DonorsChoose

In [1]:

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call dr
ive.mount("/content/drive", force_remount=True).
```

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)](https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Postal_codes)). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** - `Literacy` - `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** - `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay*
`project_essay_2`	Second application essay*
`project_essay_3`	Third application essay*
`project_essay_4`	Fourth application essay*
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: - `nan` - `Dr.` - `Mr.`

Notes on the Essay Data

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

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

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

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

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

In [2]:

```
%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

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

```
Output hidden; open in https://colab.research.google.com to view.
```

1.1 Reading Data

In [0]:

```
project_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/train_data.csv
')
resource_data = pd.read_csv('/content/drive/My Drive/Colab Notebooks/resources.csv
')
```

In [4]:
```python
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' 'schoo
l_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [5]:
```python
# 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[5]:

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

In [6]:
```python
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

Out[6]:

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

In [7]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).res
et_index()
print(price_data.shape)
# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

```
(260115, 3)
```

1.2 preprocessing of `project_subject_categories`

In [0]:
```
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", "Wa
rmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on spac
e "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to repl
ace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) e
x:"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 [0]:

```
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", "Wa
rmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on spac
e "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to repl
ace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) e
x:"Math & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing
spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

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

# count of all the words in corpus python: https://stackoverflow.com/a/22898595/408
4039
my_counter = Counter()
for word in project_data['clean_subcategories'].values:
    my_counter.update(word.split())

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

In [0]:

```
project_data=project_data.dropna(subset=['teacher_prefix'])
```

1.3 Text preprocessing

In [0]:

```
# 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 [12]:

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

Out[12]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_gra
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	G
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	

In [13]:

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

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom as
well as the STEM journals, which my students really enjoyed.  I would love to im
plement more of the Lakeshore STEM kits in my classroom for the next school year
as they provide excellent and engaging STEM lessons.My students come from a vari
ety of backgrounds, including language and socioeconomic status.  Many of them d
on'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 ro
bot to help guide my science instruction in engaging and meaningful ways.  I can
adapt the kits to my current language arts pacing guide where we already teach s
ome of the material in the kits like tall tales (Paul Bunyan) or Johnny Applesee
d.  The following units will be taught in the next school year where I will impl
ement 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 material
s.    The kits will give me additional ideas, strategies, and lessons to prepare
my students in science.It is challenging to develop high quality science activit
ies.  These kits give me the materials I need to provide my students with scienc
e 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 ef
fectively.  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 disabilitie
s. My students all vary in their ability level. However, the ultimate goal is to
increase all students literacy levels. This includes their reading, writing, and
communication levels.I teach a really dynamic group of students. However, my stu
dents face a lot of challenges. My students all live in poverty and in a dangero
us neighborhood. Despite these challenges, I have students who have the the desi
re to defeat these challenges. My students all have learning disabilities and cu
rrently all are performing below grade level. My students are visual learners an
d 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 classroo
m with the necessary supplies.  Too often I am challenged with students who come
to school unprepared for class due to economic challenges.  I want my students t
o be able to focus on learning and not how they will be able to get school suppl
ies.  The supplies will last all year.  Students will be able to complete writte
n assignments and maintain a classroom journal.  The chart paper will be used to
make learning more visual in class and to create posters to aid students in thei
r learning.  The students have access to a classroom printer.  The toner will be
used to print student work that is completed on the classroom Chromebooks.I want
to try and remove all barriers for the students learning and create opportunitie
s for learning. One of the biggest barriers is the students not having the resou
rces to get pens, paper, and folders. My students will be able to increase their
literacy skills because of this project.
==================================================
\"Life moves pretty fast. If you don't stop and look around once in awhile, you
could miss it.\"  from the movie, Ferris Bueller's Day Off.  Think back...what d
o you remember about your grandparents?  How amazing would it be to be able to f
lip through a book to see a day in their lives?My second graders are voracious r
eaders! They love to read both fiction and nonfiction books.  Their favorite cha
racters include Pete the Cat, Fly Guy, Piggie and Elephant, and Mercy Watson. Th
ey also love to read about insects, space and plants. My students are hungry boo
kworms! My students are eager to learn and read about the world around them. My
kids love to be at school and are like little sponges absorbing everything aroun
d them. Their parents work long hours and usually do not see their children. My
students are usually cared for by their grandparents or a family friend. Most of
my students do not have someone who speaks English at home. Thus it is difficult
for my students to acquire language.Now think forward... wouldn't it mean a lot
to your kids, nieces or nephews or grandchildren, to be able to see a day in you
r life today 30 years from now? Memories are so precious to us and being able to
share these memories with future generations will be a rewarding experience.  As
part of our social studies curriculum, students will be learning about changes o
ver time.  Students will be studying photos to learn about how their community h
as changed over time.  In particular, we will look at photos to study how the la
```

In [0]:

```
# 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 [0]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "yo
u're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'hi
m', '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', 'thro
ugh', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off',
'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all',
'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', '
too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've",
'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn
't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', '
mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn'
t", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [16]:

```
# 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())
```

```
100%|██████████| 109245/109245 [00:57<00:00, 1894.60it/s]
```

In [0]:

```
# after preprocesing
project_data['clean_essay']=preprocessed_essays
project_data.drop(['project_essay_1'], axis=1, inplace=True)
project_data.drop(['project_essay_2'], axis=1, inplace=True)
project_data.drop(['project_essay_3'], axis=1, inplace=True)
project_data.drop(['project_essay_4'], axis=1, inplace=True)
project_data.drop(['essay'], axis=1, inplace=True)
```

1.4 Preprocessing of `project_title`

In [18]:

```
# similarly you can preprocess the titles also

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

```
100%|██████████| 109245/109245 [00:02<00:00, 43806.81it/s]
```

In [0]:

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

1.5 Preparing data for models

In [20]:

```
project_data.columns
```

Out[20]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'project_is_approved',
       'price', 'quantity', 'clean_categories', 'clean_subcategories',
       'clean_essay', 'clean_title'],
      dtype='object')
```

we are going to consider

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

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

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

In [21]:

```
project_data.head(1)
```

Out[21]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_gra
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	G

In [22]:

```
"""a=project_data[project_data['project_is_approved']==1]
a=a.sample(n=16000)

b=project_data[project_data['project_is_approved']==0]
b=b.sample(n=16000)

temp=pd.concat([a,b])

temp = temp.sample(frac=1).reset_index(drop=True)

print(temp.shape)
print(temp['project_is_approved'].value_counts())"""
```

Out[22]:

```
"a=project_data[project_data['project_is_approved']==1]\na=a.sample(n=16000)\n\n
b=project_data[project_data['project_is_approved']==0]\nb=b.sample(n=16000) \n\n
temp=pd.concat([a,b])\n\ntemp = temp.sample(frac=1).reset_index(drop=True)\n\npr
int(temp.shape)\nprint(temp['project_is_approved'].value_counts())"
```

In [23]:

```
project_data=project_data.sample(frac=0.5)
project_data['project_is_approved'].value_counts()
```

Out[23]:

```
1    46383
0     8239
Name: project_is_approved, dtype: int64
```

In [0]:

```
from sklearn.model_selection import train_test_split

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

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, stratify=
y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.2, st
ratify=y_train)
```

In [25]:

```
print(X_train.shape)
print(X_cv.shape)
print(X_test.shape)
```

```
(34957, 15)
(8740, 15)
(10925, 15)
```

In [26]:

```
from imblearn.over_sampling import RandomOverSampler
from collections import Counter

ros = RandomOverSampler(sampling_strategy='minority',random_state=42)
X_train, y_train = ros.fit_resample(X_train, y_train)
print('Resampled dataset shape {0}'.format(Counter(y_train)))

X_train = pd.DataFrame(X_train,columns = X.columns)
X_train.head(5)
```

```
Resampled dataset shape Counter({1: 29684, 0: 29684})
```

Out[26]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_gr
0	115531	p076562	0d5605ab86fea3eb7c1d33a56148c42b	Mrs.	ME	2016-09-05 10:17:35	
1	82134	p073922	0fef1b064b1dbf52432a6385a3f1fc9a	Ms.	NC	2017-04-07 21:42:31	(
2	85836	p091324	e691a3cfff877608f81332d9745c7de4	Mrs.	TN	2016-12-24 21:54:02	(
3	24478	p170479	1050a49c040b4f7701f18726e03839bd	Mrs.	IL	2016-11-18 10:46:18	(
4	69903	p150461	357ec9e7d01d62729f213e13918899b5	Mrs.	SC	2016-07-22 18:35:15	

In [27]:

```
print(X_train.shape)
```

```
(59368, 15)
```

2 Vectorizing Categorical data

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

In [28]:

```
#Categories

from sklearn.feature_extraction.text import CountVectorizer
vectorizer1 = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True)
categories_one_hot = vectorizer1.fit(X_train['clean_categories'].values)

X_train_cat_ohe = categories_one_hot.transform(X_train['clean_categories'])
X_cv_cat_ohe = categories_one_hot.transform(X_cv['clean_categories'])
X_test_cat_ohe = categories_one_hot.transform(X_test['clean_categories'])

print(vectorizer1.get_feature_names())

print("Shape of train matrix after one hot encodig ",X_train_cat_ohe.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_cat_ohe.shape)
print("Shape of test matrix after one hot encodig ",X_test_cat_ohe.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'Sp
ecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of train matrix after one hot encodig  (59368, 9)
Shape of cv matrix after one hot encodig  (8740, 9)
Shape of test matrix after one hot encodig  (10925, 9)
```

In [29]:

```
#Subcategories

vectorizer2 = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=True)
sub_categories_one_hot = vectorizer2.fit(X_train['clean_subcategories'].values)


X_train_subcat_ohe = sub_categories_one_hot.transform(X_train['clean_subcategories'])
X_cv_subcat_ohe = sub_categories_one_hot.transform(X_cv['clean_subcategories'])
X_test_subcat_ohe = sub_categories_one_hot.transform(X_test['clean_subcategories'])

print(vectorizer2.get_feature_names())

print("Shape of train matrix after one hot encodig ",X_train_subcat_ohe.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_subcat_ohe.shape)
print("Shape of test matrix after one hot encodig ",X_test_subcat_ohe.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Ext
racurricular', 'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'W
armth', 'Care_Hunger', 'SocialSciences', 'PerformingArts', 'CharacterEducation',
'TeamSports', 'Other', 'College_CareerPrep', 'Music', 'History_Geography', 'Heal
th_LifeScience', 'EarlyDevelopment', 'ESL', 'Gym_Fitness', 'EnvironmentalScience
', 'VisualArts', 'Health_Wellness', 'AppliedSciences', 'SpecialNeeds', 'Literatu
re_Writing', 'Mathematics', 'Literacy']
Shape of train matrix after one hot encodig  (59368, 30)
Shape of cv matrix after one hot encodig  (8740, 30)
Shape of test matrix after one hot encodig  (10925, 30)
```

In [30]:

```
#School state
vectorizer = CountVectorizer( lowercase=False, binary=True)
vectorizer.fit(X_train['school_state'].values)

X_train_state_ohe = vectorizer.transform(X_train['school_state'])
X_cv_state_ohe = vectorizer.transform(X_cv['school_state'])
X_test_state_ohe = vectorizer.transform(X_test['school_state'])

print(vectorizer.get_feature_names())

print("Shape of train matrix after one hot encodig ",X_train_state_ohe.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_state_ohe.shape)
print("Shape of test matrix after one hot encodig ",X_test_state_ohe.shape)
```

```
['AK', 'AL', 'AR', 'AZ', 'CA', 'CO', 'CT', 'DC', 'DE', 'FL', 'GA', 'HI', 'IA', '
ID', 'IL', 'IN', 'KS', 'KY', 'LA', 'MA', 'MD', 'ME', 'MI', 'MN', 'MO', 'MS', 'MT
', 'NC', 'ND', 'NE', 'NH', 'NJ', 'NM', 'NV', 'NY', 'OH', 'OK', 'OR', 'PA', 'RI',
'SC', 'SD', 'TN', 'TX', 'UT', 'VA', 'VT', 'WA', 'WI', 'WV', 'WY']
Shape of train matrix after one hot encodig  (59368, 51)
Shape of cv matrix after one hot encodig  (8740, 51)
Shape of test matrix after one hot encodig  (10925, 51)
```

In [31]:

```
vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(X_train['teacher_prefix'].values)


X_train_prefix_ohe = vectorizer.transform(X_train['teacher_prefix'])
X_cv_prefix_ohe = vectorizer.transform(X_cv['teacher_prefix'])
X_test_prefix_ohe = vectorizer.transform(X_test['teacher_prefix'])

print(vectorizer.get_feature_names())

print("Shape of train matrix after one hot encodig ",X_train_prefix_ohe.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_prefix_ohe.shape)
print("Shape of test matrix after one hot encodig ",X_test_prefix_ohe.shape)
```

```
['Dr', 'Mr', 'Mrs', 'Ms', 'Teacher']
Shape of train matrix after one hot encodig  (59368, 5)
Shape of cv matrix after one hot encodig  (8740, 5)
Shape of test matrix after one hot encodig  (10925, 5)
```

In [32]:

```
vectorizer = CountVectorizer(lowercase=False, binary=True)
vectorizer.fit(X_train['project_grade_category'].values)

X_train_grade_ohe = vectorizer.transform(X_train['project_grade_category'])
X_cv_grade_ohe = vectorizer.transform(X_cv['project_grade_category'])
X_test_grade_ohe = vectorizer.transform(X_test['project_grade_category'])

print(vectorizer.get_feature_names())
print("Shape of train matrix after one hot encodig ",X_train_grade_ohe.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_grade_ohe.shape)
print("Shape of test matrix after one hot encodig ",X_test_grade_ohe.shape)
```

```
['12', 'Grades', 'PreK']
Shape of train matrix after one hot encodig  (59368, 3)
Shape of cv matrix after one hot encodig  (8740, 3)
Shape of test matrix after one hot encodig  (10925, 3)
```

3 Vectorizing Text data

3.1 Bag of words

3.1.1 Essays

```
In [33]: print(X_train['clean_essay'].values[0])
```

```
students love pe physically active unfortunately economically disadvantaged area
60 students free reduced lunches opportunities fitness primarily pe make extracu
rricular sports teams students never complain often use limited old resources sc
hool would love expand resources include new activities hope funded always sayin
g love pe make even better funding students want know fitness trackers think wou
ld cool fitness tracker record activities unfortunately cannot afford one fundin
g could least try also compare ways track fitness see best ease use inspiring ex
ercise continued accountability personal fitness want know fitbit better garmin
vvofit 2 activity tracker technology second nature students love anything electr
onic combine technology exercise instantly fun please help us compare nannan
```

```
In [34]: # We are considering only the words which appeared in at least 10 documents(rows or
projects).
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(X_train['clean_essay'])


X_train_essay_bow = vectorizer.transform(X_train['clean_essay'])
X_cv_essay_bow = vectorizer.transform(X_cv['clean_essay'])
X_test_essay_bow = vectorizer.transform(X_test['clean_essay'])


print("Shape of train matrix after one hot encodig ",X_train_essay_bow.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_essay_bow.shape)
print("Shape of test matrix after one hot encodig ",X_test_essay_bow.shape)
```

```
Shape of train matrix after one hot encodig  (59368, 13220)
Shape of cv matrix after one hot encodig  (8740, 13220)
Shape of test matrix after one hot encodig  (10925, 13220)
```

3.1.2 Titles

```
In [35]: vectorizer = CountVectorizer(min_df=10)
text_bow = vectorizer.fit(X_train['clean_title'])


X_train_title_bow = vectorizer.transform(X_train['clean_title'])
X_cv_title_bow = vectorizer.transform(X_cv['clean_title'])
X_test_title_bow = vectorizer.transform(X_test['clean_title'])


print("Shape of train matrix after one hot encodig ",X_train_title_bow.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_title_bow.shape)
print("Shape of test matrix after one hot encodig ",X_test_title_bow.shape)
```

```
Shape of train matrix after one hot encodig  (59368, 2515)
Shape of cv matrix after one hot encodig  (8740, 2515)
Shape of test matrix after one hot encodig  (10925, 2515)
```

3.2 TFIDF vectorizer

3.2.1 Essay

In [36]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['clean_essay'])

X_train_essay_tfidf = vectorizer.transform(X_train['clean_essay'])
X_cv_essay_tfidf = vectorizer.transform(X_cv['clean_essay'])
X_test_essay_tfidf = vectorizer.transform(X_test['clean_essay'])


print("Shape of train matrix after one hot encodig ",X_train_essay_tfidf.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_essay_tfidf.shape)
print("Shape of test matrix after one hot encodig ",X_test_essay_tfidf.shape)
```

```
Shape of train matrix after one hot encodig  (59368, 13220)
Shape of cv matrix after one hot encodig  (8740, 13220)
Shape of test matrix after one hot encodig  (10925, 13220)
```

3.2.2 Title

In [37]:
```
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['clean_title'])

X_train_title_tfidf = vectorizer.transform(X_train['clean_title'])
X_cv_title_tfidf = vectorizer.transform(X_cv['clean_title'])
X_test_title_tfidf = vectorizer.transform(X_test['clean_title'])


print("Shape of train matrix after one hot encodig ",X_train_title_tfidf.shape)
print("Shape of cv matrix after one hot encodig ",X_cv_title_tfidf.shape)
print("Shape of test matrix after one hot encodig ",X_test_title_tfidf.shape)
```

```
Shape of train matrix after one hot encodig  (59368, 2515)
Shape of cv matrix after one hot encodig  (8740, 2515)
Shape of test matrix after one hot encodig  (10925, 2515)
```

1.5.3 Vectorizing Numerical features

In [38]:
```
project_data.columns
```

Out[38]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', 'project_resource_summary',
       'teacher_number_of_previously_posted_projects', 'price', 'quantity',
       'clean_categories', 'clean_subcategories', 'clean_essay',
       'clean_title'],
      dtype='object')
```

In [0]:

```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklear
n.preprocessing.StandardScaler.html
from sklearn.preprocessing import Normalizer

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

price_scalar = Normalizer()
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and stan
dard deviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scala
r.var_[0])}")

# Now standardize the data with above maen and variance.
X_train_price_standardized = price_scalar.transform(X_train['price'].values.reshape
(-1, 1))
X_cv_price_standardized = price_scalar.transform(X_cv['price'].values.reshape(-1,
1))
X_test_price_standardized = price_scalar.transform(X_test['price'].values.reshape(-
1, 1))
```

In [0]:

```
proj_scalar = Normalizer()
proj_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.resh
ape(-1,1)) # finding the mean and standard deviation of this data
#print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scala
r.var_[0])}")

# Now standardize the data with above maen and variance.
X_train_proj_standardized = price_scalar.transform(X_train['price'].values.reshape
(-1, 1))
X_cv_proj_standardized = price_scalar.transform(X_cv['price'].values.reshape(-1,
1))
X_test_proj_standardized = price_scalar.transform(X_test['price'].values.reshape(-
1, 1))
```

In [41]:

```
len(X_train_price_standardized)
```

Out[41]:

```
59368
```

1.5.4 Merging all the above features

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

In [42]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train_bow = hstack((X_train_cat_ohe, X_train_subcat_ohe, X_train_state_ohe, X_train_prefix_ohe, X_train_grade_ohe , X_train_proj_standardized, X_train_price_standardized, X_train_essay_bow,  X_train_title_bow))
X_cv_bow = hstack((X_cv_cat_ohe, X_cv_subcat_ohe, X_cv_state_ohe, X_cv_prefix_ohe,
X_cv_grade_ohe , X_cv_proj_standardized, X_cv_price_standardized, X_cv_essay_bow,
X_cv_title_bow))
X_test_bow = hstack((X_test_cat_ohe, X_test_subcat_ohe, X_test_state_ohe, X_test_prefix_ohe, X_test_grade_ohe , X_test_proj_standardized, X_test_price_standardized, X_test_essay_bow,  X_test_title_bow))

print(X_train_bow.shape)
print(X_cv_bow.shape)
print(X_test_bow.shape)
```

```
(59368, 15835)
(8740, 15835)
(10925, 15835)
```

In [43]:

```
X_train_tfidf = hstack((X_train_cat_ohe, X_train_subcat_ohe, X_train_state_ohe, X_train_prefix_ohe, X_train_grade_ohe , X_train_proj_standardized, X_train_price_standardized, X_train_essay_tfidf,  X_train_title_tfidf))
X_cv_tfidf = hstack((X_cv_cat_ohe, X_cv_subcat_ohe, X_cv_state_ohe, X_cv_prefix_ohe, X_cv_grade_ohe , X_cv_proj_standardized, X_cv_price_standardized, X_cv_essay_tfidf,  X_cv_title_tfidf))
X_test_tfidf = hstack((X_test_cat_ohe, X_test_subcat_ohe, X_test_state_ohe, X_test_prefix_ohe, X_test_grade_ohe , X_test_proj_standardized, X_test_price_standardized,
X_test_essay_tfidf,  X_test_title_tfidf))

print(X_train_tfidf.shape)
print(X_cv_tfidf.shape)
print(X_test_tfidf.shape)
```

```
(59368, 15835)
(8740, 15835)
(10925, 15835)
```

Naive Bayes

In [0]:

```
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_curve, accuracy_score
from sklearn.model_selection import GridSearchCV
```

In [0]:

```
nb = MultinomialNB()
nb.fit(X_train_bow, y_train)


y_pred_train_bow=nb.predict(X_train_bow)
y_pred_cv_bow=nb.predict(X_cv_bow)
y_pred_test_bow=nb.predict(X_test_bow)
```

In [0]:

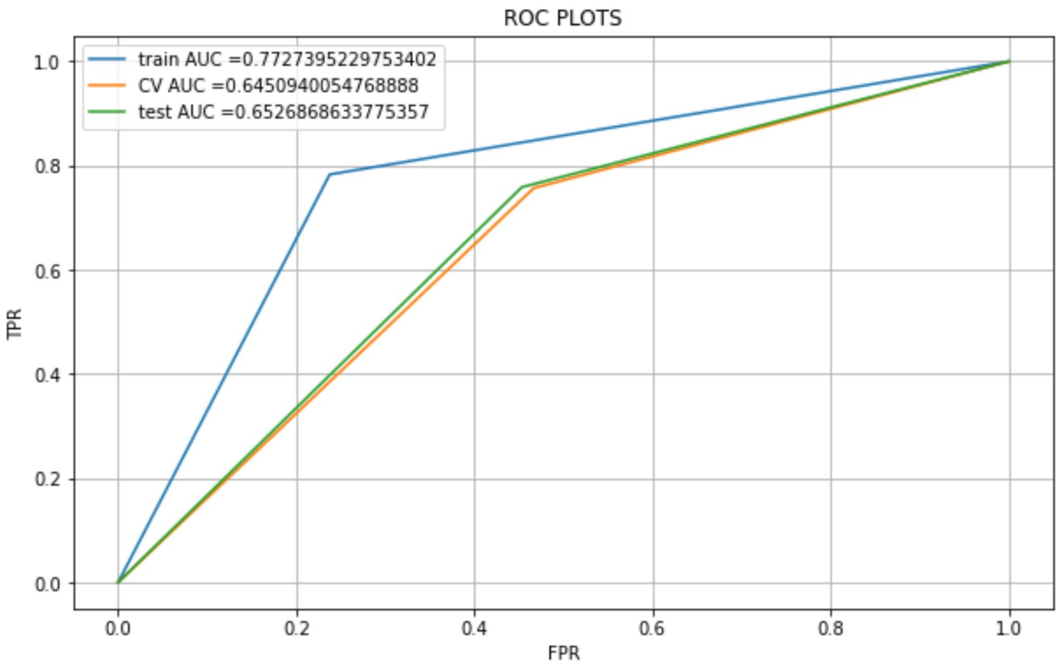
```
auc1_bow=accuracy_score(y_pred_train_bow,y_train,normalize=True)*float(100)
auc2_bow=accuracy_score(y_pred_cv_bow,y_cv,normalize=True)*float(100)
auc3_bow=accuracy_score(y_pred_test_bow,y_test,normalize=True)*float(100)
```

In [47]:
```
print(auc1_bow)
print(auc2_bow)
print(auc3_bow)
```

```
77.27395229753402
72.31121281464532
72.66819221967964
```

In [48]:
```
%%time
plt.figure(figsize=(10,6))
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_pred_train_bow)
cv_fpr, cv_tpr, te_thresholds = roc_curve(y_cv, y_pred_cv_bow)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_pred_test_bow)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(cv_fpr, cv_tpr, label="CV AUC ="+str(auc(cv_fpr, cv_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```



```
CPU times: user 179 ms, sys: 9 ms, total: 188 ms
Wall time: 188 ms
```

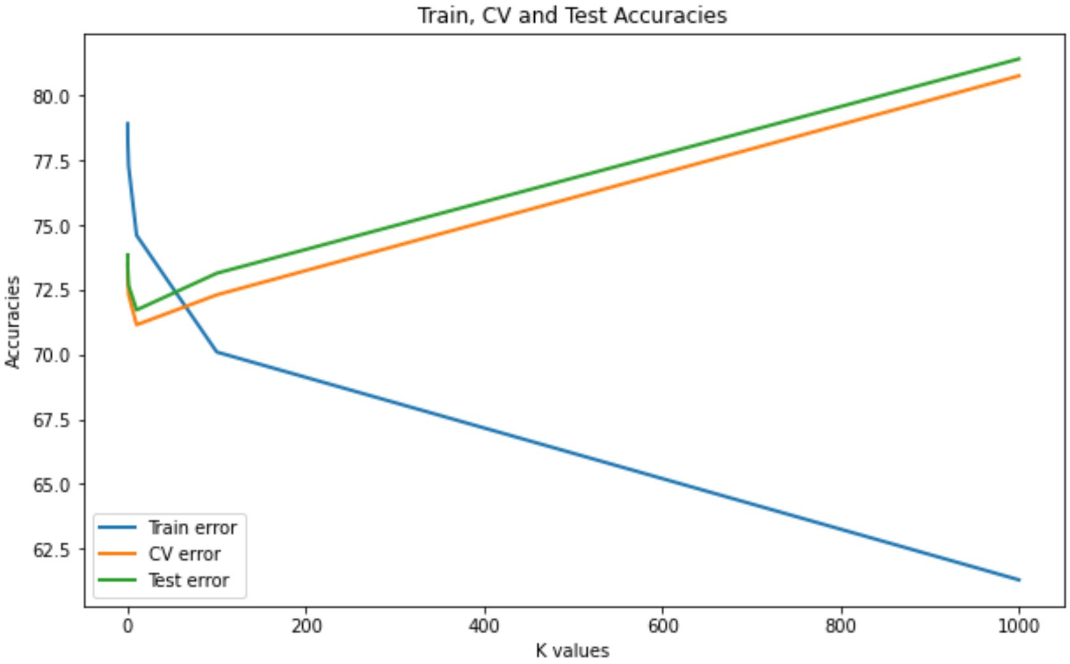
In [49]:
```
alpha=[0.0001, 0.0005, 0.001, 0.005, 0.01, 0.1, 1, 10 ,100 ,1000]
train_bow_auc=[]
cv_bow_auc=[]
test_bow_auc=[]
for i in alpha:
    nb=MultinomialNB(alpha= i)
    nb.fit(X_train_bow, y_train)
    y_pred_cv_bow=nb.predict(X_cv_bow)
    y_pred_train_bow=nb.predict(X_train_bow)
    y_pred_test_bow=nb.predict(X_test_bow)
    auc1_bow=accuracy_score(y_pred_train_bow,y_train,normalize=True)*float(100)
    auc2_bow=accuracy_score(y_pred_cv_bow,y_cv,normalize=True)*float(100)
    auc3_bow=accuracy_score(y_pred_test_bow,y_test,normalize=True)*float(100)
    train_bow_auc.append(auc1_bow)
    cv_bow_auc.append(auc2_bow)
    test_bow_auc.append(auc3_bow)
    print(auc1_bow)
    print(auc2_bow)
    print(auc3_bow)
    print("--"*10)
```

```
78.91119795175852
73.47826086956522
73.83066361556064
--------------------
78.88424740600996
73.48970251716247
73.81235697940504
--------------------
78.86740331491713
73.51258581235697
73.83066361556064
--------------------
78.73433499528365
73.39816933638444
73.7116704805492
--------------------
78.63495485783587
73.4096109839817
73.66590389016018
--------------------
78.24585635359117
72.98627002288329
73.35469107551488
--------------------
77.27395229753402
72.31121281464532
72.66819221967964
--------------------
74.5991106319903
71.1441647597254
71.71624713958809
--------------------
70.09163185554507
72.29977116704805
73.1350114416476
--------------------
61.295647486861604
80.75514874141876
81.4096109839817
--------------------
```

In [50]:

```
%%time
import matplotlib.pyplot as plt
plt.figure(figsize=(10,6))
alpha=[0.0001, 0.0005, 0.001, 0.005, 0.01, 0.1, 1, 10 ,100 ,1000]
plt.plot(alpha,train_bow_auc, label="Train error", linewidth=2)
plt.plot(alpha,cv_bow_auc, label="CV error", linewidth=2)
plt.plot(alpha,test_bow_auc, label="Test error", linewidth=2)

plt.title("Train, CV and Test Accuracies")
plt.xlabel("K values")
plt.ylabel("Accuracies")
plt.legend()
plt.show()
```



```
CPU times: user 168 ms, sys: 3.99 ms, total: 172 ms
Wall time: 172 ms
```

In [51]:

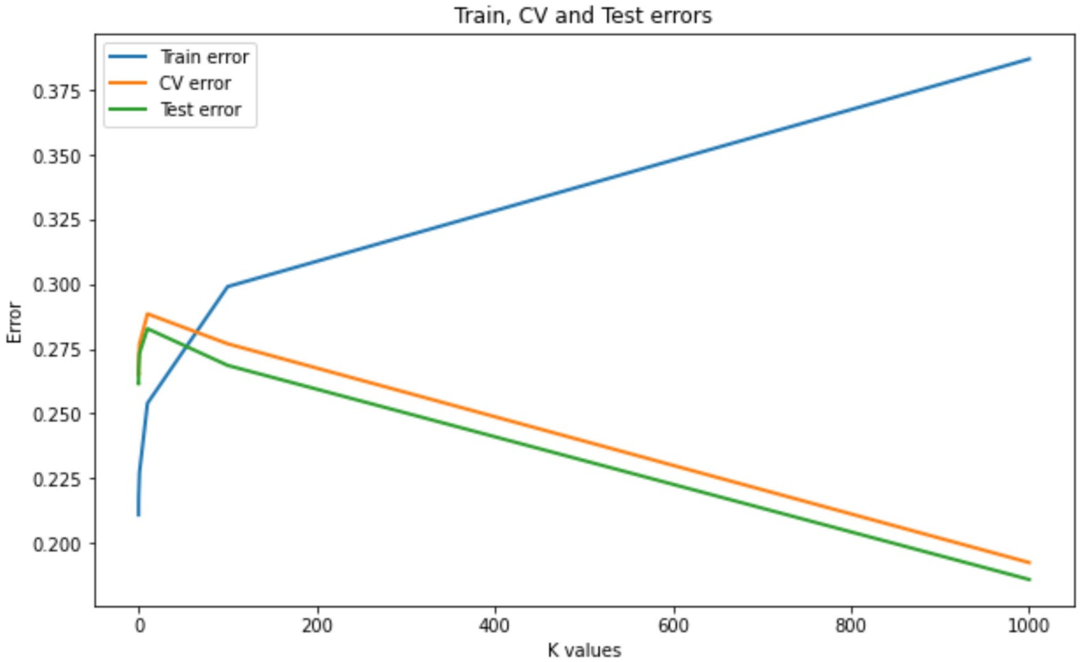
```
%%time
import matplotlib.pyplot as plt
plt.figure(figsize=(10,6))

alpha=[0.0001, 0.0005, 0.001, 0.005, 0.01, 0.1, 1, 10 ,100 ,1000]

train_bow_err=[1-(i/100) for (i) in train_bow_auc]
cv_bow_err=[1-(i/100) for (i) in cv_bow_auc]
test_bow_err=[1-(i/100) for (i) in test_bow_auc]

plt.plot(alpha,train_bow_err, label="Train error", linewidth=2)
plt.plot(alpha,cv_bow_err, label="CV error", linewidth=2)
plt.plot(alpha,test_bow_err, label="Test error", linewidth=2)

plt.title("Train, CV and Test errors")
plt.xlabel("K values")
plt.ylabel("Error")
plt.legend()
plt.show()
```



```
CPU times: user 166 ms, sys: 3 ms, total: 169 ms
Wall time: 169 ms
```

In [52]:

```
%%time
params= {'alpha':[0.0001, 0.0005, 0.001, 0.005, 0.01, 0.1, 1, 10 ,100 ,1000]}
gs=GridSearchCV(estimator= MultinomialNB(), param_grid=params, cv=3, scoring='roc_auc')
gs.fit(X_train_bow, y_train)
```

```
CPU times: user 2.19 s, sys: 25.9 ms, total: 2.22 s
Wall time: 2.22 s
```

In [53]:

```
gs.best_estimator_
```

Out[53]:

```
MultinomialNB(alpha=0.0001, class_prior=None, fit_prior=True)
```

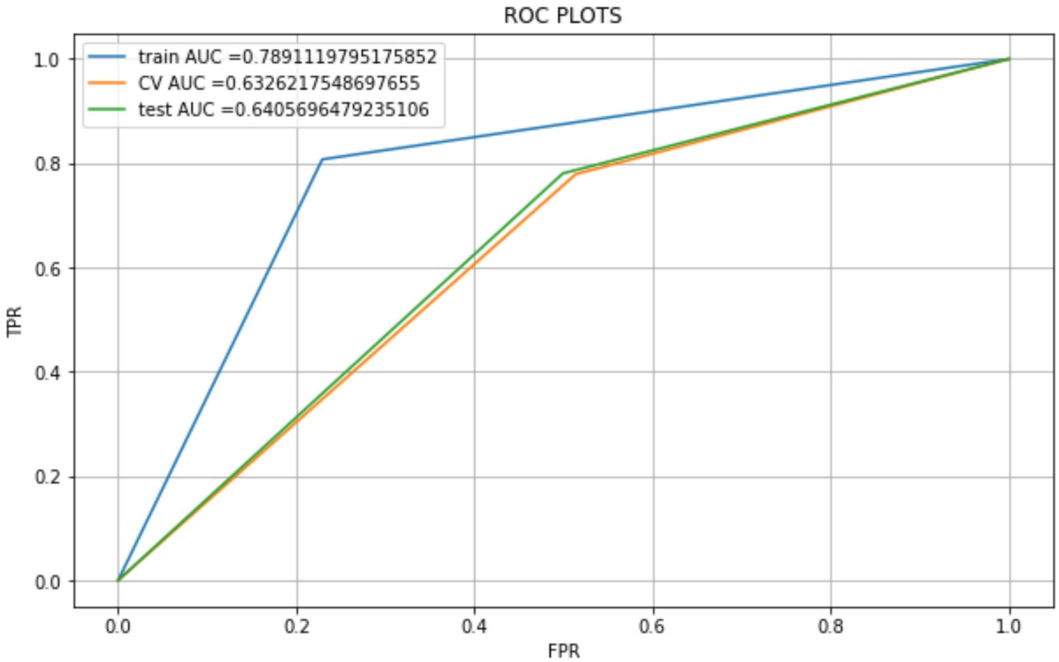
In [54]:

```
%%time

nb=MultinomialNB(alpha= 0.0001)
nb.fit(X_train_bow, y_train)
y_pred_cv_bow=nb.predict(X_cv_bow)
y_pred_train_bow=nb.predict(X_train_bow)
y_pred_test_bow=nb.predict(X_test_bow)

plt.figure(figsize=(10,6))
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_pred_train_bow)
cv_fpr, cv_tpr, te_thresholds = roc_curve(y_cv, y_pred_cv_bow)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_pred_test_bow)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(cv_fpr, cv_tpr, label="CV AUC ="+str(auc(cv_fpr, cv_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```



```
CPU times: user 438 ms, sys: 1.97 ms, total: 440 ms
Wall time: 442 ms
```

In [0]:

```
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
```

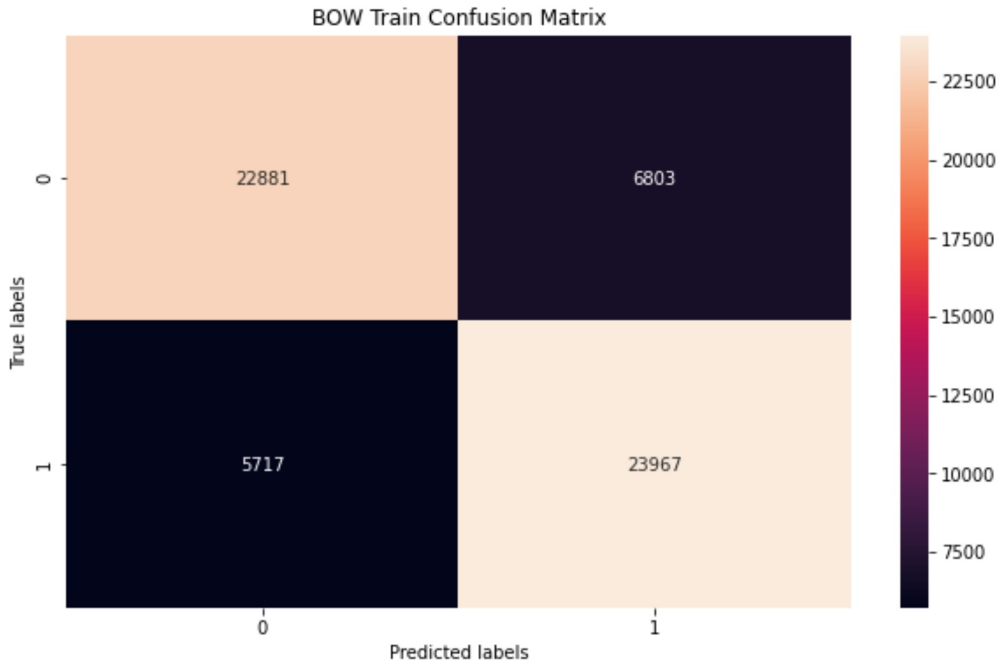
In [56]:

```
plt.figure(figsize=(10,6))
cm=confusion_matrix(y_train, y_pred_train_bow)
ax= plt.subplot()
sns.heatmap(cm,annot=True, ax = ax, fmt='d'); #annot=True to annotate cells
print(cm)
# labels, title and ticks
ax.set_xlabel('Predicted labels')
ax.set_ylabel('True labels')
ax.set_title('BOW Train Confusion Matrix')
```

```
[[22881  6803]
 [ 5717 23967]]
```

Out[56]:

```
Text(0.5, 1.0, 'BOW Train Confusion Matrix')
```



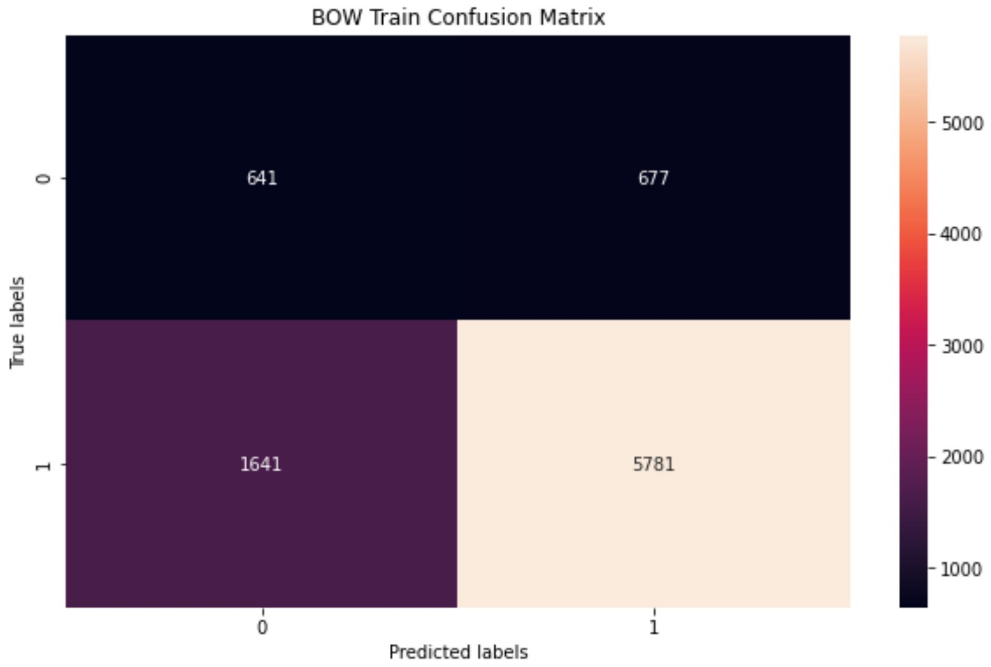
In [57]:

```
plt.figure(figsize=(10,6))
cm=confusion_matrix(y_cv, y_pred_cv_bow)
ax= plt.subplot()
sns.heatmap(cm,annot=True, ax = ax, fmt='d'); #annot=True to annotate cells
print(cm)
# labels, title and ticks
ax.set_xlabel('Predicted labels')
ax.set_ylabel('True labels')
ax.set_title('BOW Train Confusion Matrix')
```

```
[[ 641  677]
 [1641 5781]]
```

Out[57]:

```
Text(0.5, 1.0, 'BOW Train Confusion Matrix')
```



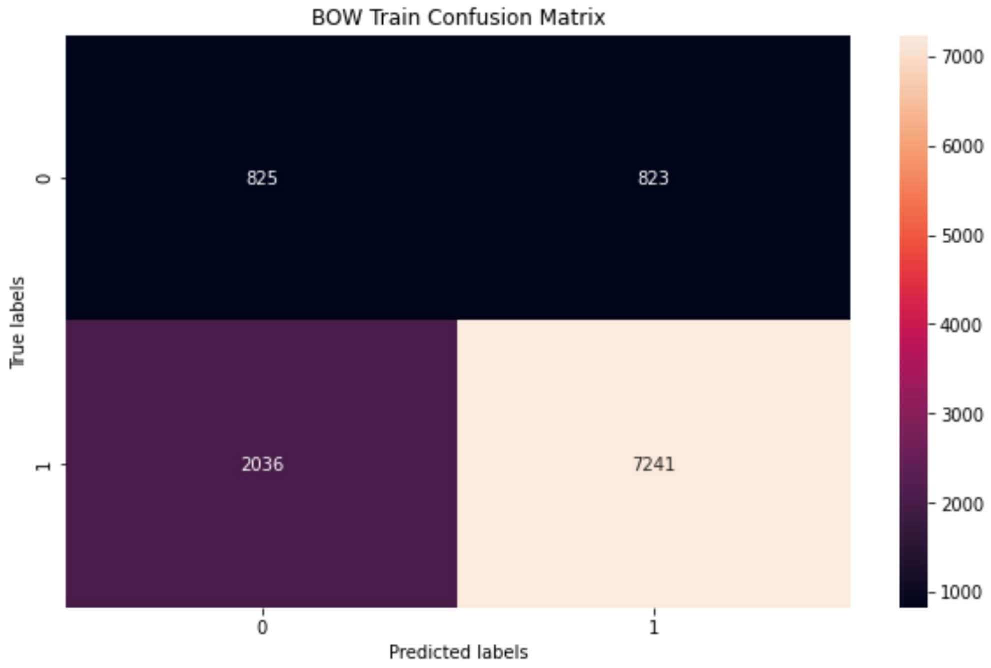
In [58]:

```
plt.figure(figsize=(10,6))
cm=confusion_matrix(y_test, y_pred_test_bow)
ax= plt.subplot()
sns.heatmap(cm,annot=True, ax = ax, fmt='d'); #annot=True to annotate cells
print(cm)
# labels, title and ticks
ax.set_xlabel('Predicted labels')
ax.set_ylabel('True labels')
ax.set_title('BOW Train Confusion Matrix')
```

```
[[ 825  823]
 [2036 7241]]
```

Out[58]:

```
Text(0.5, 1.0, 'BOW Train Confusion Matrix')
```



In [0]:

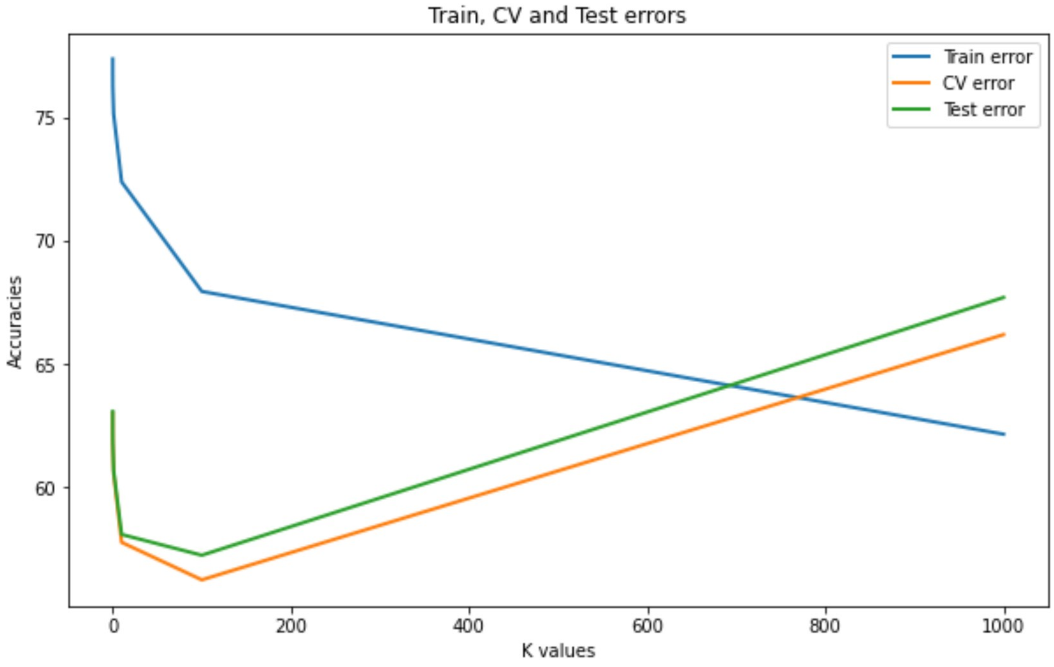
In [59]:

```
alpha=[0.0001, 0.0005, 0.001, 0.005, 0.01, 0.1, 1, 10 ,100 ,1000]
train_tf_auc=[]
cv_tf_auc=[]
test_tf_auc=[]
for i in alpha:
    nb=MultinomialNB(alpha= i)
    nb.fit(X_train_bow, y_train)
    y_pred_cv_tf=nb.predict(X_cv_tfidf)
    y_pred_train_tf=nb.predict(X_train_tfidf)
    y_pred_test_tf=nb.predict(X_test_tfidf)
    auc1_tf=accuracy_score(y_pred_train_tf,y_train,normalize=True)*float(100)
    auc2_tf=accuracy_score(y_pred_cv_tf,y_cv,normalize=True)*float(100)
    auc3_tf=accuracy_score(y_pred_test_tf,y_test,normalize=True)*float(100)
    train_tf_auc.append(auc1_tf)
    cv_tf_auc.append(auc2_tf)
    test_tf_auc.append(auc3_tf)
    print(auc1_tf)
    print(auc2_tf)
    print(auc3_tf)
    print("--"*10)
```

```
77.36996361676324
63.00915331807781
63.07551487414188
--------------------
77.22847325158334
62.76887871853547
62.883295194508
--------------------
77.1560436598841
62.66590389016018
62.77345537757437
--------------------
76.94717693033284
62.42562929061785
62.57208237986271
--------------------
76.80905538337151
62.24256292906178
62.41647597254004
--------------------
76.23467187710551
61.7162471395881
61.90389016018306
--------------------
75.13475272874275
60.58352402745996
60.68649885583524
--------------------
72.38411265328124
57.76887871853547
58.08695652173913
--------------------
67.9423258320981
56.247139588100694
57.24485125858123
--------------------
62.1530117234874
66.18993135011442
67.69794050343249
--------------------
```

```
In [60]: %%time
         import matplotlib.pyplot as plt
         plt.figure(figsize=(10,6))
         alpha=[0.0001, 0.0005, 0.001, 0.005, 0.01, 0.1, 1, 10 ,100 ,1000]
         plt.plot(alpha,train_tf_auc, label="Train error", linewidth=2)
         plt.plot(alpha,cv_tf_auc, label="CV error", linewidth=2)
         plt.plot(alpha,test_tf_auc, label="Test error", linewidth=2)

         plt.title("Train, CV and Test errors")
         plt.xlabel("K values")
         plt.ylabel("Accuracies")
         plt.legend()
         plt.show()
```



```
CPU times: user 149 ms, sys: 6 ms, total: 155 ms
Wall time: 155 ms
```

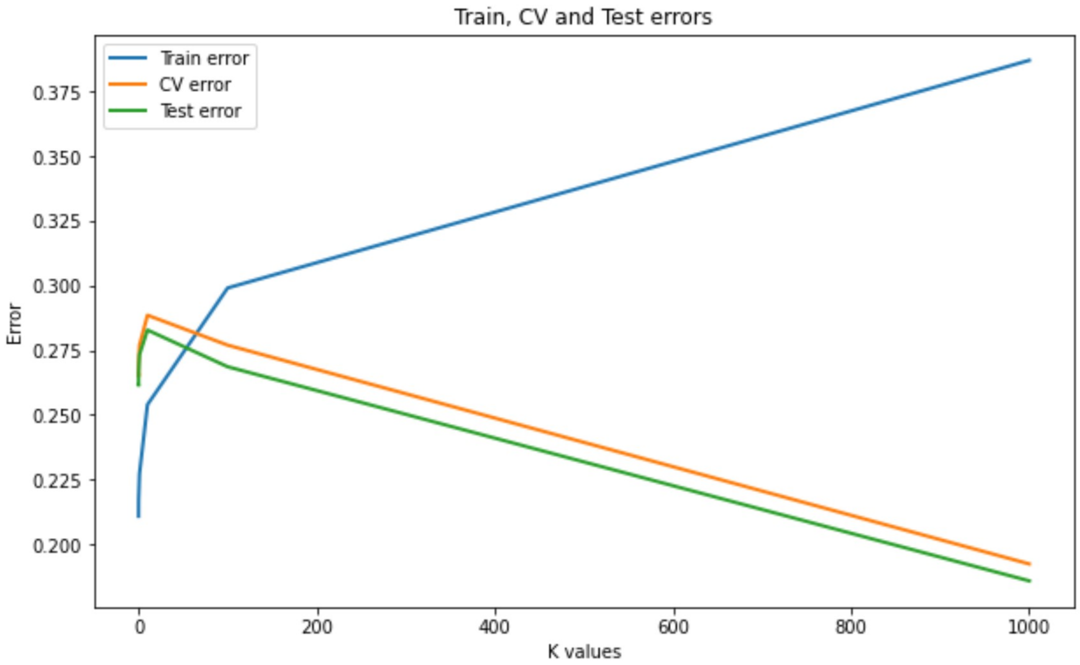
In [61]:

```
%%time
import matplotlib.pyplot as plt
plt.figure(figsize=(10,6))

train_tf_err=[1-(i/100) for (i) in train_tf_auc]
cv_tf_err=[1-(i/100) for (i) in cv_tf_auc]
test_tf_err=[1-(i/100) for (i) in test_tf_auc]

plt.plot(alpha,train_bow_err, label="Train error", linewidth=2)
plt.plot(alpha,cv_bow_err, label="CV error", linewidth=2)
plt.plot(alpha,test_bow_err, label="Test error", linewidth=2)

plt.title("Train, CV and Test errors")
plt.xlabel("K values")
plt.ylabel("Error")
plt.legend()
plt.show()
```



```
CPU times: user 175 ms, sys: 997 µs, total: 176 ms
Wall time: 178 ms
```

In [62]:

```
gs.fit(X_train_tfidf, y_train)
```

Out[62]:

```
GridSearchCV(cv=3, error_score=nan,
             estimator=MultinomialNB(alpha=1.0, class_prior=None,
                                     fit_prior=True),
             iid='deprecated', n_jobs=None,
             param_grid={'alpha': [0.0001, 0.0005, 0.001, 0.005, 0.01, 0.1, 1,
                                   10, 100, 1000]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='roc_auc', verbose=0)
```

In [63]:

```
gs.best_estimator_
```

Out[63]:

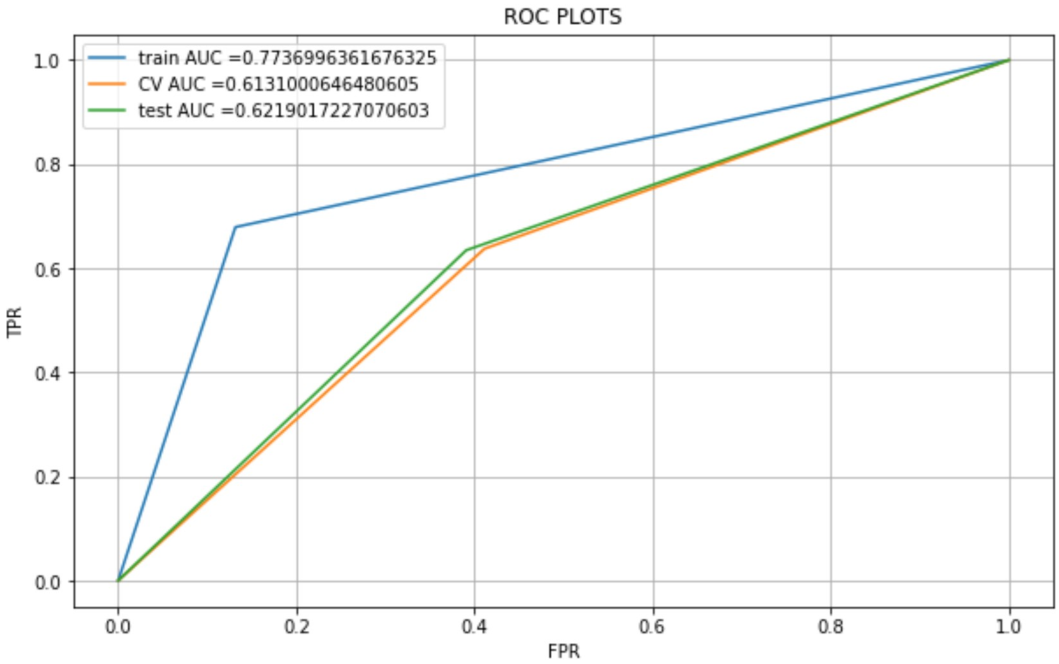
```
MultinomialNB(alpha=0.0001, class_prior=None, fit_prior=True)
```

In [64]:

```
nb=MultinomialNB(alpha= 0.0001)
nb.fit(X_train_bow, y_train)
y_pred_cv_tfidf=nb.predict(X_cv_tfidf)
y_pred_train_tfidf=nb.predict(X_train_tfidf)
y_pred_test_tfidf=nb.predict(X_test_tfidf)

plt.figure(figsize=(10,6))
train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_pred_train_tfidf)
cv_fpr, cv_tpr, te_thresholds = roc_curve(y_cv, y_pred_cv_tfidf)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_pred_test_tfidf)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(cv_fpr, cv_tpr, label="CV AUC ="+str(auc(cv_fpr, cv_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.title("ROC PLOTS")
plt.grid()
plt.show()
```



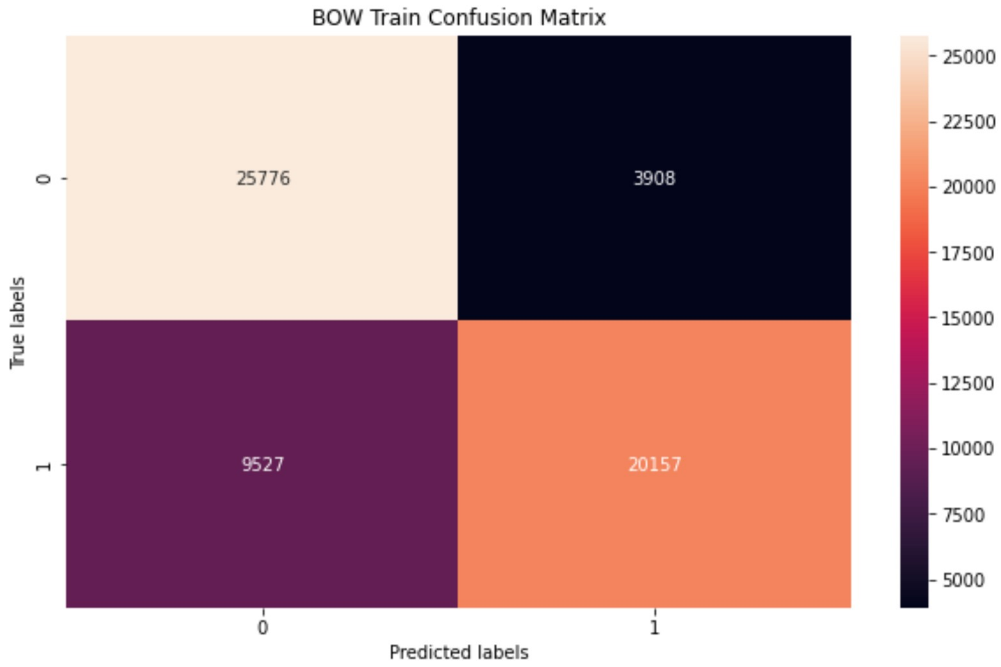
In [65]:

```
plt.figure(figsize=(10,6))
cm=confusion_matrix(y_train, y_pred_train_tfidf)
ax= plt.subplot()
sns.heatmap(cm,annot=True, ax = ax, fmt='d'); #annot=True to annotate cells
print(cm)
# labels, title and ticks
ax.set_xlabel('Predicted labels')
ax.set_ylabel('True labels')
ax.set_title('BOW Train Confusion Matrix')
```

```
[[25776  3908]
 [ 9527 20157]]
```

Out[65]:

```
Text(0.5, 1.0, 'BOW Train Confusion Matrix')
```



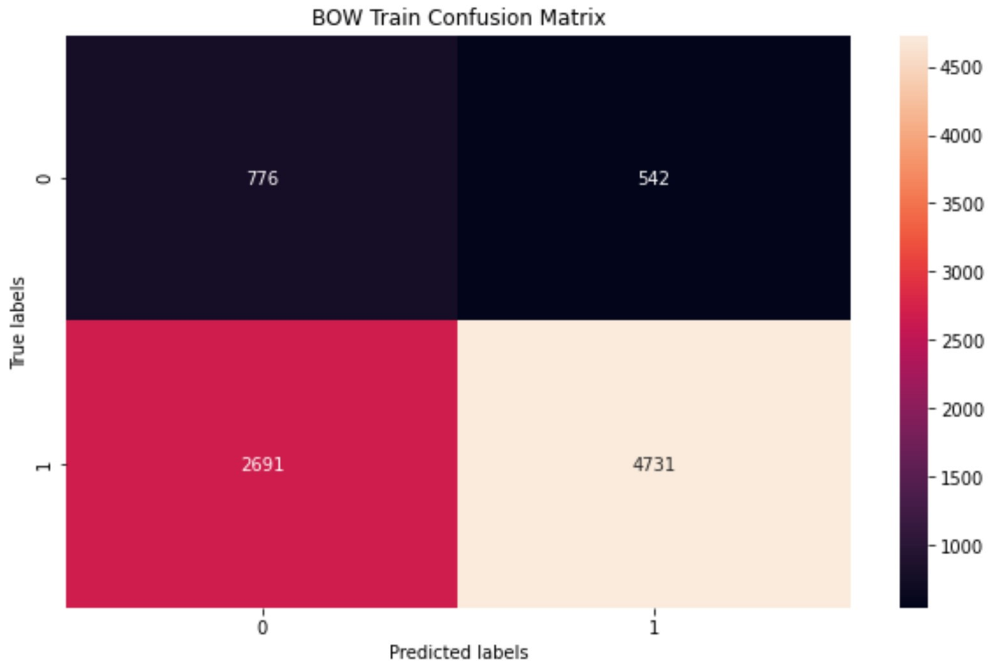
In [66]:

```python
plt.figure(figsize=(10,6))
cm=confusion_matrix(y_cv, y_pred_cv_tfidf)
ax= plt.subplot()
sns.heatmap(cm,annot=True, ax = ax, fmt='d'); #annot=True to annotate cells
print(cm)
# labels, title and ticks
ax.set_xlabel('Predicted labels')
ax.set_ylabel('True labels')
ax.set_title('BOW Train Confusion Matrix')
```

```
[[ 776  542]
 [2691 4731]]
```

Out[66]:

```
Text(0.5, 1.0, 'BOW Train Confusion Matrix')
```



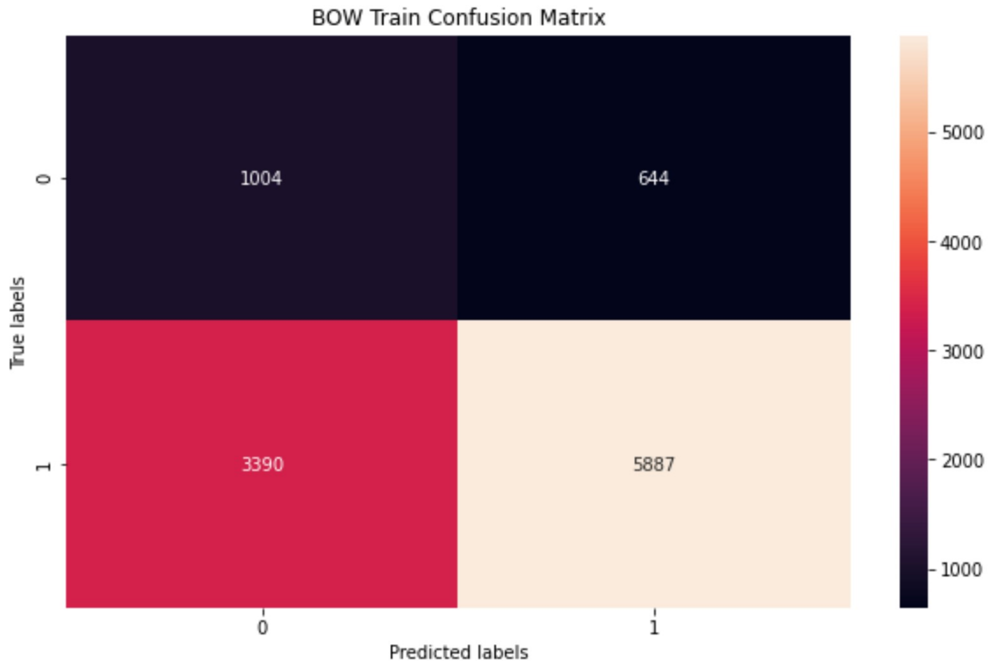
In [67]:

```
plt.figure(figsize=(10,6))
cm=confusion_matrix(y_test, y_pred_test_tfidf)
ax= plt.subplot()
sns.heatmap(cm,annot=True, ax = ax, fmt='d'); #annot=True to annotate cells
print(cm)
# labels, title and ticks
ax.set_xlabel('Predicted labels')
ax.set_ylabel('True labels')
ax.set_title('BOW Train Confusion Matrix')
```

```
[[1004  644]
 [3390 5887]]
```

Out[67]:

```
Text(0.5, 1.0, 'BOW Train Confusion Matrix')
```



In [0]: