'])
vectorizer_tfidf_essay=vectorizer

#tidf Train Data
essay_tfidf_train = vectorizer.transform(X_train['preprocessed_essays'])
print(essay_tfidf_train.shape,Y_train.shape)


#tidf Test Data
essay_tfidf_test = vectorizer.transform(X_test['preprocessed_essays'])
print(essay_tfidf_test.shape,Y_test.shape)
```

```
(81936, 14768) (81936,)
(27312, 14768) (27312,)
```

TFIDF vectorizer for Title

In [47]:

```
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['preprocessed_titles'])
vectorizer_tfidf_titles=vectorizer

#tidf Train Data
title_tfidf_train = vectorizer.transform(X_train['preprocessed_titles'])
print(title_tfidf_train.shape,Y_train.shape)


#tidf Test Data
title_tfidf_test = vectorizer.transform(X_test['preprocessed_titles'])
print(title_tfidf_test.shape,Y_test.shape)
```

```
(81936, 2799) (81936,)
(27312, 2799) (27312,)
```

Using Pretrained Models: Avg W2V

In [48]:

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

In [49]:

```
# average Word2Vec Function
# computing average word2vec for each review.
# the avg-w2v for each sentence/review is stored in this list
def avg_w2v_vectors_func(sentance):
    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
    return vector
```

Train/Test/CV Data - Avg-W2V for essay

In [50]:

```
essay_avg_w2v_train = []
essay_avg_w2v_test  = []
# Avg-w2v for Train data
for sentence in tqdm(X_train['preprocessed_essays']):
    essay_avg_w2v_train.append(avg_w2v_vectors_func(sentance))

# Avg-w2v for Train data
print("len(essay_avg_w2v_train):",len(essay_avg_w2v_train))
print("len(essay_avg_w2v_train[0])",len(essay_avg_w2v_train[0]))
# Avg-w2v for Test data
for sentence in tqdm(X_test['preprocessed_essays']):
    essay_avg_w2v_test.append(avg_w2v_vectors_func(sentance))


print("len(essay_avg_w2v_test):",len(essay_avg_w2v_test))
print("len(essay_avg_w2v_test[0])",len(essay_avg_w2v_test[0]))
```

```
100%|██████████████████████████████████| 81936/81936 [01:09<00:00, 1183.14it/s]
```

```
len(essay_avg_w2v_train): 81936
len(essay_avg_w2v_train[0]) 300
```

```
100%|██████████████████████████████████| 27312/27312 [00:23<00:00, 1143.27it/s]
```

```
len(essay_avg_w2v_test): 27312
len(essay_avg_w2v_test[0]) 300
```

Train/Test/CV Data - Avg-W2V for title

In [51]:

```
title_avg_w2v_train = []
title_avg_w2v_test  = []

for sentence in tqdm(X_train['preprocessed_titles']):
    title_avg_w2v_train.append(avg_w2v_vectors_func(sentance)) # Avg-w2v for Train data

# Avg-w2v for Train data
print("len(title_avg_w2v_train):",len(title_avg_w2v_train))
print("len(title_avg_w2v_train[0])",len(title_avg_w2v_train[0]))

for sentence in tqdm(X_test['preprocessed_titles']):
    title_avg_w2v_test.append(avg_w2v_vectors_func(sentance)) # Avg-w2v for Test data

# Avg-w2v for Test data
print("len(title_avg_w2v_test):",len(title_avg_w2v_test))
print("len(title_avg_w2v_test[0])",len(title_avg_w2v_test[0]))
```

```
100%|█████████████████████████████████| 81936/81936 [00:03<00:00, 26549.36it/s]
```

```
len(title_avg_w2v_train): 81936
len(title_avg_w2v_train[0]) 300
```

```
100%|█████████████████████████████████| 27312/27312 [00:00<00:00, 43907.46it/s]
```

```
len(title_avg_w2v_test): 27312
len(title_avg_w2v_test[0]) 300
```

Using Pretrained Models: TFIDF weighted W2V

In [52]:

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

In [53]:

```
# Compute  TFIDF weighted W2V for each sentence of the review.

def tf_idf_weight_func(sentence): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    return vector
```

Train/Test/CV Data - TFIDF weighted W2V for essays

In [54]:

```
essay_tfidf_w2v_train = []
essay_tfidf_w2v_test  = []
#  TFIDF weighted W2V for Train data
for sentence in tqdm(X_train['preprocessed_essays']):
    essay_tfidf_w2v_train.append(tf_idf_weight_func(sentance))
print("len(essay_tfidf_w2v_train)",len(essay_tfidf_w2v_train))
print("len(essay_tfidf_w2v_train[0])",len(essay_tfidf_w2v_train[0]))

#  TFIDF weighted W2V for Test data
for sentence in tqdm(X_test['preprocessed_essays']):
    essay_tfidf_w2v_test.append(tf_idf_weight_func(sentance))
print("len(essay_tfidf_w2v_test)",len(essay_tfidf_w2v_test))
print("len(essay_tfidf_w2v_test[0])",len(essay_tfidf_w2v_test[0]))
```

```
100%|██████████████████████████████| 81936/81936 [00:00<00:00, 209008.35it/s]
```

```
len(essay_tfidf_w2v_train) 81936
len(essay_tfidf_w2v_train[0]) 300
```

```
100%|██████████████████████████████| 27312/27312 [00:00<00:00, 190982.33it/s]
```

```
len(essay_tfidf_w2v_test) 27312
len(essay_tfidf_w2v_test[0]) 300
```

Train/Test/CV Data - TFIDF weighted W2V for Project Titles

In [55]:

```
title_tfidf_w2v_train  = []
title_tfidf_w2v_test  = []

for sentence in tqdm(X_train['preprocessed_titles']):
    title_tfidf_w2v_train.append(tf_idf_weight_func(sentance)) #  TFIDF weighted W2V for Train
data
print("len(title_tfidf_w2v_train)",len(title_tfidf_w2v_train))
print("len(title_tfidf_w2v_train[0])",len(title_tfidf_w2v_train[0]))

for sentence in tqdm(X_test['preprocessed_titles']):
    title_tfidf_w2v_test.append(tf_idf_weight_func(sentance)) #  TFIDF weighted W2V for Test data
print("len(title_tfidf_w2v_test)",len(title_tfidf_w2v_test))
print("len(title_tfidf_w2v_test[0])",len(title_tfidf_w2v_test[0]))
```

```
100%|██████████████████████████████| 81936/81936 [00:00<00:00, 194149.87it/s]
```

```
len(title_tfidf_w2v_train) 81936
len(title_tfidf_w2v_train[0]) 300
```

```
100%|████████████████████████████████| 27312/27312 [00:00<00:00, 196478.17it/s]
```

```
len(title_tfidf_w2v_test) 27312
len(title_tfidf_w2v_test[0]) 300
```

1.5.3 Vectorizing Numerical features

In [56]:

```python
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(3)
```

Out[56]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21
2	p000003	298.97	4

In [57]:

```python
X_train = pd.merge(X_train, price_data, on='id', how='left')
X_test = pd.merge(X_test, price_data, on='id', how='left')
```

In [58]:

```python
from sklearn.preprocessing import Normalizer

normalizer = Normalizer()

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

normalizer.fit(X_train['price'].values.reshape(1,-1))

price_data_train = normalizer.transform(X_train['price'].values.reshape(-1,1))

price_data_test = normalizer.transform(X_test['price'].values.reshape(-1,1))


print("After vectorizations")
print("="*100)
print(price_data_train.shape, Y_train.shape)
print(price_data_test.shape, Y_test.shape)
print("="*100)
```

```
After vectorizations
====================================================================================================
(81936, 1) (81936,)
(27312, 1) (27312,)
====================================================================================================
```

Vectorizing Quantity Feature

In [59]:

```python
normalizer = Normalizer()
```

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

normalizer.fit(X_train['quantity'].values.reshape(1,-1))

quant_train = normalizer.transform(X_train['quantity'].values.reshape(-1,1))
quant_test = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

print("="*100)
print("After vectorizations")
print(quant_train.shape, Y_train.shape)
print(quant_test.shape, Y_test.shape)
print("="*100)
```

```
====================================================================================================
After vectorizations
(81936, 1) (81936,)
(27312, 1) (27312,)
====================================================================================================
```

Vectorizing teacher_number_of_previously_posted_projects

In [60]:

```
normalizer = Normalizer()

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

normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

prev_no_projects_train =
normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_no_projects_test = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'
].values.reshape(-1,1))

print("="*100)
print("After vectorizations")
print(prev_no_projects_train.shape, Y_train.shape)
print(prev_no_projects_test.shape, Y_test.shape)
print("="*100)
```

```
====================================================================================================
After vectorizations
(81936, 1) (81936,)
(27312, 1) (27312,)
====================================================================================================
```

Assignment 7: SVM

1. **[Task-1] Apply Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on these feature sets**
    - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **The hyper paramter tuning (best alpha in range [10^-4 to 10^4], and the best penalty among 'l1', 'l2')**

    - Find the best hyper parameter which will give the maximum AUC value
    - Find the best hyper paramter using k-fold cross validation or simple cross validation data
    - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

3. **Representation of results**

    - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure.
    - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
    - Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points. Please visualize your confusion matrices using seaborn heatmaps.

4. **[Task-2] Apply the Support Vector Machines on these features by finding the best hyper paramter as suggested in step 2 and step 3**

    - Consider these set of features Set 5 :
        - **school_state** : categorical data
        - **clean_categories** : categorical data
        - **clean_subcategories** : categorical data
        - **project_grade_category** :categorical data
        - **teacher_prefix** : categorical data
        - **quantity** : numerical data
        - **teacher_number_of_previously_posted_projects** : numerical data
        - **price** : numerical data
        - **sentiment score's of each of the essay** : numerical data
        - **number of words in the title** : numerical data
        - **number of words in the combine essays** : numerical data
        - **Apply TruncatedSVD on TfidfVectorizer of essay text, choose the number of components (`n_components`) using elbow method** : numerical data

    - **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

2. Support Vector Machines

2.4.1 Applying Logistic Regression brute force on BOW, SET 1

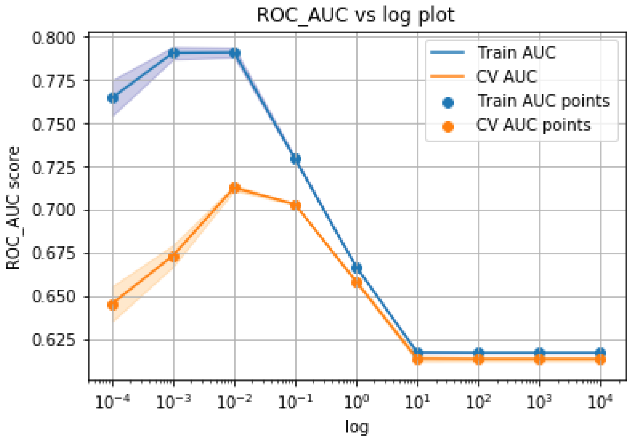
In [61]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_train_merge = hstack((categories_one_hot_train, sub_cat_one_hot_train,
school_state_one_hot_train, project_grade_cat_one_hot_train, teacher_prefix_cat_one_hot_train, pri
ce_data_train, quant_train, prev_no_projects_train,title_bow_train, essay_bow_train)).tocsr()
X_test_merge = hstack((categories_one_hot_test, sub_cat_one_hot_test, school_state_one_hot_test, p
roject_grade_cat_one_hot_test,
teacher_prefix_cat_one_hot_test,price_data_test,quant_test,prev_no_projects_test,title_bow_test, e
ssay_bow_test)).tocsr()

print("Final Data matrix")
print("="*100)
print(X_train_merge.shape, Y_train.shape)
print(X_test_merge.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
====================================================================================================
(81936, 17670) (81936,)
(27312, 17670) (27312,)
====================================================================================================
```

In [62]:

```
## By using "l2" Regulrizer

import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.grid_search import GridSearchCV
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
from sklearn.model_selection import learning_curve, GridSearchCV

# hyperparameter tuning with l2 reg


sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
classifier = GridSearchCV(sd, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train);

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


plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color=
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')


plt.legend()
plt.xscale('log')
plt.xlabel("log")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```



In [63]:

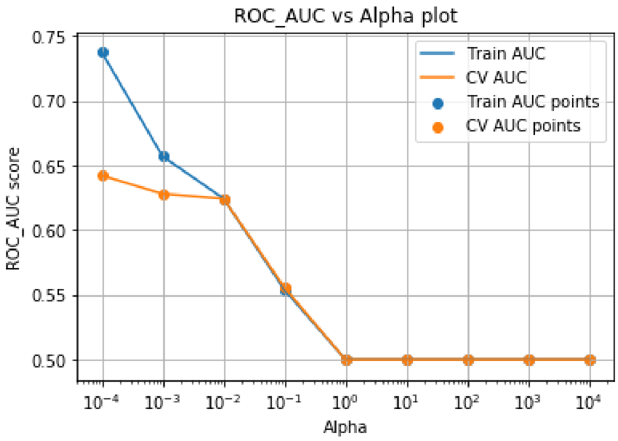
```
score_t_cv = [x for x in cv_auc]
```

```
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding Alpha value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.712437162158772
Corresponding Alpha value of cv is: 0.01

0.01
```

In [64]:

```
#By using  "l1" Regularization
# hyperparameter tuning with l1 reg
#parameters = {'alpha':
[0.007,0.009,0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,1.2,1.4,1.6,1.8,2,2.2,2.4,2.6,2.8,3,3,
4,4.5,5]}
import warnings
warnings.filterwarnings("ignore")
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

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


plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Alpha")
plt.xscale('log')
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```



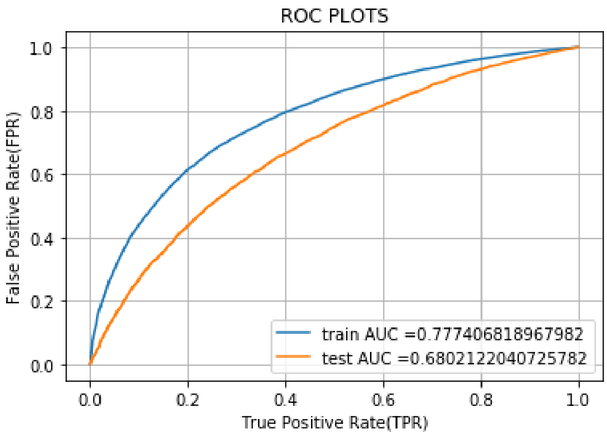
In [65]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding lambda value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.6421915447419272
Corresponding lambda value of cv is: 0.0001

0.0001
```

In [66]:

```
#Fitting Model to Hyper-Parameter Curve
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_bow = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 0.001,class_weight='balanced
' )
Classifier_bow.fit(X_train_merge,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 = Classifier_bow.decision_function(X_train_merge)
y_test_pred = Classifier_bow.decision_function(X_test_merge)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
train_fpr, train_tpr, thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, thresholds = roc_curve(Y_test, y_test_pred)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))



plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

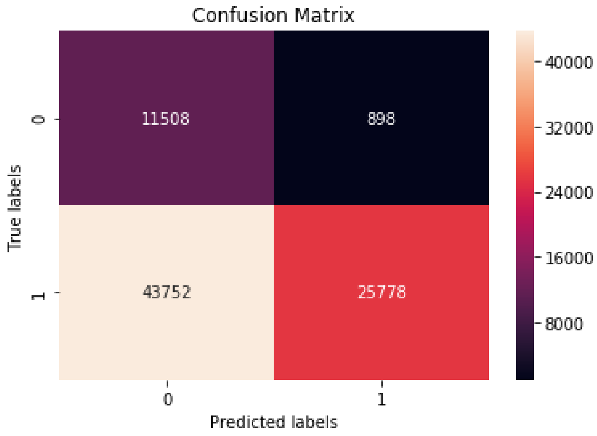


Confusion Matrix

In [67]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_train, Classifier_bow.predict(X_train_merge )), annot=True, ax = ax,
fmt='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

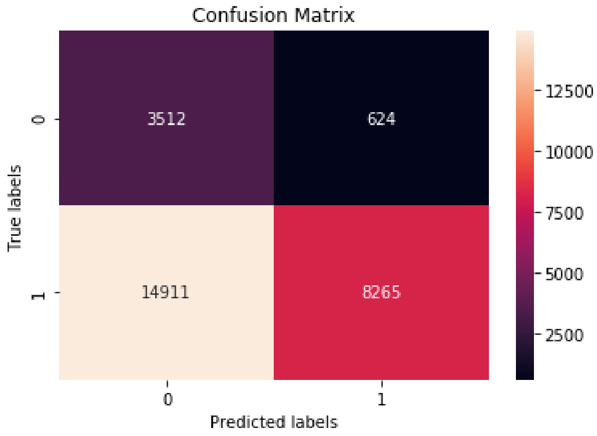
```
====================================================================================================
Train confusion matrix
====================================================================================================
```



In [68]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Test confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, Classifier_bow.predict(X_test_merge )), annot=True, ax = ax,fm
t='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

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

Test confusion matrix
====================================================================================================
```



Set 2 : categorical, numerical features + project_title(TFIDF) + preprocessed_essay (TFIDF)

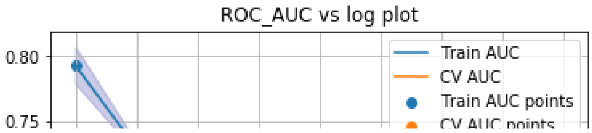
In [69]:

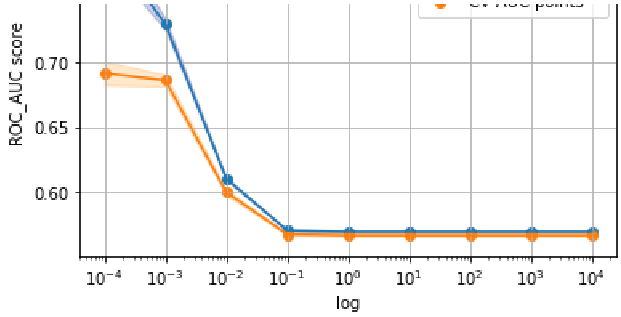
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_train_merge = hstack((categories_one_hot_train, sub_cat_one_hot_train,
school_state_one_hot_train, project_grade_cat_one_hot_train, teacher_prefix_cat_one_hot_train, pri
ce_data_train, quant_train, prev_no_projects_train,title_tfidf_train, essay_tfidf_train)).tocsr()
X_test_merge = hstack((categories_one_hot_test, sub_cat_one_hot_test, school_state_one_hot_test, p
roject_grade_cat_one_hot_test,
teacher_prefix_cat_one_hot_test,price_data_test,quant_test,prev_no_projects_test,title_tfidf_test,
essay_tfidf_test)).tocsr()

print("Final Data matrix")
print("="*100)
print(X_train_merge.shape, Y_train.shape)
print(X_test_merge.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
====================================================================================================

(81936, 17670) (81936,)
(27312, 17670) (27312,)
====================================================================================================
```

In [70]:

```
## By using "l2" Regulrizer

import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.grid_search import GridSearchCV
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
from sklearn.model_selection import learning_curve, GridSearchCV

# hyperparameter tuning with l2 reg


sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
classifier = GridSearchCV(sd, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train);

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


plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color=
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')


plt.legend()
plt.xscale('log')
plt.xlabel("log")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```





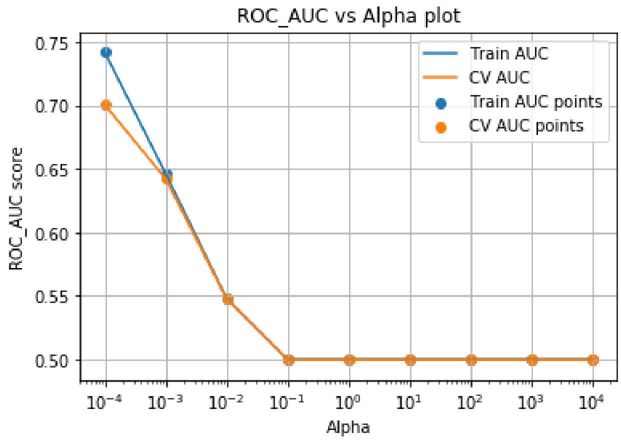
In [71]:

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

```
Maximum AUC score of cv is: 0.6916281309289685
Corresponding alpha value of cv is: 0.0001

0.0001
```

In [72]:

```
#By using  "l1" Regularization
# hyperparameter tuning with l1 reg
#parameters = {'alpha':
[0.007,0.009,0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,1.2,1.4,1.6,1.8,2,2.2,2.4,2.6,2.8,3,3,
4,4.5,5]}
import warnings
warnings.filterwarnings("ignore")
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

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


plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Alpha")
plt.xscale('log')
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```



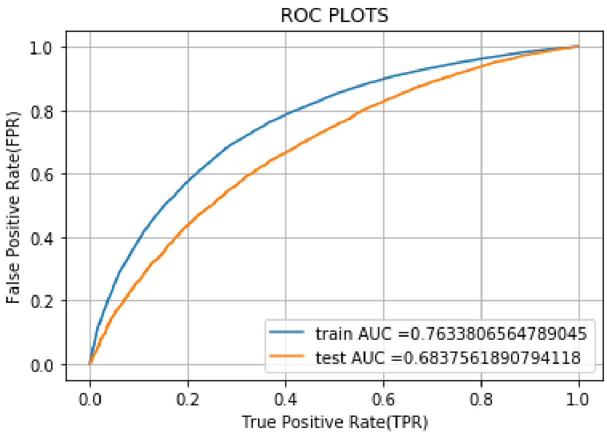
In [73]:

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

```
Maximum AUC score of cv is: 0.7005874636601496
Corresponding alpha value of cv is: 0.0001

0.0001
```

In [74]:

```
#Fitting Model to Hyper-Parameter Curve
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_tfidf = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 0.0001,class_weight='balan
ced')
Classifier_tfidf.fit(X_train_merge,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 = Classifier_tfidf.decision_function(X_train_merge)
y_test_pred = Classifier_tfidf.decision_function(X_test_merge)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
train_fpr, train_tpr, thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, thresholds = roc_curve(Y_test, y_test_pred)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))



plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

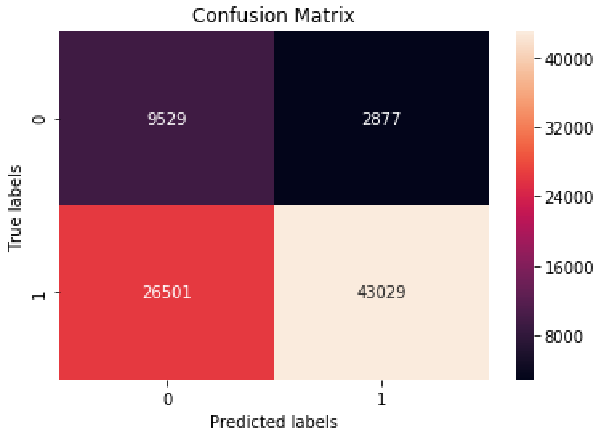


Confusion Matrix

In [75]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_train, Classifier_tfidf.predict(X_train_merge )), annot=True, ax = a
x,fmt='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

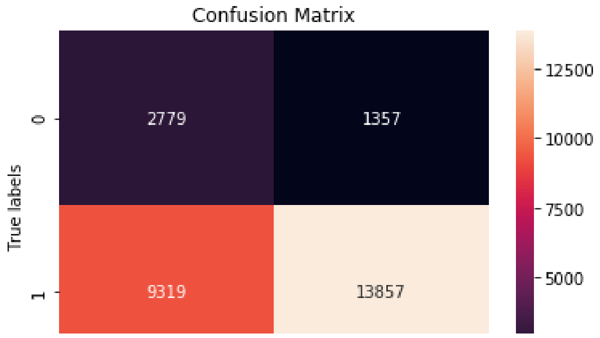
```
====================================================================================================
Train confusion matrix
====================================================================================================
```



In [76]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, Classifier_tfidf.predict(X_test_merge )), annot=True, ax = ax,
fmt='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

```
====================================================================================================
Train confusion matrix
====================================================================================================
```



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

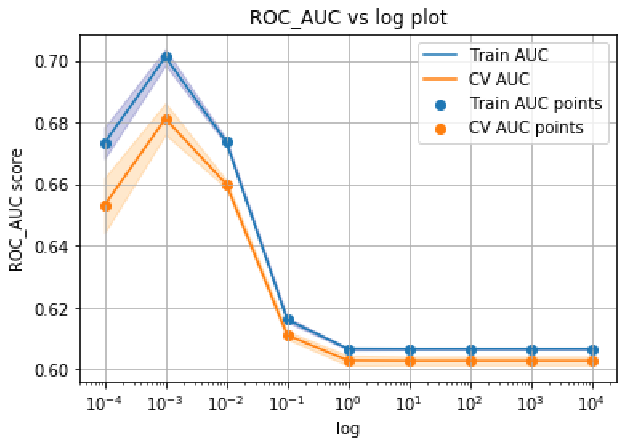
In [77]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_train_merge = hstack((categories_one_hot_train, sub_cat_one_hot_train,
school_state_one_hot_train, project_grade_cat_one_hot_train, teacher_prefix_cat_one_hot_train, pri
ce_data_train, quant_train, prev_no_projects_train,title_avg_w2v_train,
essay_avg_w2v_train)).tocsr()
X_test_merge = hstack((categories_one_hot_test, sub_cat_one_hot_test, school_state_one_hot_test, p
roject_grade_cat_one_hot_test, teacher_prefix_cat_one_hot_test, price_data_test, quant_test,
prev_no_projects_test,title_avg_w2v_test, essay_avg_w2v_test)).tocsr()

print("Final Data matrix")
print("="*100)
print(X_train_merge.shape, Y_train.shape)
print(X_test_merge.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
====================================================================================================

(81936, 703) (81936,)
(27312, 703) (27312,)
====================================================================================================
```

In [78]:

```
## By using "l2" Regulrizer

import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.grid_search import GridSearchCV
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
from sklearn.model_selection import learning_curve, GridSearchCV

# hyperparameter tuning with l2 reg


sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
classifier = GridSearchCV(sd, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train);

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


plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color=
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')


plt.legend()
plt.xscale('log')
plt.xlabel("log")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```



In [79]:

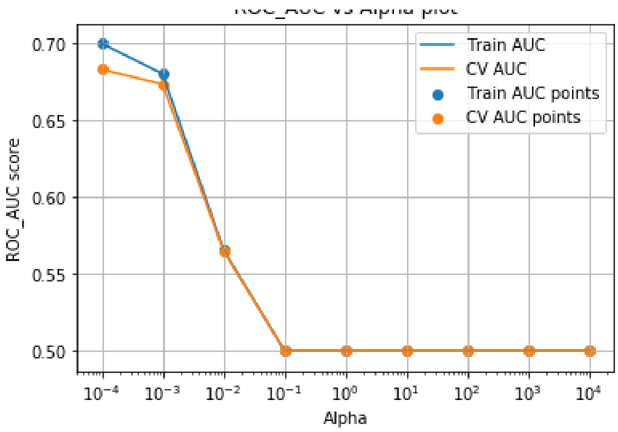
```
score_t_cv = [x for x in cv_auc]
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding lambda value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.6812773586348944
Corresponding lambda value of cv is: 0.001

0.001
```

In [80]:

```
#By using  "l1" Regularization
# hyperparameter tuning with l1 reg
#parameters = {'alpha':
[0.007,0.009,0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,1.2,1.4,1.6,1.8,2,2.2,2.4,2.6,2.8,3,3,
4,4.5,5]}
import warnings
warnings.filterwarnings("ignore")
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

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


plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Alpha")
plt.xscale('log')
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```

ROC_AUC vs Alpha plot



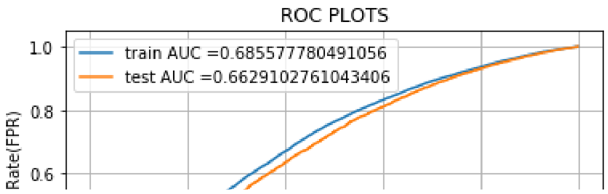
In [81]:

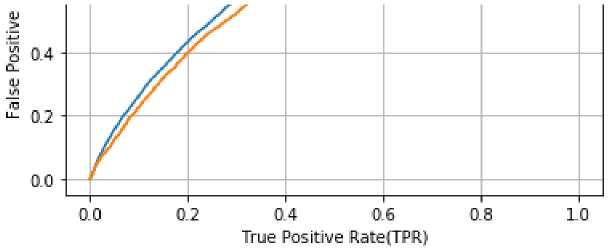
```
score_t_cv = [x for x in cv_auc]
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding lambda value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.6828904269851128
Corresponding lambda value of cv is: 0.0001

0.0001
```

In [82]:

```
#Fitting Model to Hyper-Parameter Curve
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_avg_w2v = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 0.0001,class_weight='bal
anced')
Classifier_avg_w2v.fit(X_train_merge,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 = Classifier_avg_w2v.decision_function(X_train_merge)
y_test_pred = Classifier_avg_w2v.decision_function(X_test_merge)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
train_fpr, train_tpr, thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, thresholds = roc_curve(Y_test, y_test_pred)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))



plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```



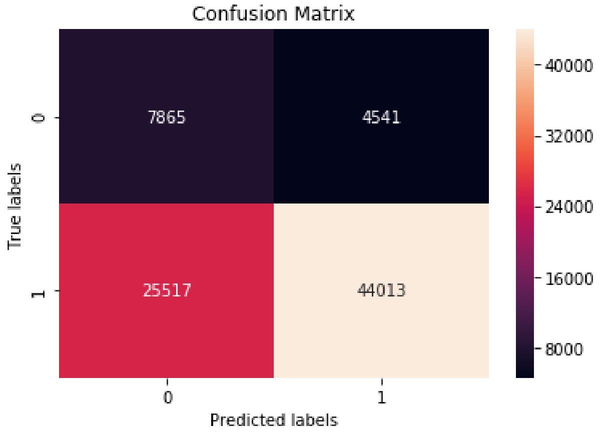


Confusion Matrix

In [83]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_train, Classifier_avg_w2v.predict(X_train_merge )), annot=True, ax =
ax,fmt='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

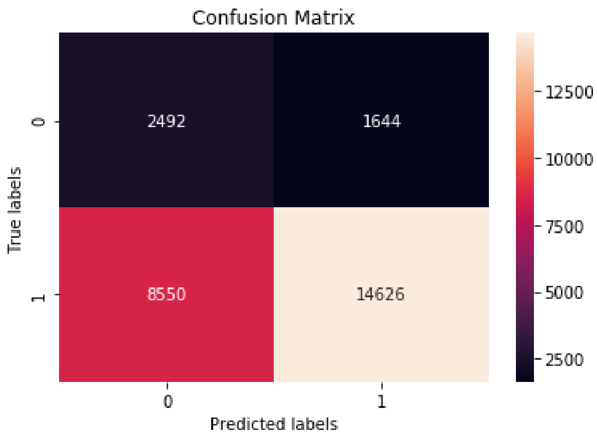
```
====================================================================================================

Train confusion matrix
====================================================================================================
```



In [84]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, Classifier_avg_w2v.predict(X_test_merge )), annot=True, ax = a
x,fmt='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

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

Train confusion matrix
Train confusion matrix
====================================================================================================
```



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

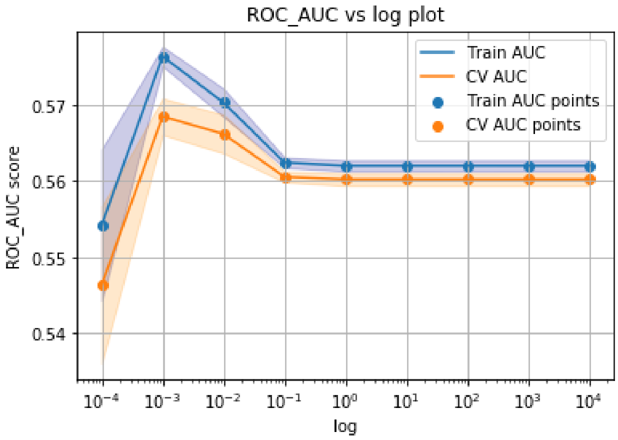
In [85]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_train_merge = hstack((categories_one_hot_train, sub_cat_one_hot_train,
school_state_one_hot_train, project_grade_cat_one_hot_train, teacher_prefix_cat_one_hot_train, pri
ce_data_train, quant_train, prev_no_projects_train,title_tfidf_w2v_train, essay_tfidf_w2v_train)).
tocsr()
X_test_merge = hstack((categories_one_hot_test, sub_cat_one_hot_test, school_state_one_hot_test, p
roject_grade_cat_one_hot_test, teacher_prefix_cat_one_hot_test, price_data_test, quant_test,
prev_no_projects_test,title_tfidf_w2v_test, essay_tfidf_w2v_test)).tocsr()

print("Final Data matrix")
print("="*100)
print(X_train_merge.shape, Y_train.shape)
print(X_test_merge.shape, Y_test.shape)
print("="*100)
```

```
Final Data matrix
====================================================================================================
(81936, 703) (81936,)
(27312, 703) (27312,)
====================================================================================================
```

In [86]:

```
## By using "l2" Regulrizer

import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.grid_search import GridSearchCV
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
from sklearn.model_selection import learning_curve, GridSearchCV

# hyperparameter tuning with l2 reg


sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
classifier = GridSearchCV(sd, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train);
classifier.fit(X_train_merge, Y_train)

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


plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color=
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')


plt.legend()
plt.xscale('log')
plt.xlabel("log")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```



In [87]:

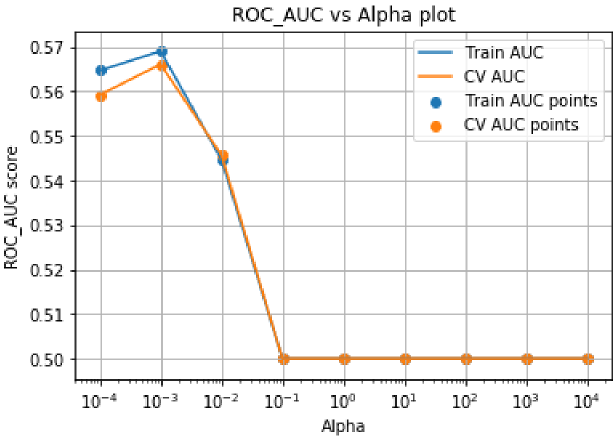
```
score_t_cv = [x for x in cv_auc]
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding lambda value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.5685048408739318
Corresponding lambda value of cv is: 0.001

0.001
```

In [88]:

```
#By using  "l1" Regularization
# hyperparameter tuning with l1 reg
#parameters = {'alpha':
[0.007,0.009,0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,1.2,1.4,1.6,1.8,2,2.2,2.4,2.6,2.8,3,3,
4,4.5,5]}
import warnings
warnings.filterwarnings("ignore")
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']
```

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


plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Alpha")
plt.xscale('log')
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```



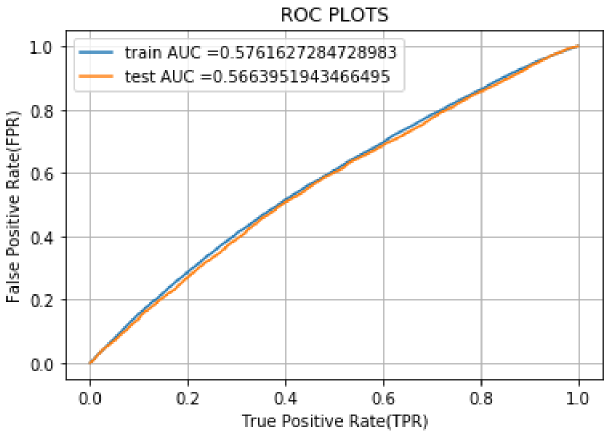
In [89]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding lambda value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.5660670755384832
Corresponding lambda value of cv is: 0.001

0.001
```

In [90]:

```
#Fitting Model to Hyper-Parameter Curve
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_tfidf_w2v = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 0.001,class_weight='ba
lanced' )
Classifier_tfidf_w2v.fit(X_train_merge,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 = Classifier_tfidf_w2v.decision_function(X_train_merge)
y_test_pred = Classifier_tfidf_w2v.decision_function(X_test_merge)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
train_fpr, train_tpr, thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, thresholds = roc_curve(Y_test, y_test_pred)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```

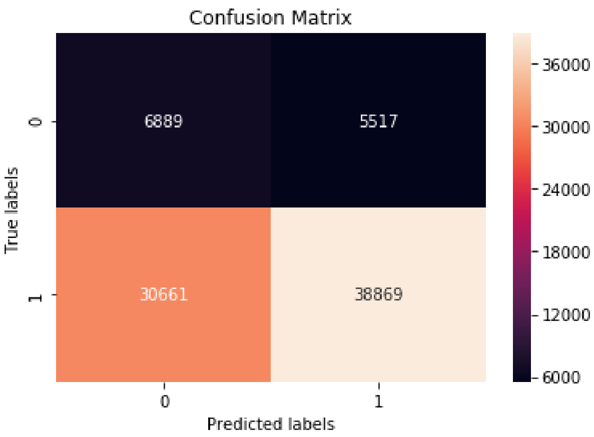


Confusion Matrix

In [91]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_train, Classifier_tfidf_w2v.predict(X_train_merge )), annot=True,
ax = ax,fmt='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

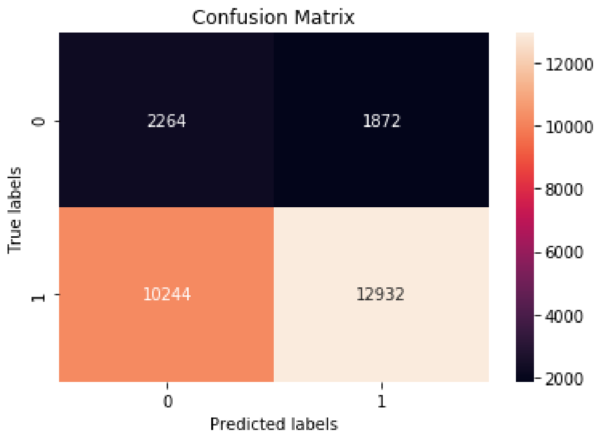
```
====================================================================================================
Train confusion matrix
====================================================================================================
```



In [92]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, Classifier_tfidf_w2v.predict(X_test_merge )), annot=True, ax =
ax,fmt='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

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

Train confusion matrix
====================================================================================================
```



New feature(No. of words in title)

In [93]:

```
#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
# For train data
title_length_train=[]
for i in range(0,81936):
    title_length_train.append(len(X_train["project_title"][i].split()))


title_length_train=np.array(title_length_train)
print(title_length_train.shape)
#for test data titles
title_length_test=[]
for i in range(0,27312):
    title_length_test.append(len(X_test["project_title"][i].split()))

title_length_test=np.array(title_length_test)
print(title_length_test.shape)
```

```
(81936,)
(27312,)
```

New feature(No. of words in combined essays)

In [94]:

```
# https://github.com/shashimanyam/LOISTIC-RREGRESSION-ON-DONORS-CHOOSE-
DATASET/blob/master/LOGISTIC%20REGRESSION%20ON%20DONORSCHOOSEee.ipynb

# For train data
essay_length_train=[]
```

```
for i in range(0,81936):
    essay_length_train.append(len(X_train["essay"][i].split()))

essay_length_train=np.array(essay_length_train)
print(essay_length_train.shape)
#for test data titles
essay_length_test=[]
for i in range(0,27312):
    essay_length_test.append(len(X_test["essay"][i].split()))

essay_length_test=np.array(essay_length_test)
print(essay_length_test.shape)
```

```
(81936,)
(27312,)
```

New feature(Sentiment scores of each combined essay's)

In [97]:

```
import warnings
warnings.filterwarnings('ignore')
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
nltk.download('vader_lexicon')


#https://www.programcreek.com/python/example/100005/nltk.sentiment.vader.SentimentIntensityAnalyze

def analyze_sentiment(df):
    sentiments = []
    sid = SentimentIntensityAnalyzer()
    for i in range(df.shape[0]):
        line = df['essay'][i]# take one essay
        sentiment = sid.polarity_scores(line)# calculate the sentiment
        sentiments.append([sentiment['neg'], sentiment['pos'],sentiment['neu'],
sentiment['compound']])# list of lists
    df[['neg', 'pos', 'neu', 'compound']] = pd.DataFrame(sentiments)
    df['Negative'] = df['compound'] < -0.1
    df['Positive'] = df['compound'] > 0.1
    return df
```

```
[nltk_data] Error loading vader_lexicon: <urlopen error [Errno 11004]
[nltk_data]     getaddrinfo failed>
```

In [98]:

```
X_train=analyze_sentiment(X_train)
X_test=analyze_sentiment(X_test)
```

Apply TruncatedSVD on TfidfVectorizer of essay text, choose the number of components (n_components) using elbow method :numerical data

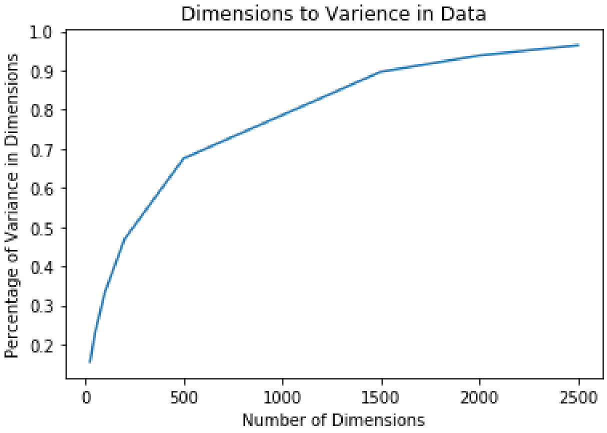
In [99]:

```
#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
#Dimensions are very large so thats why i take less here.
essay_tfidf_train=essay_tfidf_train[:,0:4000]
essay_tfidf_test=essay_tfidf_test[:,0:4000]

from sklearn.decomposition import TruncatedSVD
#https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html
#declaring index as Dimensions in train_text_tfidf
Di = [25,50,100,200,500,1500,2000,2500]
Varience_sum = []
for i in tqdm(Di):
    svd = TruncatedSVD(n_components = i, random_state = 42)
    svd.fit(essay_tfidf_train)
    Varience_sum.append(svd.explained_variance_ratio_.sum())
    varience_sum.append(svd.explained_variance_ratio_.sum())
```

```
100%|████████████████████████████████████████| 8/8 [2:16:29<00:00, 1295.48s/it]
```

In [100]:

```
plt.xlabel("Number of Dimensions")
plt.ylabel("Percentage of Variance in Dimensions")
plt.title("Dimensions to Varience in Data")
plt.plot(Di,Varience_sum)
plt.show()
```



In [101]:

```
svd = TruncatedSVD(n_components= 2000)
svd.fit(essay_tfidf_train)
#Transforms:
#Train SVD
essay_tfidf_train= svd.transform(essay_tfidf_train )
#Test SVD
essay_tfidf_test = svd.transform(essay_tfidf_test )
```

In [102]:

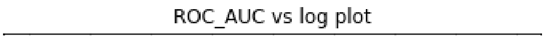
```
#for train
pos_tr=list(X_train['pos'])
pos_tr=np.array(pos_tr)
neg_tr=list(X_train['neg'])
neg_tr=np.array(neg_tr)
neu_tr=list(X_train['neu'])
neu_tr=np.array(neu_tr)
com_tr=list(X_train['compound'])
com_tr=np.array(com_tr)


#for test
pos_tes=list(X_test['pos'])
pos_tes=np.array(pos_tes)
neg_tes=list(X_test['neg'])
neg_tes=np.array(neg_tes)
neu_tes=list(X_test['neu'])
neu_tes=np.array(neu_tes)
com_tes=list(X_test['compound'])
com_tes=np.array(com_tes)





# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack

X_train_merge = hstack((categories_one_hot_train, sub_cat_one_hot_train,
school_state_one_hot_train, project_grade_cat_one_hot_train, teacher_prefix_cat_one_hot_train, pri
ce_data_train, quant_train, prev_no_projects_train,essay_tfidf_train,title_length_train.reshape(-1
,1), essay_length_train.reshape(-1,1),pos_tr.reshape(-1,1),neg_tr.reshape(-1,1),com_tr.reshape(-1,1
))).tocsr()
X_test_merge = hstack((categories_one_hot_test, sub_cat_one_hot_test, school_state_one_hot_test, p
roject_grade_cat_one_hot_test, teacher_prefix_cat_one_hot_test, price_data_test,
quant_test,essay_tfidf_test, prev_no_projects_test,title_length_test.reshape(-1,1),
essay_length_test.reshape(-1,1),pos_tes.reshape(-1,1),neg_tes.reshape(-1,1),com_tes.reshape(-1,1)))
.tocsr()

print("Final Data matrix")
print("="*100)
print(X_train_merge.shape, Y_train.shape)
print(X_test_merge.shape, Y_test.shape)
print("="*100)
```

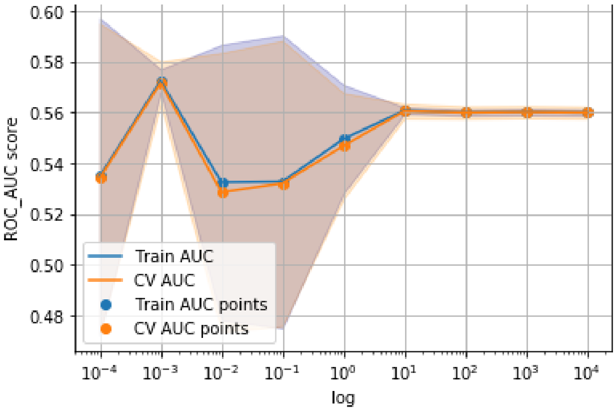
```
Final Data matrix
====================================================================================================

(81936, 2108) (81936,)
(27312, 2108) (27312,)
====================================================================================================
```

logistic regression on SET 5

In [103]:

```
## By using "l2" Regulrizer

import warnings
warnings.filterwarnings('ignore')
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.grid_search import GridSearchCV
from sklearn import linear_model
from sklearn.linear_model import SGDClassifier
from sklearn import svm
from sklearn.model_selection import learning_curve, GridSearchCV

# hyperparameter tuning with l2 reg


sd = SGDClassifier(loss = 'hinge', penalty = 'l2', class_weight = 'balanced')
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
classifier = GridSearchCV(sd, parameters, cv= 3, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train);

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


plt.plot(parameters['alpha'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')
plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,color=
'darkorange')
plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')


plt.legend()
plt.xscale('log')
plt.xlabel("log")
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs log plot")
plt.grid()
plt.show()
```





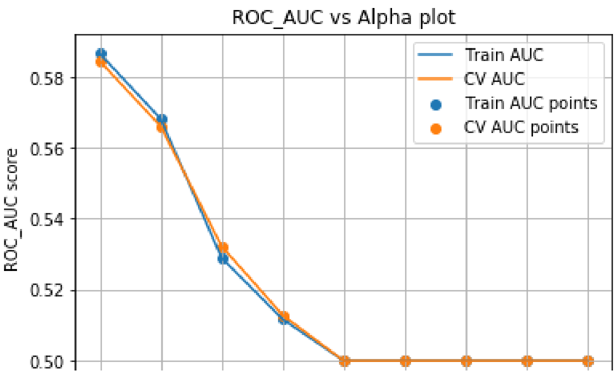
In [104]:

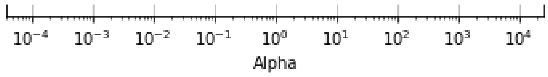
```
score_t_cv = [x for x in cv_auc]
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding lambda value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.5715974832407061
Corresponding lambda value of cv is: 0.001

0.001
```

In [105]:

```
#By using  "l1" Regularization
# hyperparameter tuning with l1 reg
#parameters = {'alpha':
[0.007,0.009,0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1,1.2,1.4,1.6,1.8,2,2.2,2.4,2.6,2.8,3,3,
4,4.5,5]}
import warnings
warnings.filterwarnings("ignore")
parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10**4]}
sd = SGDClassifier(loss = 'hinge', penalty = 'l1', class_weight = 'balanced')
classifier = GridSearchCV(sd, parameters, cv= 5, scoring='roc_auc',return_train_score=True)
classifier.fit(X_train_merge, Y_train)
train_auc = classifier.cv_results_['mean_train_score']
cv_auc= classifier.cv_results_['mean_test_score']

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


plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("Alpha")
plt.xscale('log')
plt.ylabel("ROC_AUC score")
plt.title("ROC_AUC vs Alpha plot")
plt.grid()
plt.show()
```





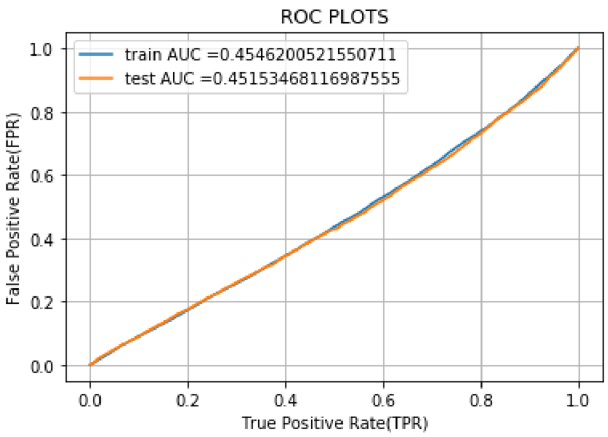
In [106]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = parameters['alpha'][score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding lambda value of cv is:",opt_t_cv, '\n')
best_alp=opt_t_cv
print(best_alp)
```

```
Maximum AUC score of cv is: 0.5844462031791753
Corresponding lambda value of cv is: 0.0001

0.0001
```

In [113]:

```
#Fitting Model to Hyper-Parameter Curve
#
https://scikitlearn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc
ve
from sklearn.metrics import roc_curve, auc
Classifier_5 = SGDClassifier(loss = 'hinge', penalty = 'l2', alpha = 0.0001,class_weight="balanced"
)
Classifier_5.fit(X_train_merge,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 = Classifier_5.decision_function(X_train_merge)
y_test_pred = Classifier_5.decision_function(X_test_merge)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
train_fpr, train_tpr, thresholds = roc_curve(Y_train, y_train_pred)
test_fpr, test_tpr, thresholds = roc_curve(Y_test, y_test_pred)

#https://github.com/shashimanyam/SVM-ON-DONORSCHOOSE-
DATASET/blob/master/SVM%20ON%20DONORSCHOOSE.ipynb
plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))



plt.legend()
plt.xlabel("True Positive Rate(TPR)")
plt.ylabel("False Positive Rate(FPR)")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```



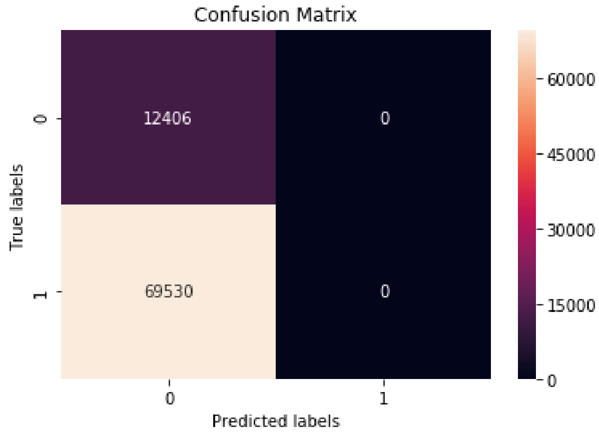
Confusion Matrix

Confusion Matrix

In [114]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_train, Classifier_5.predict(X_train_merge )), annot=True, ax = ax,fm
t='g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

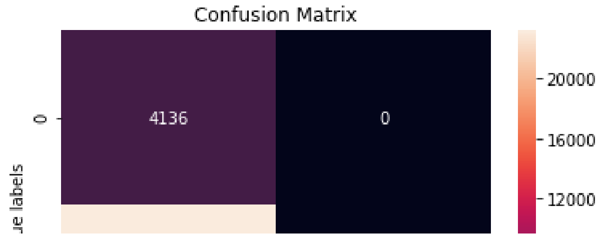
```
====================================================================================================

Train confusion matrix
====================================================================================================
```

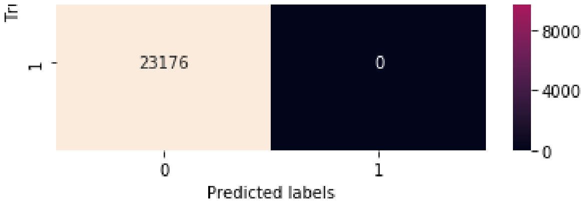


In [109]:

```
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
import seaborn as sns
import matplotlib.pyplot as plt
print("="*100)
print("Train confusion matrix")

ax= plt.subplot()
sns.heatmap(confusion_matrix(Y_test, Classifier_5.predict(X_test_merge )), annot=True, ax = ax,fmt=
'g');
# labels, title and ticks
ax.set_xlabel('Predicted labels');
ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix');
print("="*100)
```

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

Train confusion matrix
====================================================================================================
```





3. Conclusions

In [110]:

```
# Please compare all your models using Prettytable library
# Please compare all your models using Prettytable library
#how to use pretty table http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

tb = PrettyTable()
tb.field_names= ("Vectorizer", "Model", "HyperParameter L1", "AUC L1","HyperParameter L2","AUC L2"
)
tb.add_row(["BOW", "Auto",0.0001, 65.02,0.01,71.6])
tb.add_row(["Tf-Idf", "Auto",0.0001, 69.89,0.0001,68.99])
tb.add_row(["AVGW2V", "Auto",0.0001, 67.79,0.001,68.0])
tb.add_row(["Tf-Idf w2v", "Auto", 0.001, 56.79,0.001,0.5692])
tb.add_row(["Set 5", "Auto",0.0001, 58.1,0.0001,57.48])
print(tb.get_string(titles = "Logistic Reg> - Observations"))
```

```
+------------+-------+-------------------+--------+-------------------+--------+
| Vectorizer | Model | HyperParameter L1 | AUC L1 | HyperParameter L2 | AUC L2 |
+------------+-------+-------------------+--------+-------------------+--------+
|    BOW     |  Auto |       0.0001      | 65.02  |        0.01       |  71.6  |
|   Tf-Idf   |  Auto |       0.0001      | 69.89  |       0.0001      | 68.99  |
|   AVGW2V   |  Auto |       0.0001      | 67.79  |       0.001       |  68.0  |
| Tf-Idf w2v |  Auto |       0.001       | 56.79  |       0.001       | 0.5692 |
|   Set 5    |  Auto |       0.0001      |  58.1  |       0.0001      | 57.48  |
+------------+-------+-------------------+--------+-------------------+--------+
```

In [ ]:

```
+................................................
```