Assignment-7: Apply SVM on Donors Choose dataset

This exercise is to apply SVM on Donors Choose dataset and predict approval of a new project proposal.

Relevant Information : The dataset is divided into two files -

1. train.csv file which contains information regarding projects, schools and teachers who submitted the projects.
2. resources.csv which provides information about the resources required for each project.

OBJECTIVE : The goal 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 using SVM.

In [2]:
```
# Importing the required libraries
# Warning reference : https://stackoverflow.com/questions/41658568/chunkize-warning-while-installing-gensim

%matplotlib inline
import warnings
warnings.filterwarnings(action='ignore', category = UserWarning , module = 'gensim')

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
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. Reading the data

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

print("\nNumber of data points in train data", project_data.shape)
print('-'*120)
print("The attributes of data :", project_data.columns.values)
```

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

In [4]:
```
project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 109248 entries, 0 to 109247
Data columns (total 17 columns):
Unnamed: 0                                      109248 non-null int64
id                                              109248 non-null object
teacher_id                                      109248 non-null object
teacher_prefix                                  109245 non-null object
school_state                                    109248 non-null object
project_submitted_datetime                      109248 non-null object
project_grade_category                          109248 non-null object
project_subject_categories                      109248 non-null object
project_subject_subcategories                   109248 non-null object
project_title                                   109248 non-null object
project_essay_1                                 109248 non-null object
project_essay_2                                 109248 non-null object
project_essay_3                                 3758 non-null object
project_essay_4                                 3758 non-null object
project_resource_summary                        109248 non-null object
teacher_number_of_previously_posted_projects    109248 non-null int64
project_is_approved                             109248 non-null int64
dtypes: int64(3), object(14)
memory usage: 14.2+ MB
```

NOTE:

1. We have a total of 109248 datapoints and 17 columns.
2. Now we have to sort the data according to date and time so as to have a better prediction on the future data (Test data).
3. As we can see there are null points for project_essay_3 and project_essay_4. Only 3758 points are not null.
4. In teacher_prefix there are 109245 points which means 3 points are null.

Sorting according to date

In [5]:
```
# 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]

print(cols)
```

```
['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state', 'Date', '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_approve
d']
```

In [6]:
```
# Dropping the Unnamed column

project_data.drop('Unnamed: 0', axis=1, inplace=True)
```

Adding the price and quantity column from resource_data to the project_data

In [7]:
```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()

# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')

# Deleting the resource data variable
del resource_data
```

NOTE:

1. As we can see that the price and the quantity column has been added to the project_data
2. This is where the preprocessing will start.
3. 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
- essay : text data

- quantity : numerical
- teacher_number_of_previously_posted_projects : numerical
- price : numerical

2. Preprocessing Data

project_subject_categories

In [8]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Sci
            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]))
```

project_subject_subcategories

In [9]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

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

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

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

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

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

Text Preprocessing

Essay

In [10]:
```
# Combining all the essay
# 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 [11]:
```
project_data['essay'].describe()
```

Out[11]:
```
count                                                109248
unique                                               108986
top       At our school, we strive to always be \"Chargi...
freq                                                      5
Name: essay, dtype: object
```

In [12]:
```
# Making the decontracted function

# 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


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


# Combining all the above statements
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%|████████████████████████████████████████████████████████████████| 109248/109248 [01:39<00:00, 1093.47it/s]
```

project_title

In [13]:
```
project_data['project_title'].describe()
```

Out[13]:
```
count               109248
unique              100851
top       Flexible Seating
freq                   234
Name: project_title, dtype: object
```

In [14]:
```
# Project_title

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

```
100%|██████████████████████████████████████████████████████████████| 109248/109248 [00:03<00:00, 27916.76it/s]
```

Replacing the columns with new cleaned columns - Project_title and Essay

In [15]:
```
# Adding processed essay columns in place of previous essays columns and dropping the previous columns

## ESSAY

project_data['clean_essays'] = 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)
```

In [16]:
```
## Project_title

# Adding processed project_title columns in place of previous project_title column and dropping the previous column

project_data['clean_titles'] = preprocessed_titles

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

Dropping the nan rows present in teacher_prefix

In [17]:
```
# Dropping NAN row
# https://stackoverflow.com/questions/46091924/python-how-to-drop-a-row-whose-particular-column-is-empty-nan

project_data.dropna(axis = 0, inplace = True, subset = ['teacher_prefix'])
```

In [18]:
```
project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 109245 entries, 0 to 109247
Data columns (total 15 columns):
id                                              109245 non-null object
teacher_id                                      109245 non-null object
teacher_prefix                                  109245 non-null object
school_state                                    109245 non-null object
Date                                            109245 non-null datetime64[ns]
project_grade_category                          109245 non-null object
project_resource_summary                        109245 non-null object
teacher_number_of_previously_posted_projects    109245 non-null int64
project_is_approved                             109245 non-null int64
price                                           109245 non-null float64
quantity                                        109245 non-null int64
clean_categories                                109245 non-null object
clean_subcategories                             109245 non-null object
clean_essays                                    109245 non-null object
clean_titles                                    109245 non-null object
dtypes: datetime64[ns](1), float64(1), int64(3), object(10)
memory usage: 13.3+ MB
```

Creating the features for FEATURE 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 (http://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html) on TfidfVectorizer (https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfVectorizer.html) of essay text, choose the number of components (`n_components`) using elbow method (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/pca-code-example-using-non-visualization/)** : numerical data

NOTE:

```
- Now we have to get:
    - number of words in the title
    - number of words in the combined essays
    - the sentiment score's of each of the essay
    - choose the n_components using elbow method and apply TruncatedSVD on TfidfVectorizer of essay text
    - WE ARE TAKING THE clean_essay AND clean_title TO FIND THE NUMBER OF WORDS IN EACH OF THEM, INSTEAD OF THE ORIG
    INAL
      ESSAYS AND TITLES
```

- Number of words in the title

In [19]:
```
# List to contain the number of words per sentence
words_in_clean_title = []

# Looping over each title and counting the words
for sent in project_data['clean_titles'].values:
    num_words = len(sent.split())
    words_in_clean_title.append(num_words)

# Adding a new column to the project_data
project_data['words_in_title'] = words_in_clean_title
```

In [20]:
```
project_data['clean_titles'].head(3)
```

Out[20]:
```
0        engineering steam primary classroom
1                          sensory tools focus
2    mobile learning mobile listening center
Name: clean_titles, dtype: object
```

In [21]:
```
project_data['words_in_title'].head(3)
```

Out[21]:
```
0    4
1    3
2    5
Name: words_in_title, dtype: int64
```

NOTE:

```
    - The words in each of the clean_titles are counted and are stored in the new column named : words_in_title
```

- Number of words in the combined essays

In [22]:
```
# List to contain the number of words per sentence
words_in_clean_essay = []

# Looping over each essay and counting the words
for sent in project_data['clean_essays'].values:
    num_words = len(sent.split())
    words_in_clean_essay.append(num_words)

# Adding a new column to the project_data
project_data['words_in_essay'] = words_in_clean_essay
```

In [23]:
```
project_data['clean_essays'].head(3)
```

Out[23]:
```
0    fortunate enough use fairy tale stem kits clas...
1    imagine 8 9 years old third grade classroom se...
2    class 24 students comes diverse learners stude...
Name: clean_essays, dtype: object
```

In [24]:
```
project_data['words_in_essay'].head(3)
```

Out[24]:
```
0    156
1    159
2    106
Name: words_in_essay, dtype: int64
```

NOTE:

- The words in each of the clean_essay are counted and are stored in the new column named : words_in_essay

- Sentiment score's of each of the essay

In [26]:
```
from nltk.sentiment.vader import SentimentIntensityAnalyzer

# List that contain all the scores (NEGATIVE : neg, NEUTRAL : neu, POSITIVE : pos, COMPOUND)
sentiment = []
for sent in tqdm(project_data['clean_essays'].values):

    sid = SentimentIntensityAnalyzer()
    sentiment.append(sid.polarity_scores(sent))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 109245/109245 [24:08<00:00, 75.45it/s]
```

In [27]:
```
sentiment[0:5]
```

Out[27]:
```
[{'neg': 0.013, 'neu': 0.773, 'pos': 0.214, 'compound': 0.9867},
 {'neg': 0.078, 'neu': 0.65, 'pos': 0.272, 'compound': 0.9899},
 {'neg': 0.016, 'neu': 0.706, 'pos': 0.278, 'compound': 0.9864},
 {'neg': 0.031, 'neu': 0.775, 'pos': 0.194, 'compound': 0.9524},
 {'neg': 0.031, 'neu': 0.653, 'pos': 0.315, 'compound': 0.9873}]
```

Converting the dictionary to the dataframe

In [28]:
```
# Converting the dict to dataframe
sentiment_data = pd.DataFrame(sentiment)

#### Saving the data in csv file for further use (as it takes a lot of time)
sentiment_data.to_csv('sentiment_data.csv', index=False)

### Reading from the scv file
#sentiment_data = pd.read_csv('sentiment_data.csv')
```

In [29]:
```
# Resetting the indexs
# https://stackoverflow.com/questions/40339886/pandas-concat-generates-nan-values
sentiment_data.reset_index(drop=True, inplace=True)
project_data.reset_index(drop=True, inplace=True)

# concatenating the two data frames
project_data = pd.concat([project_data, sentiment_data], axis=1)
```

In [30]:
```
sentiment_data.head(3)
```

Out[30]:

	compound	neg	neu	pos
0	0.9867	0.013	0.773	0.214
1	0.9899	0.078	0.650	0.272
2	0.9864	0.016	0.706	0.278

In [31]:
```
project_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 109245 entries, 0 to 109244
Data columns (total 21 columns):
id                                              109245 non-null object
teacher_id                                      109245 non-null object
teacher_prefix                                  109245 non-null object
school_state                                    109245 non-null object
Date                                            109245 non-null datetime64[ns]
project_grade_category                          109245 non-null object
project_resource_summary                        109245 non-null object
teacher_number_of_previously_posted_projects    109245 non-null int64
project_is_approved                             109245 non-null int64
price                                           109245 non-null float64
quantity                                        109245 non-null int64
clean_categories                                109245 non-null object
clean_subcategories                             109245 non-null object
clean_essays                                    109245 non-null object
clean_titles                                    109245 non-null object
words_in_title                                  109245 non-null int64
words_in_essay                                  109245 non-null int64
compound                                        109245 non-null float64
neg                                             109245 non-null float64
neu                                             109245 non-null float64
pos                                             109245 non-null float64
dtypes: datetime64[ns](1), float64(5), int64(5), object(10)
memory usage: 17.5+ MB
```

NOTE:

- Till now we have preprocessed the data.
- Now we have to split the data and vectorize the data for BOW, TF-IDF, Avg W2V and TFIDF weighted W2Vec

**********ASSIGNMENT**********

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

In [32]:
```
# Creating label and feature data frame : Label- y, Features- X

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

print(y.shape)
print(X.shape)
```

```
(109245,)
(109245, 20)
```

In [33]:
```
## train test cross-validation split
# Referance : https://stackoverflow.com/questions/34842405/parameter-stratify-from-method-train-test-split-scikit-learn

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

NOTE:

- This `stratify` parameter makes a split so that the proportion of values in the sample produced will be the same as the proportion of values provided to parameter stratify.

- For example, if variable y is a binary categorical variable with values 0 and 1 and there are 25% of zeros and 75% of ones, stratify=y will make sure that your random split has 25% of 0's and 75% of 1's.

In [34]:
```
## Shape of the matrices

print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)
```

```
(49039, 20) (49039,)
(24155, 20) (24155,)
(36051, 20) (36051,)
```

NOTE:

1. We will now use the train data for training our model, cv data to validate the model and perform testing on the test data

4. Make Data Model Ready: encoding numerical, categorical features

Vectorizing Categorical Features

1. clean_categories

In [35]:
```
# We use count vectorizer to convert the values into one hot encoded features
from sklearn.feature_extraction.text import CountVectorizer

vectorizer_clean_categories = CountVectorizer()

# We will fit the train data only
vectorizer_clean_categories.fit(X_train['clean_categories'].values)


# we use the fitted CountVectorizer to convert the text to vector
X_train_clean_category = vectorizer_clean_categories.transform(X_train['clean_categories'].values)
X_cv_clean_category = vectorizer_clean_categories.transform(X_cv['clean_categories'].values)
X_test_clean_category = vectorizer_clean_categories.transform(X_test['clean_categories'].values)

print("Clean categories are vectorized\n")
print(X_train_clean_category.shape, y_train.shape)
print(X_cv_clean_category.shape, y_cv.shape)
print(X_test_clean_category.shape, y_test.shape)

print(vectorizer_clean_categories.get_feature_names())
```

```
Clean categories are vectorized

(49039, 9) (49039,)
(24155, 9) (24155,)
(36051, 9) (36051,)
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'literacy_language', 'math_science', 'music_art
s', 'specialneeds', 'warmth']
```

2. clean_subcategories

In [36]:
```
vectorizer_clean_subcategories = CountVectorizer()

# We will fit the train data only
vectorizer_clean_subcategories.fit(X_train['clean_subcategories'].values)


# we use the fitted CountVectorizer to convert the text to vector
X_train_clean_subcategories = vectorizer_clean_subcategories.transform(X_train['clean_subcategories'].values)
X_cv_clean_subcategories = vectorizer_clean_subcategories.transform(X_cv['clean_subcategories'].values)
X_test_clean_subcategories = vectorizer_clean_subcategories.transform(X_test['clean_subcategories'].values)

print("Clean_subcategories are vectorized\n")
print(X_train_clean_subcategories.shape, y_train.shape)
print(X_cv_clean_subcategories.shape, y_cv.shape)
print(X_test_clean_subcategories.shape, y_test.shape)
print(vectorizer_clean_subcategories.get_feature_names())
```

```
Clean_subcategories are vectorized

(49039, 30) (49039,)
(24155, 30) (24155,)
(36051, 30) (36051,)
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government', 'college_careerprep', 'communityservice',
'earlydevelopment', 'economics', 'environmentalscience', 'esl', 'extracurricular', 'financialliteracy', 'foreignlanguag
es', 'gym_fitness', 'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'ma
thematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socialsciences', 'specialne
eds', 'teamsports', 'visualarts', 'warmth']
```

3. teacher_prefix

In [37]:
```
vectorizer_teacher_prefix = CountVectorizer()

# We will fit the train data only
vectorizer_teacher_prefix.fit(X_train['teacher_prefix'].values)


# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_prefix = vectorizer_teacher_prefix.transform(X_train['teacher_prefix'].values)
X_cv_teacher_prefix = vectorizer_teacher_prefix.transform(X_cv['teacher_prefix'].values)
X_test_teacher_prefix = vectorizer_teacher_prefix.transform(X_test['teacher_prefix'].values)


print("Teacher_prefix are vectorized\n")
print(X_train_teacher_prefix.shape, y_train.shape)
print(X_cv_teacher_prefix.shape, y_cv.shape)
print(X_test_teacher_prefix.shape, y_test.shape)
print(vectorizer_teacher_prefix.get_feature_names())
```

```
Teacher_prefix are vectorized

(49039, 5) (49039,)
(24155, 5) (24155,)
(36051, 5) (36051,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
```

4. school state

In [38]:
```
vectorizer_school_state = CountVectorizer()

# We will fit the train data only
vectorizer_school_state.fit(X_train['school_state'].values)

# we use the fitted CountVectorizer to convert the text to vector
X_train_school_state = vectorizer_school_state.transform(X_train['school_state'].values)
X_cv_school_state = vectorizer_school_state.transform(X_cv['school_state'].values)
X_test_school_state = vectorizer_school_state.transform(X_test['school_state'].values)

print("School_state are vectorized\n")
print(X_train_school_state.shape, y_train.shape)
print(X_cv_school_state.shape, y_cv.shape)
print(X_test_school_state.shape, y_test.shape)
print(vectorizer_school_state.get_feature_names())
```

```
School_state are vectorized

(49039, 51) (49039,)
(24155, 51) (24155,)
(36051, 51) (36051,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'ia', 'id', 'il', 'in', 'ks', 'ky', 'la', 'm
a', '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']
```

5. project_grade_category

In [39]:
```
#This step is to intialize a vectorizer with vocab from train data

# Creating the list of grades

grades = list(set(project_data['project_grade_category'].values))

# we use count vectorizer to convert the values into one hot encoded features
# We will fit the train data only
vectorizer_grade_category = CountVectorizer(vocabulary = grades, lowercase=False, binary=True)
vectorizer_grade_category.fit(X_train['project_grade_category'].values)


# we use the fitted CountVectorizer to convert the text to vector
X_train_project_grade = vectorizer_grade_category.transform(X_train['project_grade_category'].values)
X_cv_project_grade = vectorizer_grade_category.transform(X_cv['project_grade_category'].values)
X_test_project_grade = vectorizer_grade_category.transform(X_test['project_grade_category'].values)

print("Project_grade_category are vectorized\n")
print(X_train_project_grade.shape, y_train.shape)
print(X_cv_project_grade.shape, y_cv.shape)
print(X_test_project_grade.shape, y_test.shape)
print(vectorizer_grade_category.get_feature_names())
```

```
Project_grade_category are vectorized

(49039, 4) (49039,)
(24155, 4) (24155,)
(36051, 4) (36051,)
['Grades 3-5', 'Grades 9-12', 'Grades 6-8', 'Grades PreK-2']
```

Standardizing Numerical features

1. price

In [40]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html

from sklearn.preprocessing import StandardScaler

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

price_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
price_scalar.fit(X_train['price'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])}")


# Now standardize the data with above mean and variance.
X_train_price = price_scalar.transform(X_train['price'].values.reshape(-1,1))
X_cv_price = price_scalar.transform(X_cv['price'].values.reshape(-1,1))
X_test_price = price_scalar.transform(X_test['price'].values.reshape(-1,1))

print("Price is standardized\n")
print(X_train_price.shape, y_train.shape)
print(X_cv_price.shape, y_cv.shape)
print(X_test_price.shape, y_test.shape)
```

```
Mean : 296.5975807010746, Standard deviation : 359.59895678381787
Price is standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

2. teacher_number_of_previously _posted_projects

In [41]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
# price_standardized = standardScalar.fit(project_data['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.

# https://stackoverflow.com/questions/29086398/sklearn-turning-off-warnings
from sklearn.exceptions import DataConversionWarning
warnings.filterwarnings(action='ignore', category=DataConversionWarning)

from sklearn.preprocessing import StandardScaler
previous_post_scalar = StandardScaler(with_mean = False)

# 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.

# We will fit the train data only
# finding the mean and standard deviation of this data
previous_post_scalar.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
print(f"Mean : {previous_post_scalar.mean_[0]}, Standard deviation : {np.sqrt(previous_post_scalar.var_[0])}")

X_train_previous_projects = previous_post_scalar.transform(X_train['teacher_number_of_previously_posted_projects'].value
X_cv_previous_projects = previous_post_scalar.transform(X_cv['teacher_number_of_previously_posted_projects'].values.resh
X_test_previous_projects = previous_post_scalar.transform(X_test['teacher_number_of_previously_posted_projects'].values.

print("Teacher_number_of_previously_posted_projects is standardized\n")
print(X_train_previous_projects.shape, y_train.shape)
print(X_cv_previous_projects.shape, y_cv.shape)
print(X_test_previous_projects.shape, y_test.shape)
```

```
Mean : 11.360203103652195, Standard deviation : 28.762215873224893
Teacher_number_of_previously_posted_projects is standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

3. quantity

In [42]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html
# price_standardized = standardScalar.fit(project_data['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.

# https://stackoverflow.com/questions/29086398/sklearn-turning-off-warnings
from sklearn.exceptions import DataConversionWarning
warnings.filterwarnings(action='ignore', category=DataConversionWarning)

from sklearn.preprocessing import StandardScaler
quantity_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
# finding the mean and standard deviation of this data
quantity_scalar.fit(X_train['quantity'].values.reshape(-1,1))
print(f"Mean : {quantity_scalar.mean_[0]}, Standard deviation : {np.sqrt(quantity_scalar.var_[0])}")


# Now standardize the data with above maen and variance.
X_train_quantity = quantity_scalar.transform(X_train['quantity'].values.reshape(-1,1))
X_cv_quantity = quantity_scalar.transform(X_cv['quantity'].values.reshape(-1,1))
X_test_quantity = quantity_scalar.transform(X_test['quantity'].values.reshape(-1,1))


print("quantity is standardized")
print(X_train_quantity.shape, y_train.shape)
print(X_cv_quantity.shape, y_cv.shape)
print(X_test_quantity.shape, y_test.shape)
```

```
Mean : 16.873549623768838, Standard deviation : 25.735142841168447
quantity is standardized
(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

4. words_in_title

In [43]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html

from sklearn.preprocessing import StandardScaler

# 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.

words_title_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
words_title_scalar.fit(X_train['words_in_title'].values.reshape(-1,1)) # finding the mean and standard deviation of this
print(f"Mean : {words_title_scalar.mean_[0]}, Standard deviation : {np.sqrt(words_title_scalar.var_[0])}")


# Now standardize the data with above mean and variance.
X_train_words_in_title = words_title_scalar.transform(X_train['words_in_title'].values.reshape(-1,1))
X_cv_words_in_title = words_title_scalar.transform(X_cv['words_in_title'].values.reshape(-1,1))
X_test_words_in_title = words_title_scalar.transform(X_test['words_in_title'].values.reshape(-1,1))

print("Words_in_title are standardized\n")
print(X_train_words_in_title.shape, y_train.shape)
print(X_cv_words_in_title.shape, y_cv.shape)
print(X_test_words_in_title.shape, y_test.shape)
```

```
Mean : 4.342360162319786, Standard deviation : 1.789494432720516
Words_in_title are standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

5. words_in_essay

In [44]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html

# 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.

words_essay_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
words_essay_scalar.fit(X_train['words_in_essay'].values.reshape(-1,1)) # finding the mean and standard deviation of this
print(f"Mean : {words_essay_scalar.mean_[0]}, Standard deviation : {np.sqrt(words_essay_scalar.var_[0])}")


# Now standardize the data with above mean and variance.
X_train_words_in_essay = words_essay_scalar.transform(X_train['words_in_essay'].values.reshape(-1,1))
X_cv_words_in_essay = words_essay_scalar.transform(X_cv['words_in_essay'].values.reshape(-1,1))
X_test_words_in_essay = words_essay_scalar.transform(X_test['words_in_essay'].values.reshape(-1,1))

print("Words_in_essay are standardized\n")
print(X_train_words_in_essay.shape, y_train.shape)
print(X_cv_words_in_essay.shape, y_cv.shape)
print(X_test_words_in_essay.shape, y_test.shape)
```

```
Mean : 137.95607577642284, Standard deviation : 36.092570074980735
Words_in_essay are standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

- Sentiment Scores [NEGATIVE : neg, NEUTRAL : neu, POSITIVE : pos, COMPOUND]

6. NEGATIVE : neg

In [45]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html

# 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.

neg_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
neg_scalar.fit(X_train['neg'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {neg_scalar.mean_[0]}, Standard deviation : {np.sqrt(neg_scalar.var_[0])}")


# Now standardize the data with above mean and variance.
X_train_neg = neg_scalar.transform(X_train['neg'].values.reshape(-1,1))
X_cv_neg = neg_scalar.transform(X_cv['neg'].values.reshape(-1,1))
X_test_neg = neg_scalar.transform(X_test['neg'].values.reshape(-1,1))

print("Sentiment score : NEGATIVE are standardized\n")
print(X_train_neg.shape, y_train.shape)
print(X_cv_neg.shape, y_cv.shape)
print(X_test_neg.shape, y_test.shape)
```

```
Mean : 0.048029160464120396, Standard deviation : 0.0358891363036442
Sentiment score : NEGATIVE are standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

7. NEUTRAL : neu

In [46]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html

# 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.

neu_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
neu_scalar.fit(X_train['neu'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {neu_scalar.mean_[0]}, Standard deviation : {np.sqrt(neu_scalar.var_[0])}")


# Now standardize the data with above mean and variance.
X_train_neu = neu_scalar.transform(X_train['neu'].values.reshape(-1,1))
X_cv_neu = neu_scalar.transform(X_cv['neu'].values.reshape(-1,1))
X_test_neu = neu_scalar.transform(X_test['neu'].values.reshape(-1,1))

print("Sentiment score : NEUTRAL are standardized\n")
print(X_train_neu.shape, y_train.shape)
print(X_cv_neu.shape, y_cv.shape)
print(X_test_neu.shape, y_test.shape)
```

```
Mean : 0.6704444829625401, Standard deviation : 0.0754919163744942
Sentiment score : NEUTRAL are standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

8. POSITIVE : pos

In [47]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html

# 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.

pos_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
pos_scalar.fit(X_train['pos'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {pos_scalar.mean_[0]}, Standard deviation : {np.sqrt(pos_scalar.var_[0])}")


# Now standardize the data with above mean and variance.
X_train_pos = pos_scalar.transform(X_train['pos'].values.reshape(-1,1))
X_cv_pos = pos_scalar.transform(X_cv['pos'].values.reshape(-1,1))
X_test_pos = pos_scalar.transform(X_test['pos'].values.reshape(-1,1))

print("Sentiment score : POSITIVE are standardized\n")
print(X_train_pos.shape, y_train.shape)
print(X_cv_pos.shape, y_cv.shape)
print(X_test_pos.shape, y_test.shape)
```

```
Mean : 0.2815242358123127, Standard deviation : 0.07766079306481413
Sentiment score : POSITIVE are standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

9. COMPOUND

In [48]:
```
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.StandardScaler.html

# 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.

compound_scalar = StandardScaler(with_mean = False)

# We will fit the train data only
compound_scalar.fit(X_train['compound'].values.reshape(-1,1)) # finding the mean and standard deviation of this data
print(f"Mean : {compound_scalar.mean_[0]}, Standard deviation : {np.sqrt(compound_scalar.var_[0])}")


# Now standardize the data with above mean and variance.
X_train_compound = compound_scalar.transform(X_train['compound'].values.reshape(-1,1))
X_cv_compound = compound_scalar.transform(X_cv['compound'].values.reshape(-1,1))
X_test_compound = compound_scalar.transform(X_test['compound'].values.reshape(-1,1))

print("Sentiment score : COMPOUND are standardized\n")
print(X_train_compound.shape, y_train.shape)
print(X_cv_compound.shape, y_cv.shape)
print(X_test_compound.shape, y_test.shape)
```

```
Mean : 0.9577791105038848, Standard deviation : 0.15636727471717216
Sentiment score : COMPOUND are standardized

(49039, 1) (49039,)
(24155, 1) (24155,)
(36051, 1) (36051,)
```

5. Make Data Model Ready: encoding eassay, and project_title

BOW

1. clean_essay

In [49]:
```
%%time
# Vectorizing the essay column

from sklearn.feature_extraction.text import CountVectorizer

# We are considering only the words which appeared in at least 10 documents(rows or projects).
# https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.CountVectorizer.html
# Taking top 5000 features

# Creating the vectorizer with bi-grams
vectorizer_bow_essay = CountVectorizer(min_df=10, ngram_range=(2,2), max_features=5000)

# We will fit the train data only
vectorizer_bow_essay.fit(X_train['clean_essays'].values)

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer_bow_essay.transform(X_train['clean_essays'].values)
X_cv_essay_bow = vectorizer_bow_essay.transform(X_cv['clean_essays'].values)
X_test_essay_bow = vectorizer_bow_essay.transform(X_test['clean_essays'].values)

print("Essay vectorized")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
```

```
Essay vectorized
(49039, 5000) (49039,)
(24155, 5000) (24155,)
(36051, 5000) (36051,)
Wall time: 38.4 s
```

Finding the vocabulary

In [50]:
```
# Getting the vocabulary
# https://stackoverflow.com/questions/52141785/sort-dict-by-values-in-python-3-6
vocab = vectorizer_bow_essay.vocabulary_

vocab_sorted = {k: v for k, v in sorted(vocab.items(), key=lambda x: x[1], reverse=True)}

# vocabuaries as per their indexes
vocab_sorted
```

Out[50]:
```
{'younger students': 4999,
 'younger siblings': 4998,
 'young students': 4997,
 'young readers': 4996,
 'young people': 4995,
 'young minds': 4994,
 'young men': 4993,
 'young learners': 4992,
 'young children': 4991,
 'young age': 4990,
 'young adults': 4989,
 'york city': 4988,
 'yoga mats': 4987,
 'yoga balls': 4986,
 'yoga ball': 4985,
 'yet students': 4984,
 'years teaching': 4983,
 'years students': 4982,
 'years school': 4981,
 'years old': 4980
```

2. clean_titles

In [51]:
```
# Vectorizing the project_title column

# We are considering only the words which appeared in at least 10 documents(rows or projects).
# https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.CountVectorizer.html
# Taking top 5000 features

# Creating the vectorizer with bi-grams
vectorizer_bow_title = CountVectorizer(min_df=10, ngram_range=(2,2), max_features=5000)

# We will fit the train data only
vectorizer_bow_title.fit(X_train['clean_titles'].values)

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_bow = vectorizer_bow_title.transform(X_train['clean_titles'].values)
X_cv_titles_bow = vectorizer_bow_title.transform(X_cv['clean_titles'].values)
X_test_titles_bow = vectorizer_bow_title.transform(X_test['clean_titles'].values)

print("Project Titles vectorized")
print(X_train_titles_bow.shape, y_train.shape)
print(X_cv_titles_bow.shape, y_cv.shape)
print(X_test_titles_bow.shape, y_test.shape)
```

```
Project Titles vectorized
(49039, 1691) (49039,)
(24155, 1691) (24155,)
(36051, 1691) (36051,)
```

Finding the vocabulary

In [52]:
```
# Getting the vocabulary
# https://stackoverflow.com/questions/52141785/sort-dict-by-values-in-python-3-6
vocab = vectorizer_bow_title.vocabulary_

vocab_sorted = {k: v for k, v in sorted(vocab.items(), key=lambda x: x[1], reverse=True)}

# vocabuaries as per their indexes
vocab_sorted
```

Out[52]:
```
{'your wiggles': 1690,
 'your way': 1689,
 'your seat': 1688,
 'your own': 1687,
 'your mind': 1686,
 'your help': 1685,
 'your heart': 1684,
 'your garden': 1683,
 'your feet': 1682,
 'your brain': 1681,
 'young scientists': 1680,
 'young readers': 1679,
 'young minds': 1678,
 'young learners': 1677,
 'young authors': 1676,
 'young artists': 1675,
 'you work': 1674,
 'you will': 1673,
 'you see': 1672,
```

TF-IDF

1. clean_essay

In [53]:
```
%%time
# Vectorizing the essay column

from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_selection import SelectKBest, chi2

# Creating the vectorizer with bi-grams
vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)

# We will fit the train data only
vectorizer_tfidf_essay.fit(X_train['clean_essays'].values)

# we use the fitted TfidfVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer_tfidf_essay.transform(X_train['clean_essays'].values)
X_cv_essay_tfidf = vectorizer_tfidf_essay.transform(X_cv['clean_essays'].values)
X_test_essay_tfidf = vectorizer_tfidf_essay.transform(X_test['clean_essays'].values)


print("Essay vectorized")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
```

```
Essay vectorized
(49039, 12036) (49039,)
(24155, 12036) (24155,)
(36051, 12036) (36051,)
Wall time: 23.2 s
```

Finding the vocabulary

In [54]:
```
# Getting the vocabulary
# https://stackoverflow.com/questions/52141785/sort-dict-by-values-in-python-3-6
vocab = vectorizer_tfidf_essay.vocabulary_

vocab_sorted = {k: v for k, v in sorted(vocab.items(), key=lambda x: x[1], reverse=True)}

# vocabuaries as per their indexes
vocab_sorted
```

Out[54]:
```
{'zumba': 12035,
 'zoos': 12034,
 'zooming': 12033,
 'zoom': 12032,
 'zoo': 12031,
 'zones': 12030,
 'zoned': 12029,
 'zone': 12028,
 'zombies': 12027,
 'zippers': 12026,
 'ziplock': 12025,
 'ziploc': 12024,
 'zip': 12023,
 'zest': 12022,
 'zero': 12021,
 'zenergy': 12020,
 'zen': 12019,
 'zearn': 12018,
 'zeal': 12017,
```

2. clean_titles

In [55]:
```
%%time
# Vectorizing the project_title column

from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_selection import SelectKBest, chi2

# Creating the vectorizer with bi-grams
vectorizer_tfidf_titles = TfidfVectorizer(min_df=10)

# We will fit the train data only
vectorizer_tfidf_titles.fit(X_train['clean_titles'].values)

# we use the fitted CountVectorizer to convert the text to vector
X_train_titles_tfidf = vectorizer_tfidf_titles.transform(X_train['clean_titles'].values)
X_cv_titles_tfidf = vectorizer_tfidf_titles.transform(X_cv['clean_titles'].values)
X_test_titles_tfidf = vectorizer_tfidf_titles.transform(X_test['clean_titles'].values)


print("Titles vectorized")
print(X_train_titles_tfidf.shape, y_train.shape)
print(X_cv_titles_tfidf.shape, y_cv.shape)
print(X_test_titles_tfidf.shape, y_test.shape)
```

```
Titles vectorized
(49039, 2085) (49039,)
(24155, 2085) (24155,)
(36051, 2085) (36051,)
Wall time: 1.13 s
```

Finding the most important vocabulary

In [56]:
```
# Getting the vocabulary
# https://stackoverflow.com/questions/52141785/sort-dict-by-values-in-python-3-6
vocab = vectorizer_tfidf_titles.vocabulary_

vocab_sorted = {k: v for k, v in sorted(vocab.items(), key=lambda x: x[1], reverse=True)}

# vocabuaries as per their indexes
vocab_sorted
```

Out[56]:
```
{'zone': 2084,
 'youth': 2083,
 'yourself': 2082,
 'your': 2081,
 'young': 2080,
 'you': 2079,
 'yoga': 2078,
 'yet': 2077,
 'yes': 2076,
 'yearbook': 2075,
 'year': 2074,
 'ye': 2073,
 'writing': 2072,
 'writers': 2071,
 'writer': 2070,
 'write': 2069,
 'wrestling': 2068,
 'wow': 2067,
 'would': 2066,
```

Average W2V

1. clean_essay

In [57]:
```
%%time
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())


# average Word2Vec
# compute average word2vec
train_w2v_vectors_essays = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(X_train['clean_essays'].values): # for each essay in training data
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_w2v_vectors_essays.append(vector)
print("Train  vector")
print(len(train_w2v_vectors_essays))
print(len(train_w2v_vectors_essays[0]))
print('='*120)


# average Word2Vec
# compute average word2vec
test_w2v_vectors_essays = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(X_test['clean_essays'].values): # for each essay in test data
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    test_w2v_vectors_essays.append(vector)

print("Test vec")
print(len(test_w2v_vectors_essays))
print(len(test_w2v_vectors_essays[0]))
print('='*120)


# average Word2Vec
# compute average word2vec
cv_w2v_vectors_essays = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(X_cv['clean_essays'].values): # for each essay in cv data
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the essay
    for word in sentence.split(): # for each word in a essay
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    cv_w2v_vectors_essays.append(vector)

print("CV vec")
print(len(cv_w2v_vectors_essays))
print(len(cv_w2v_vectors_essays[0]))
print('='*120)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 49039/49039 [00:17<00:00, 2789.20it/s]

Train  vector
49039
300
============================================================================================================================
=

100%|████████████████████████████████████████████████████████████████████████████| 36051/36051 [00:12<00:00, 2824.62it/s]

Test vec
36051
300
============================================================================================================================
=

100%|████████████████████████████████████████████████████████████████████████████| 24155/24155 [00:08<00:00, 2791.01it/s]

CV vec
24155
300
```

```
==========================================================================================================
=
Wall time: 40.7 s
```

In [58]:
```
# Changing list to numpy arrays
train_w2v_vectors_essays = np.array(train_w2v_vectors_essays)
test_w2v_vectors_essays = np.array(test_w2v_vectors_essays)
cv_w2v_vectors_essays = np.array(cv_w2v_vectors_essays)

print("Essay vectorized")
print(train_w2v_vectors_essays.shape, y_train.shape)
print(cv_w2v_vectors_essays.shape, y_cv.shape)
print(test_w2v_vectors_essays.shape, y_test.shape)
```

```
Essay vectorized
(49039, 300) (49039,)
(24155, 300) (24155,)
(36051, 300) (36051,)
```

2. clean_titles

In [59]:
```
%%time
# average Word2Vec
# compute average word2vec
train_w2v_vectors_titles = []; # the avg-w2v for each title is stored in this list
for sentence in tqdm(X_train['clean_titles'].values): # for each title in training data
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the title
    for word in sentence.split(): # for each word in a title
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_w2v_vectors_titles.append(vector)
print("Train  vector")
print(len(train_w2v_vectors_titles))
print(len(train_w2v_vectors_titles[0]))
print('='*120)

# average Word2Vec
# compute average word2vec
test_w2v_vectors_titles = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(X_test['clean_titles'].values): # for each essay in test data
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the title
    for word in sentence.split(): # for each word in a title
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    test_w2v_vectors_titles.append(vector)

print("Test vec")
print(len(test_w2v_vectors_titles))
print(len(test_w2v_vectors_titles[0]))
print('='*120)

# average Word2Vec
# compute average word2vec
cv_w2v_vectors_titles = []; # the avg-w2v for each essay is stored in this list
for sentence in tqdm(X_cv['clean_titles'].values): # for each essay in cv data
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the title
    for word in sentence.split(): # for each word in a title
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    cv_w2v_vectors_titles.append(vector)

print("CV vec")
print(len(cv_w2v_vectors_titles))
print(len(cv_w2v_vectors_titles[0]))
print('='*120)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 49039/49039 [00:00<00:00, 50637.34it/s]

Train  vector
49039
300
============================================================================================================================
=

100%|████████████████████████████████████████████████████████████████████████████| 36051/36051 [00:00<00:00, 48455.07it/s]

Test vec
36051
300
============================================================================================================================
=

100%|████████████████████████████████████████████████████████████████████████████| 24155/24155 [00:00<00:00, 52423.24it/s]

CV vec
24155
300
============================================================================================================================
=
Wall time: 2.22 s
```

In [60]:
```
# Changing list to numpy arrays
train_w2v_vectors_titles = np.array(train_w2v_vectors_titles)
test_w2v_vectors_titles = np.array(test_w2v_vectors_titles)
cv_w2v_vectors_titles = np.array(cv_w2v_vectors_titles)

print("Title vectorized")
print(train_w2v_vectors_titles.shape, y_train.shape)
print(cv_w2v_vectors_titles.shape, y_cv.shape)
print(test_w2v_vectors_titles.shape, y_test.shape)
```

```
Title vectorized
(49039, 300) (49039,)
(24155, 300) (24155,)
(36051, 300) (36051,)
```

TF-IDF weighted W2V

1. clean_essay

In [61]:
```
%%time
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())


# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['clean_essays'].values)
# 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())


# average Word2Vec
# compute average word2vec for each review.
train_tfidf_w2v_essays = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_essays'].values): # 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.sp
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each wo
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    train_tfidf_w2v_essays.append(vector)

print("Train matrix:")
print(len(train_tfidf_w2v_essays))
print(len(train_tfidf_w2v_essays[0]))
print('='*120)


cv_tfidf_w2v_essays = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_essays'].values): # 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.sp
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each wo
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    cv_tfidf_w2v_essays.append(vector)

print("CV matrix:")
print(len(cv_tfidf_w2v_essays))
print(len(cv_tfidf_w2v_essays[0]))
print('='*120)


test_tfidf_w2v_essays = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_essays'].values): # 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.sp
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each wo
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    test_tfidf_w2v_essays.append(vector)

print("Test matrix:")
print(len(test_tfidf_w2v_essays))
print(len(test_tfidf_w2v_essays[0]))
print('='*120)
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 49039/49039 [01:55<00:00, 423.57it/s]

Train matrix:
49039
300
============================================================================================================================
=
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 24155/24155 [00:57<00:00, 421.47it/s]

CV matrix:
24155
300
==========================================================================================================================
=

100%|██████████████████████████████████████████████████████████████████████████████| 36051/36051 [01:25<00:00, 423.48it/s]

Test matrix:
36051
300
==========================================================================================================================
=
Wall time: 4min 25s
```

In [62]:
```
# Changing list to numpy arrays
train_tfidf_w2v_essays = np.array(train_tfidf_w2v_essays)
test_tfidf_w2v_essays = np.array(test_tfidf_w2v_essays)
cv_tfidf_w2v_essays = np.array(cv_tfidf_w2v_essays)

print("Essay vectorized")
print(train_tfidf_w2v_essays.shape, y_train.shape)
print(cv_tfidf_w2v_essays.shape, y_cv.shape)
print(test_tfidf_w2v_essays.shape, y_test.shape)
```

```
Essay vectorized
(49039, 300) (49039,)
(24155, 300) (24155,)
(36051, 300) (36051,)
```

2. clean_titles

In [63]:
```
%%time
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['clean_titles'].values)
# 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())


# average Word2Vec
# compute average word2vec for each review.
train_tfidf_w2v_titles = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_titles'].values): # 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.sp
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each wo
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    train_tfidf_w2v_titles.append(vector)

print("Train matrix:")
print(len(train_tfidf_w2v_titles))
print(len(train_tfidf_w2v_titles[0]))
print('='*120)


cv_tfidf_w2v_titles = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_titles'].values): # 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.sp
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each wo
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    cv_tfidf_w2v_titles.append(vector)

print("CV matrix:")
print(len(cv_tfidf_w2v_titles))
print(len(cv_tfidf_w2v_titles[0]))
print('='*120)


test_tfidf_w2v_titles = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_titles'].values): # 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.sp
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each wo
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    test_tfidf_w2v_titles.append(vector)

print("Test matrix:")
print(len(test_tfidf_w2v_titles))
print(len(test_tfidf_w2v_titles[0]))
print('='*120)
```

```
100%|████████████████████████████████████████████████████████████████████████████| 49039/49039 [00:01<00:00, 24636.16it/s]

Train matrix:
49039
300
============================================================================================================================
=

100%|████████████████████████████████████████████████████████████████████████████| 24155/24155 [00:01<00:00, 23870.04it/s]

CV matrix:
24155
300
============================================================================================================================
=
```

```
100%|██████████████████████████████████████████████████████████████████████████| 36051/36051 [00:01<00:00, 25396.40it/s]

Test matrix:
36051
300
==========================================================================================================================
=
Wall time: 4.91 s
```

In [64]:
```
# Changing list to numpy arrays
train_tfidf_w2v_titles = np.array(train_tfidf_w2v_titles)
test_tfidf_w2v_titles = np.array(test_tfidf_w2v_titles)
cv_tfidf_w2v_titles = np.array(cv_tfidf_w2v_titles)

print("Title vectorized")
print(train_tfidf_w2v_titles.shape, y_train.shape)
print(cv_tfidf_w2v_titles.shape, y_cv.shape)
print(test_tfidf_w2v_titles.shape, y_test.shape)
```

```
Title vectorized
(49039, 300) (49039,)
(24155, 300) (24155,)
(36051, 300) (36051,)
```

[Task-1] Appling SVM on different kind of featurization

1. Applying SVM on BOW, SET 1

Merging the categorical, numerical and text features

In [49]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# https://stackoverflow.com/questions/54226138/constructing-sparse-csr-matrix-directly-vs-using-coo-tocsr-scipy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)

from scipy.sparse import hstack

# Training data
X_tr = hstack((X_train_essay_bow, X_train_titles_bow, X_train_clean_category, X_train_clean_subcategories,
               X_train_project_grade, X_train_school_state, X_train_teacher_prefix,
               X_train_previous_projects, X_train_price, X_train_quantity)).tocsr()
# CV data
X_cr = hstack((X_cv_essay_bow, X_cv_titles_bow, X_cv_clean_category, X_cv_clean_subcategories,
               X_cv_project_grade, X_cv_school_state, X_cv_teacher_prefix,
               X_cv_previous_projects, X_cv_price, X_cv_quantity)).tocsr()
# Test data
X_te = hstack((X_test_essay_bow, X_test_titles_bow, X_test_clean_category, X_test_clean_subcategories,
               X_test_project_grade, X_test_school_state, X_test_teacher_prefix,
               X_test_previous_projects, X_test_price, X_test_quantity)).tocsr()
```

In [50]:
```
## Print the final data matrix

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49039, 6770) (49039,)
(24155, 6770) (24155,)
(36051, 6770) (36051,)
```

Dimensions of the hstacked features

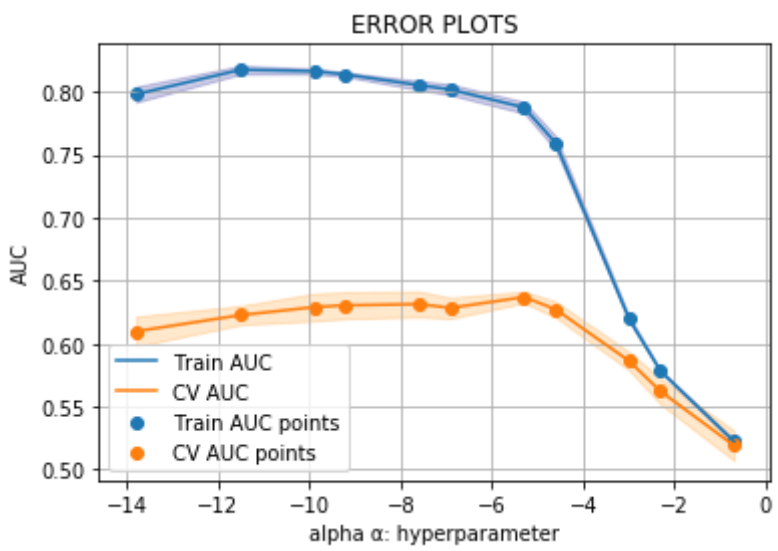
In [51]:
```
print('Training DATA\n')
print('ESSAY : ', X_train_essay_bow.shape)
print('Title : ', X_train_titles_bow.shape)
print('Categorical Data : ', (X_train_clean_category.shape + X_train_clean_subcategories.shape + X_train_project_grade.s
                              X_train_school_state.shape + X_train_teacher_prefix.shape))
print('Numerical Data : ', (X_train_previous_projects.shape + X_train_price.shape + X_train_quantity.shape))

print('\n','='*120)

print('CV DATA\n')
print('ESSAY : ', X_cv_essay_bow.shape)
print('Title : ', X_cv_titles_bow.shape)
print('Categorical Data : ', (X_cv_clean_category.shape + X_cv_clean_subcategories.shape + X_cv_project_grade.shape + \
                              X_cv_school_state.shape + X_cv_teacher_prefix.shape))
print('Numerical Data : ', (X_cv_previous_projects.shape + X_cv_price.shape + X_cv_quantity.shape))

print('\n','='*120)

print('Test DATA\n')
print('ESSAY : ', X_test_essay_bow.shape)
print('Title : ', X_test_titles_bow.shape)
print('Categorical Data : ', (X_test_clean_category.shape + X_test_clean_subcategories.shape + X_test_project_grade.shap
                              X_test_school_state.shape + X_test_teacher_prefix.shape))
print('Numerical Data : ', (X_test_previous_projects.shape + X_test_price.shape + X_test_quantity.shape))

print('\n','='*120)
```

```
Training DATA

ESSAY :  (49039, 5000)
Title :  (49039, 1668)
Categorical Data :  (49039, 9, 49039, 30, 49039, 4, 49039, 51, 49039, 5)
Numerical Data :  (49039, 1, 49039, 1, 49039, 1)

 ========================================================================================================================
==
CV DATA

ESSAY :  (24155, 5000)
Title :  (24155, 1668)
Categorical Data :  (24155, 9, 24155, 30, 24155, 4, 24155, 51, 24155, 5)
Numerical Data :  (24155, 1, 24155, 1, 24155, 1)

 ========================================================================================================================
==
Test DATA

ESSAY :  (36051, 5000)
Title :  (36051, 1668)
Categorical Data :  (36051, 9, 36051, 30, 36051, 4, 36051, 51, 36051, 5)
Numerical Data :  (36051, 1, 36051, 1, 36051, 1)

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

Hyper paramter tuning to find best α (alpha) (Using GridSearchCV)

Using penalty = 'L2'

In [52]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating svm regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l2', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
Wall time: 1min 21s
```

In [53]:
```
clf.best_estimator_
```

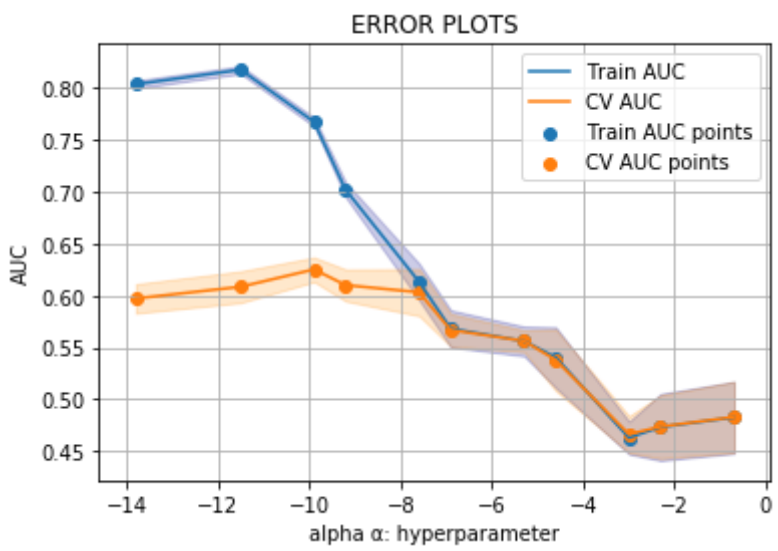
Out[53]:
```
SGDClassifier(alpha=0.005, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

In [54]:
```
clf.best_params_
```

Out[54]:
```
{'alpha': 0.005}
```

Using penalty = 'L1'

In [53]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating svm regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l1', max_iter = 100000, tol = 1e-3)

# Lambda values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
Wall time: 3min 14s
```

In [54]:
```
clf.best_params_
```

Out[54]:
```
{'alpha': 5e-05}
```

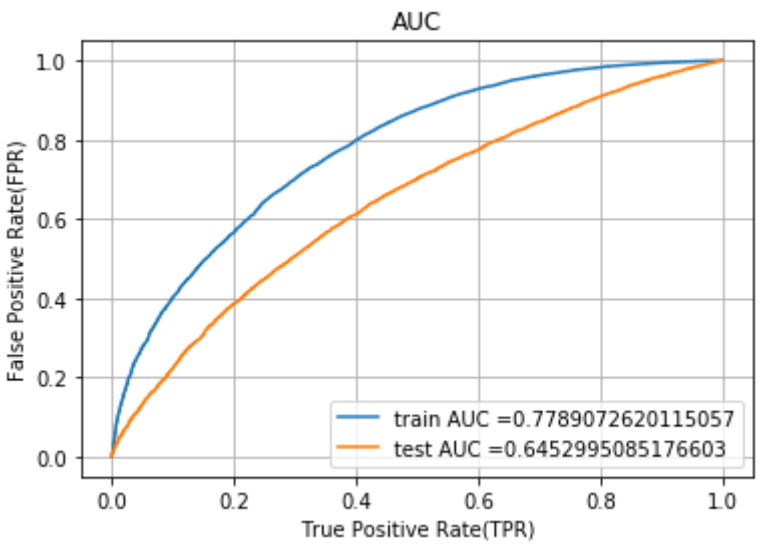
NOTE:

- As we can see that the L2 parameter gives the best results.
- L1 regularization yields a comparitively lower AUC score and the range seems to be more thicker, making it difficult to choose an appropriate value.

Now creating the model with best α and penalty

In [52]:
```
# From the error plot we choose α such that, we will have maximum AUC on cv data and gap between the train and cv is les

# Here we are choosing the best_α based on GridSearchCV results

best_α = 0.005
```

In [53]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

# Creating the classifier with best α
classifier = SGDClassifier(loss = 'hinge', alpha = best_α, penalty='l2', max_iter = 100000, tol = 1e-3)
classifier.fit(X_tr, y_train)

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

# Getting the Predict confidence scores for test and train values
y_train_pred = classifier.decision_function(X_tr)
y_test_pred = classifier.decision_function(X_te)

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

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




```
CPU times: user 604 ms, sys: 4 ms, total: 608 ms
Wall time: 410 ms
```

NOTE:

- As we can see from the graph.The AUC curve is lower for the test set than the train set.
- The AUC scores for the Train and Test data are : 78% and 64% respectively
- We choose the α value equal to 0.005 because it has maximum AUC on the CV data

In [54]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshold, fpr, tpr):

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

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

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

In [55]:
```
%%time
# https://scikit-learn.org/stable/modules/classes.html#module-sklearn.metrics
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = classifier.predict(X_te)
print("Accuracy on test set: {}".format(accuracy_score(y_test, y_pred_new)))
print("Precision on test set: {}".format(precision_score(y_test, y_pred_new)))
print("Recall on test set: {}".format(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: {}".format(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 0.8485756289700702
Precision on test set: 0.8485756289700702
Recall on test set: 1.0
F1-Score on test set: 0.9180859205017782
CPU times: user 36.6 ms, sys: 4 µs, total: 36.6 ms
Wall time: 35 ms
```

In [56]:
```
from sklearn.metrics import confusion_matrix

print("="*120)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*120)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr)))
```

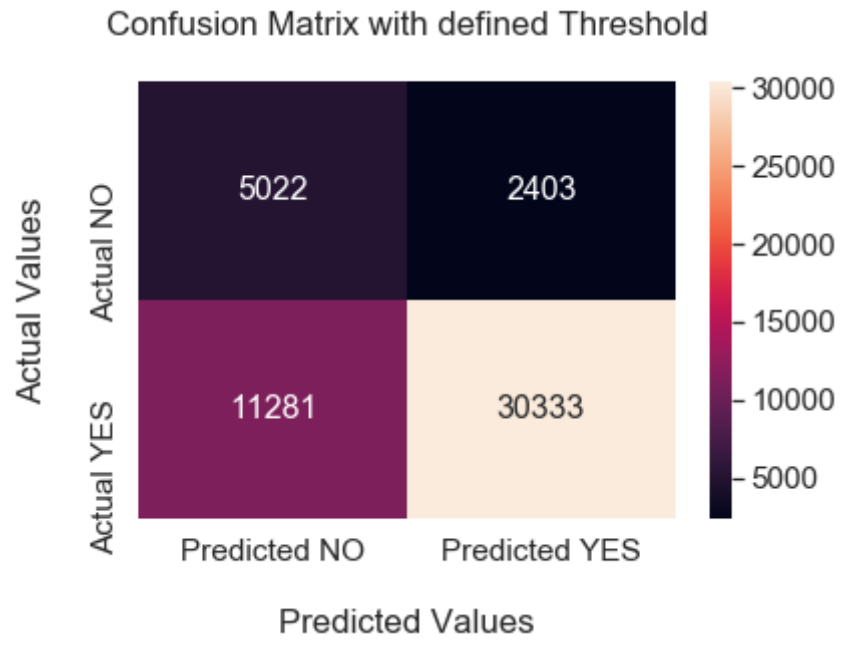
```
========================================================================================================================
=
Train confusion matrix
[[ 5022  2403]
 [11281 30333]]
========================================================================================================================
=
Test confusion matrix
[[ 3345  2114]
 [12150 18442]]
```

Function to create the confusion matrix

In [57]:
```
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

def get_confusion_matrix(y_tr_ts, y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr):

    """Function to get heatmap confusion matrix"""

    # Creating the confusion matrix dataframe
    df_cm = pd.DataFrame(confusion_matrix(y_tr_ts, predict(y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr))
                         , range(2),range(2))

    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})

    plt.title('Confusion Matrix with defined Threshold\n ')

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

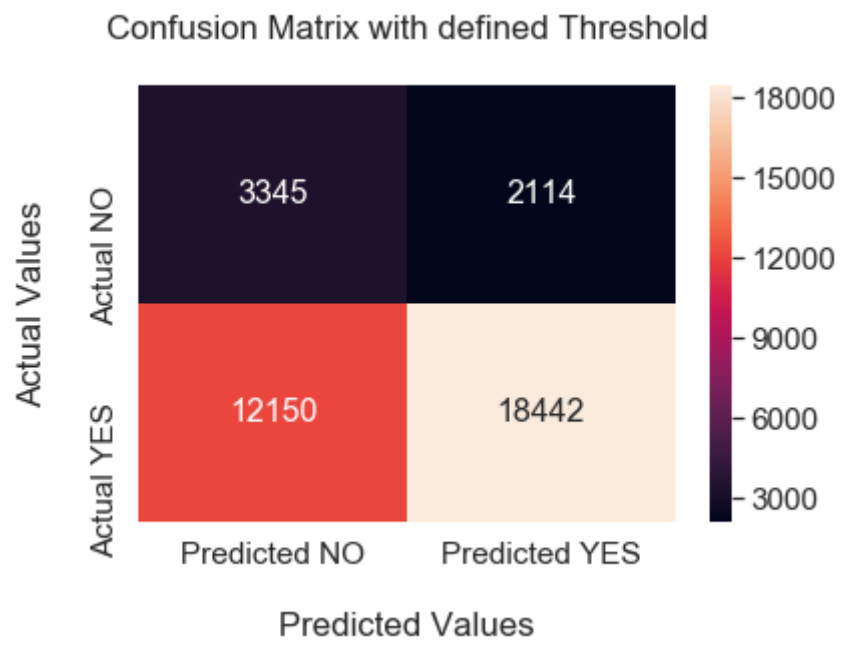
Confusion Matrix on train data

In [59]:
```
get_confusion_matrix(y_train, y_train_pred, tr_thresholds, train_fpr, train_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



Confusion Matrix on test data

In [60]:
```
get_confusion_matrix(y_test, y_test_pred, te_thresholds, test_fpr, test_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



NOTE:

1. The model predicts the test set correctly with a AUC score of 64%
2. The F1 score obtained is 0.9180859205017782
3. The alpha value that we got after GridSearchCV is 0.005

2. Applying SVM on TF-IDF, SET 2

Merging the categorical, numerical and text features

In [53]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# https://stackoverflow.com/questions/54226138/constructing-sparse-csr-matrix-directly-vs-using-coo-tocsr-scipy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)

from scipy.sparse import hstack

# Training data
X_tr = hstack((X_train_essay_tfidf, X_train_titles_tfidf, X_train_clean_category, X_train_clean_subcategories,
               X_train_project_grade, X_train_school_state, X_train_teacher_prefix,
               X_train_previous_projects, X_train_price, X_train_quantity)).tocsr()
# CV data
X_cr = hstack((X_cv_essay_tfidf, X_cv_titles_tfidf, X_cv_clean_category, X_cv_clean_subcategories,
               X_cv_project_grade, X_cv_school_state, X_cv_teacher_prefix,
               X_cv_previous_projects, X_cv_price, X_cv_quantity)).tocsr()
# Test data
X_te = hstack((X_test_essay_tfidf, X_test_titles_tfidf, X_test_clean_category, X_test_clean_subcategories,
               X_test_project_grade, X_test_school_state, X_test_teacher_prefix,
               X_test_previous_projects, X_test_price, X_test_quantity)).tocsr()


## Print the final data matrix

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49039, 14235) (49039,)
(24155, 14235) (24155,)
(36051, 14235) (36051,)
```

Dimensions of the hstacked features

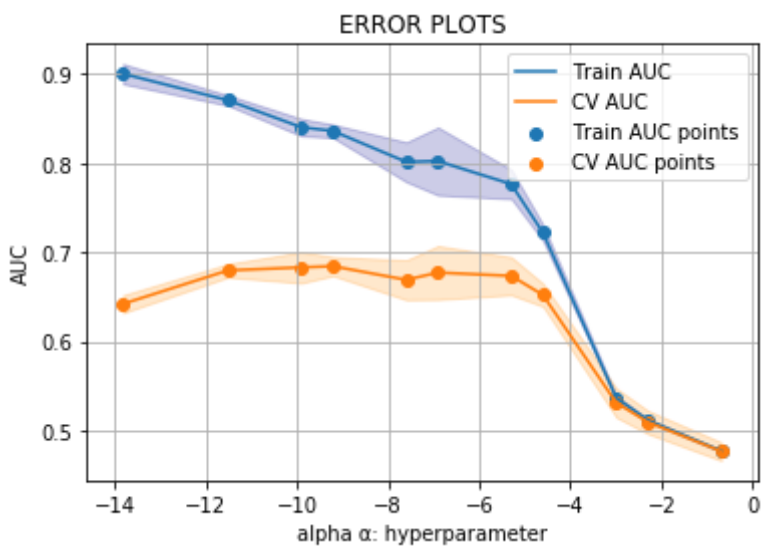
In [54]:
```
print('Training DATA\n')
print('ESSAY : ', X_train_essay_tfidf.shape)
print('Title : ', X_train_titles_tfidf.shape)
print('Categorical Data : ', (X_train_clean_category.shape + X_train_clean_subcategories.shape + X_train_project_grade.s
                              X_train_school_state.shape + X_train_teacher_prefix.shape))
print('Numerical Data : ', (X_train_previous_projects.shape + X_train_price.shape + X_train_quantity.shape))

print('\n','='*120)

print('CV DATA\n')
print('ESSAY : ', X_cv_essay_tfidf.shape)
print('Title : ', X_cv_titles_tfidf.shape)
print('Categorical Data : ', (X_cv_clean_category.shape + X_cv_clean_subcategories.shape + X_cv_project_grade.shape + \
                              X_cv_school_state.shape + X_cv_teacher_prefix.shape))
print('Numerical Data : ', (X_cv_previous_projects.shape + X_cv_price.shape + X_cv_quantity.shape))

print('\n','='*120)

print('Test DATA\n')
print('ESSAY : ', X_test_essay_tfidf.shape)
print('Title : ', X_test_titles_tfidf.shape)
print('Categorical Data : ', (X_test_clean_category.shape + X_test_clean_subcategories.shape + X_test_project_grade.shap
                              X_test_school_state.shape + X_test_teacher_prefix.shape))
print('Numerical Data : ', (X_test_previous_projects.shape + X_test_price.shape + X_test_quantity.shape))

print('\n','='*120)
```

```
Training DATA

ESSAY :  (49039, 12057)
Title :  (49039, 2076)
Categorical Data :  (49039, 9, 49039, 30, 49039, 4, 49039, 51, 49039, 5)
Numerical Data :  (49039, 1, 49039, 1, 49039, 1)

 ============================================================================================================
==
CV DATA

ESSAY :  (24155, 12057)
Title :  (24155, 2076)
Categorical Data :  (24155, 9, 24155, 30, 24155, 4, 24155, 51, 24155, 5)
Numerical Data :  (24155, 1, 24155, 1, 24155, 1)

 ============================================================================================================
==
Test DATA

ESSAY :  (36051, 12057)
Title :  (36051, 2076)
Categorical Data :  (36051, 9, 36051, 30, 36051, 4, 36051, 51, 36051, 5)
Numerical Data :  (36051, 1, 36051, 1, 36051, 1)

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

Hyper paramter tuning to find best α (alpha) (Using GridSearchCV)

Using penalty = 'L2'

In [55]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating SVM regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l2', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 1min 40s, sys: 2.16 s, total: 1min 43s
Wall time: 1min 11s
```

In [56]:
```
clf.best_estimator_
```

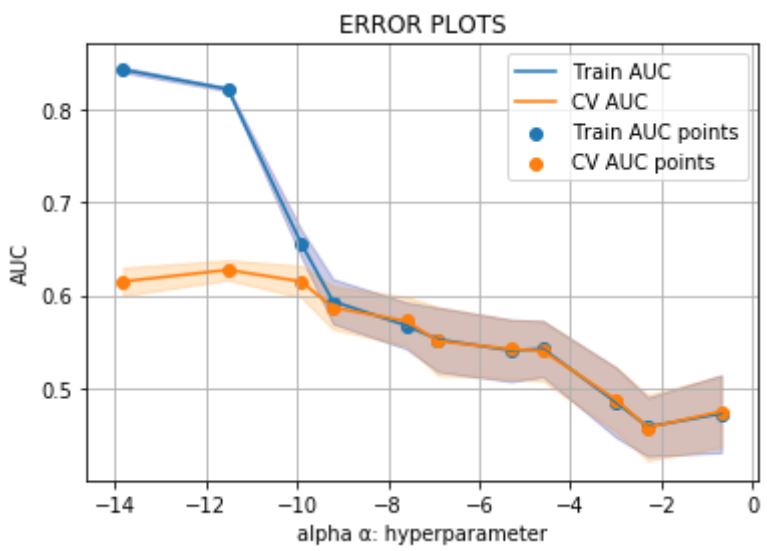
Out[56]:
```
SGDClassifier(alpha=0.0001, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

In [57]:
```
clf.best_params_
```

Out[57]:
```
{'alpha': 0.0001}
```

Using penalty = 'L1'

In [54]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating svm regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l1', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 2min 9s, sys: 498 ms, total: 2min 9s
Wall time: 1min 48s
```

In [55]:
```
clf.best_estimator_
```

Out[55]:
```
SGDClassifier(alpha=1e-05, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l1',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

In [56]:
```
clf.best_params_
```

Out[56]:
```
{'alpha': 1e-05}
```

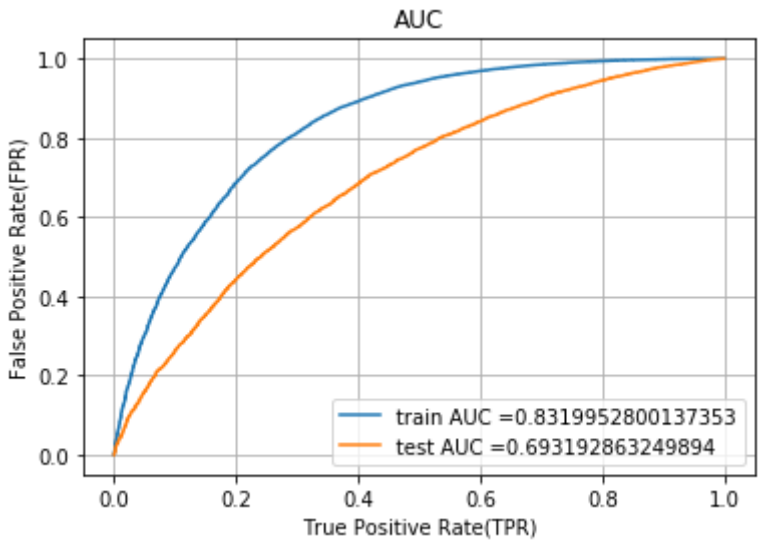
NOTE:

- As we can see that the L2 parameter gives the best results.
- L1 regularization yields a comparitively lower AUC score and the range seems to be more thicker, making it difficult to choose an appropriate value.

Now creating the model with best α and penalty

In [58]:
```
# From the error plot we choose α such that, we will have maximum AUC on cv data and gap between the train and cv is les

# Here we are choosing the best_α based on GridSearchCV results

best_α = 0.0001
```

In [59]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

# Creating the classifier with best α
classifier = SGDClassifier(loss = 'hinge', alpha = best_α, penalty='l2', max_iter = 100000, tol = 1e-3)
classifier.fit(X_tr, y_train)

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

# Getting the Predict confidence scores for test and train values
y_train_pred = classifier.decision_function(X_tr)
y_test_pred = classifier.decision_function(X_te)

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

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




```
CPU times: user 1.08 s, sys: 24 ms, total: 1.11 s
Wall time: 707 ms
```

NOTE:

- As we can see from the graph.The AUC curve is lower for the test set than the train set.
- The AUC scores for the Train and Test data are : 83% and 69% respectively
- We choose the α value equal to 0.0001 because it has maximum AUC on the CV data

In [60]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshold, fpr, tpr):

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

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

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

In [61]:
```
%%time
# https://scikit-learn.org/stable/modules/classes.html#module-sklearn.metrics
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = classifier.predict(X_te)
print("Accuracy on test set: {}".format(accuracy_score(y_test, y_pred_new)))
print("Precision on test set: {}".format(precision_score(y_test, y_pred_new)))
print("Recall on test set: {}".format(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: {}".format(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 0.8485756289700702
Precision on test set: 0.8485756289700702
Recall on test set: 1.0
F1-Score on test set: 0.9180859205017782
CPU times: user 39.2 ms, sys: 0 ns, total: 39.2 ms
Wall time: 38 ms
```

In [62]:
```
from sklearn.metrics import confusion_matrix

print("="*120)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*120)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr)))
```

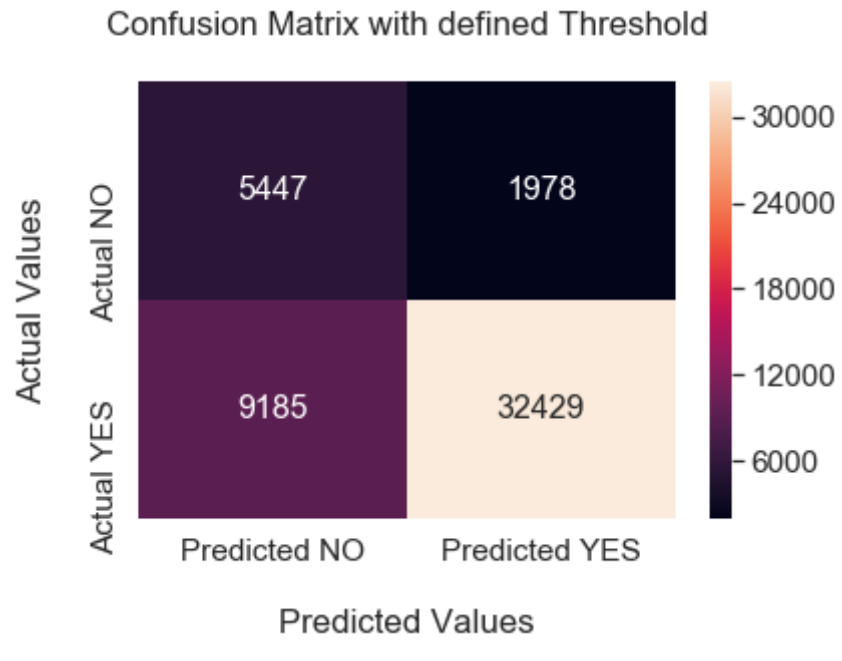
```
========================================================================================================================
=
Train confusion matrix
[[ 5447  1978]
 [ 9185 32429]]
========================================================================================================================
=
Test confusion matrix
[[ 3453  2006]
 [10681 19911]]
```

Function to create the confusion matrix

In [63]:
```
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

def get_confusion_matrix(y_tr_ts, y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr):

    """Function to get heatmap confusion matrix"""

    # Creating the confusion matrix dataframe
    df_cm = pd.DataFrame(confusion_matrix(y_tr_ts, predict(y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr))
                         , range(2),range(2))

    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})

    plt.title('Confusion Matrix with defined Threshold\n ')

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

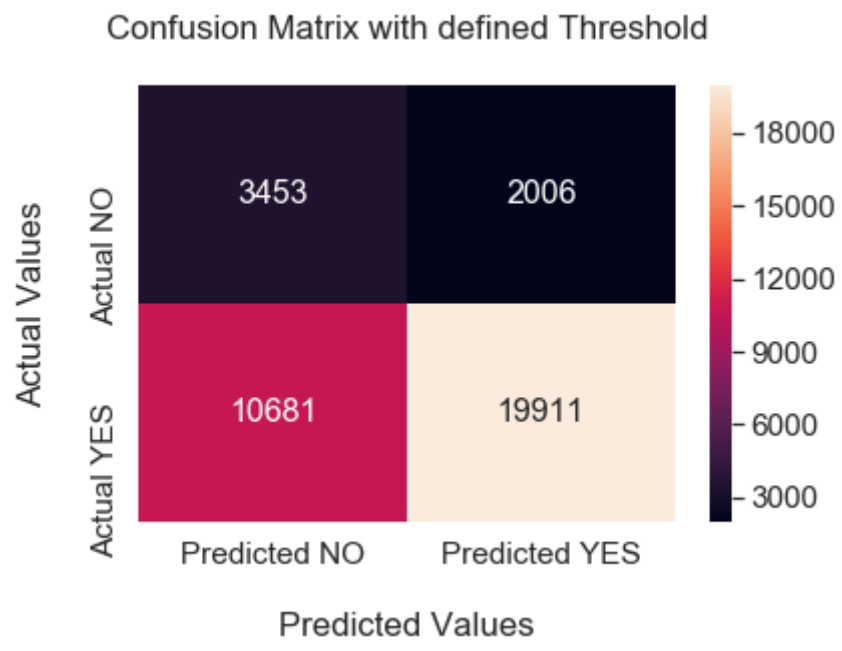
Confusion Matrix on train data

In [65]:
```
get_confusion_matrix(y_train, y_train_pred, tr_thresholds, train_fpr, train_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



Confusion Matrix on test data

In [66]:
```
get_confusion_matrix(y_test, y_test_pred, te_thresholds, test_fpr, test_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



NOTE:

1. The model predicts the test set correctly with a AUC score of 69%
2. The F1 score obtained is 0.9180859205017782
3. The alpha value that we got after GridSearchCV is 0.0001

3. Applying SVM Regression on AVG W2V, SET 3

Merging the categorical, numerical and text features

In [49]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# https://stackoverflow.com/questions/54226138/constructing-sparse-csr-matrix-directly-vs-using-coo-tocsr-scipy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)

from scipy.sparse import hstack

# Training data
X_tr = hstack((train_w2v_vectors_essays, train_w2v_vectors_titles, X_train_clean_category, X_train_clean_subcategories,
               X_train_project_grade, X_train_school_state, X_train_teacher_prefix,
               X_train_previous_projects, X_train_price, X_train_quantity)).tocsr()
# CV data
X_cr = hstack((cv_w2v_vectors_essays, cv_w2v_vectors_titles, X_cv_clean_category, X_cv_clean_subcategories,
               X_cv_project_grade, X_cv_school_state, X_cv_teacher_prefix,
               X_cv_previous_projects, X_cv_price, X_cv_quantity)).tocsr()
# Test data
X_te = hstack((test_w2v_vectors_essays, test_w2v_vectors_titles, X_test_clean_category, X_test_clean_subcategories,
               X_test_project_grade, X_test_school_state, X_test_teacher_prefix,
               X_test_previous_projects, X_test_price, X_test_quantity)).tocsr()


## Print the final data matrix

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49039, 702) (49039,)
(24155, 702) (24155,)
(36051, 702) (36051,)
```

Dimensions of the hstacked features

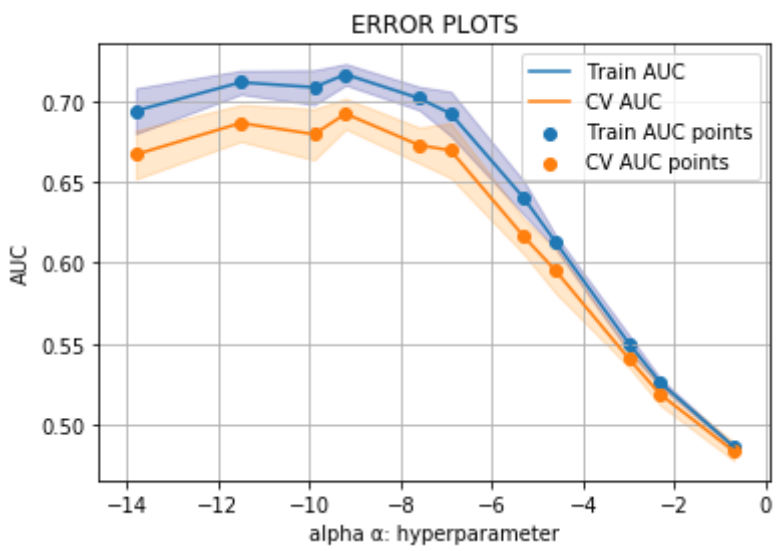
In [50]:
```
print('Training DATA\n')
print('ESSAY : ', train_w2v_vectors_essays.shape)
print('Title : ', train_w2v_vectors_titles.shape)
print('Categorical Data : ', (X_train_clean_category.shape + X_train_clean_subcategories.shape + X_train_project_grade.s
                              X_train_school_state.shape + X_train_teacher_prefix.shape))
print('Numerical Data : ', (X_train_previous_projects.shape + X_train_price.shape + X_train_quantity.shape))

print('\n','='*120)

print('CV DATA\n')
print('ESSAY : ', cv_w2v_vectors_essays.shape)
print('Title : ', cv_w2v_vectors_titles.shape)
print('Categorical Data : ', (X_cv_clean_category.shape + X_cv_clean_subcategories.shape + X_cv_project_grade.shape + \
                              X_cv_school_state.shape + X_cv_teacher_prefix.shape))
print('Numerical Data : ', (X_cv_previous_projects.shape + X_cv_price.shape + X_cv_quantity.shape))

print('\n','='*120)

print('Test DATA\n')
print('ESSAY : ', test_w2v_vectors_essays.shape)
print('Title : ', test_w2v_vectors_titles.shape)
print('Categorical Data : ', (X_test_clean_category.shape + X_test_clean_subcategories.shape + X_test_project_grade.shap
                              X_test_school_state.shape + X_test_teacher_prefix.shape))
print('Numerical Data : ', (X_test_previous_projects.shape + X_test_price.shape + X_test_quantity.shape))

print('\n','='*120)
```

```
Training DATA

ESSAY :  (49039, 300)
Title :  (49039, 300)
Categorical Data :  (49039, 9, 49039, 30, 49039, 4, 49039, 51, 49039, 5)
Numerical Data :  (49039, 1, 49039, 1, 49039, 1)

 ========================================================================================================================
==
CV DATA

ESSAY :  (24155, 300)
Title :  (24155, 300)
Categorical Data :  (24155, 9, 24155, 30, 24155, 4, 24155, 51, 24155, 5)
Numerical Data :  (24155, 1, 24155, 1, 24155, 1)

 ========================================================================================================================
==
Test DATA

ESSAY :  (36051, 300)
Title :  (36051, 300)
Categorical Data :  (36051, 9, 36051, 30, 36051, 4, 36051, 51, 36051, 5)
Numerical Data :  (36051, 1, 36051, 1, 36051, 1)

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

Hyper paramter tuning to find best α (alpha) (Using GridSearchCV)

Using penalty = 'L2'

In [51]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating SVM regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l2', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 7min 57s, sys: 10.3 s, total: 8min 8s
Wall time: 8min 8s
```

In [52]:
```
clf.best_estimator_
```

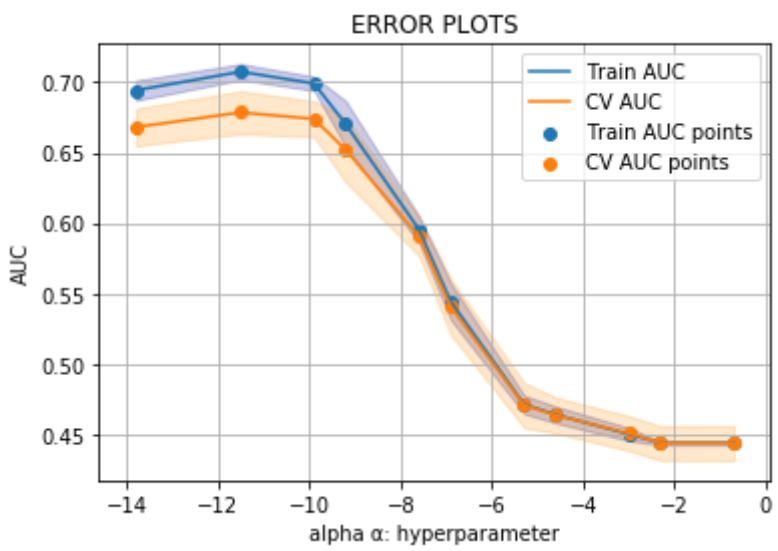
Out[52]:
```
SGDClassifier(alpha=0.0001, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

In [53]:
```
clf.best_params_
```

Out[53]:
```
{'alpha': 0.0001}
```

Using penalty = 'L1'

In [51]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating SVM regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l1', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 10min 40s, sys: 9.93 s, total: 10min 50s
Wall time: 10min 50s
```

In [52]:
```
clf.best_params_
```

Out[52]:
```
{'alpha': 1e-05}
```

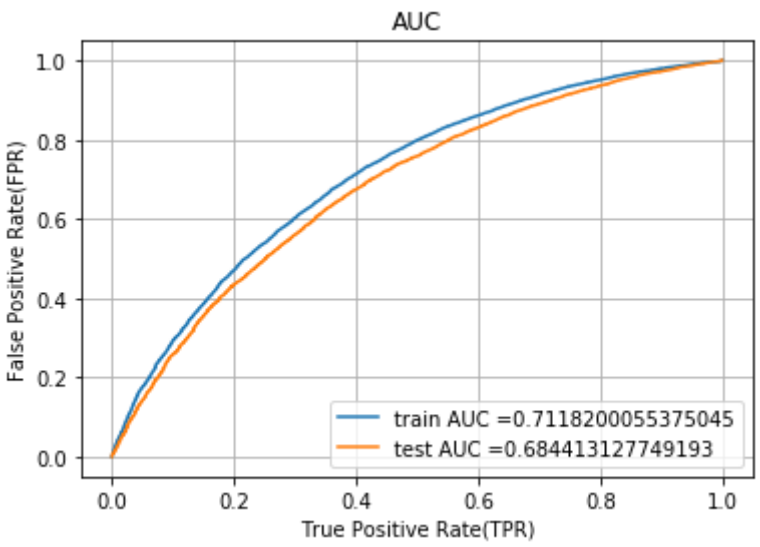
NOTE:

- As we can see that the L2 parameter gives the best results.
- L1 regularization yields a comparitively lower AUC score and the range seems to be more thicker, making it difficult to choose an appropriate value.

Now creating the model with best α and penalty

In [62]:
```
# From the error plot we choose α such that, we will have maximum AUC on cv data and gap between the train and cv is les

# Here we are choosing the best_α based on GridSearchCV results

best_α = 0.0001
```

In [65]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

# Creating the classifier with best α
classifier = SGDClassifier(loss = 'hinge', alpha = best_α, penalty='l2', max_iter = 100000, tol = 1e-3)
classifier.fit(X_tr, y_train)

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

# Getting the Predict confidence scores for test and train values
y_train_pred = classifier.decision_function(X_tr)
y_test_pred = classifier.decision_function(X_te)

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

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




```
CPU times: user 4.33 s, sys: 3.65 ms, total: 4.34 s
Wall time: 4.34 s
```

NOTE:

- As we can see from the graph.The AUC curve is lower for the test set than the train set.
- The AUC scores for the Train and Test data are : 71% and 68% respectively
- We choose the α value equal to 0.0001 because it has maximum AUC on the CV data

In [66]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshold, fpr, tpr):

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

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

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

In [67]:
```
%%time
# https://scikit-learn.org/stable/modules/classes.html#module-sklearn.metrics
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = classifier.predict(X_te)
print("Accuracy on test set: {}".format(accuracy_score(y_test, y_pred_new)))
print("Precision on test set: {}".format(precision_score(y_test, y_pred_new)))
print("Recall on test set: {}".format(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: {}".format(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 0.8484369365620926
Precision on test set: 0.8486126526082131
Recall on test set: 0.9997384937238494
F1-Score on test set: 0.9179973586264857
CPU times: user 78.4 ms, sys: 48 µs, total: 78.5 ms
Wall time: 76.9 ms
```

In [68]:
```
from sklearn.metrics import confusion_matrix

print("="*120)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*120)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr)))
```

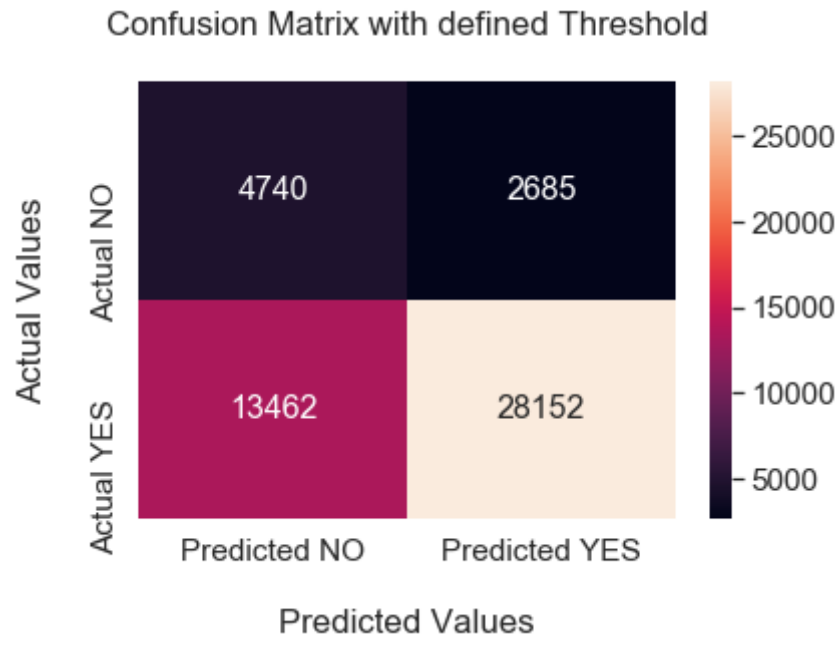
```
========================================================================================================================
=
Train confusion matrix
[[ 4740  2685]
 [13462 28152]]
========================================================================================================================
=
Test confusion matrix
[[ 3447  2012]
 [10878 19714]]
```

Function to create the confusion matrix

In [69]:
```
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

def get_confusion_matrix(y_tr_ts, y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr):

    """Function to get heatmap confusion matrix"""

    # Creating the confusion matrix dataframe
    df_cm = pd.DataFrame(confusion_matrix(y_tr_ts, predict(y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr))
                         , range(2),range(2))

    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})

    plt.title('Confusion Matrix with defined Threshold\n ')

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

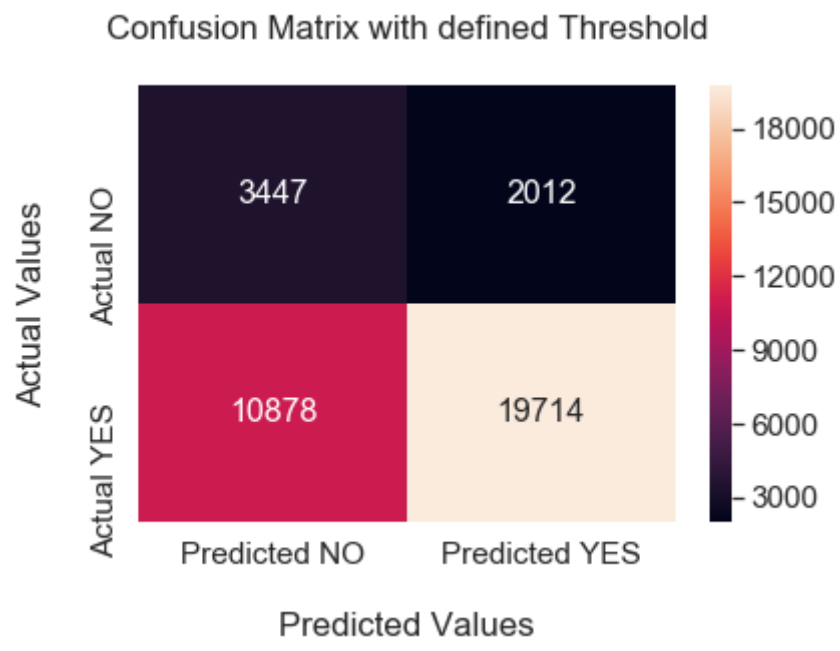
Confusion Matrix on train data

In [71]:
```
get_confusion_matrix(y_train, y_train_pred, tr_thresholds, train_fpr, train_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



Confusion Matrix on test data

In [72]:
```
get_confusion_matrix(y_test, y_test_pred, te_thresholds, test_fpr, test_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



NOTE:

1. The model predicts the test set correctly with a AUC score of 70%
2. The F1 score obtained is 0.9170699149007174
3. The alpha value that we got after GridSearchCV is 0.0001

4. Applying SVM Regression on TFIDF W2V, SET 4

Merging the categorical, numerical and text features

In [49]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# https://stackoverflow.com/questions/54226138/constructing-sparse-csr-matrix-directly-vs-using-coo-tocsr-scipy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)

from scipy.sparse import hstack

# Training data
X_tr = hstack((train_tfidf_w2v_essays, train_tfidf_w2v_titles, X_train_clean_category, X_train_clean_subcategories,
               X_train_project_grade, X_train_school_state, X_train_teacher_prefix,
               X_train_previous_projects, X_train_price, X_train_quantity)).tocsr()
# CV data
X_cr = hstack((cv_tfidf_w2v_essays, cv_tfidf_w2v_titles, X_cv_clean_category, X_cv_clean_subcategories,
               X_cv_project_grade, X_cv_school_state, X_cv_teacher_prefix,
               X_cv_previous_projects, X_cv_price, X_cv_quantity)).tocsr()
# Test data
X_te = hstack((test_tfidf_w2v_essays, test_tfidf_w2v_titles, X_test_clean_category, X_test_clean_subcategories,
               X_test_project_grade, X_test_school_state, X_test_teacher_prefix,
               X_test_previous_projects, X_test_price, X_test_quantity)).tocsr()


## Print the final data matrix

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49039, 702) (49039,)
(24155, 702) (24155,)
(36051, 702) (36051,)
```

Dimensions of the hstacked features

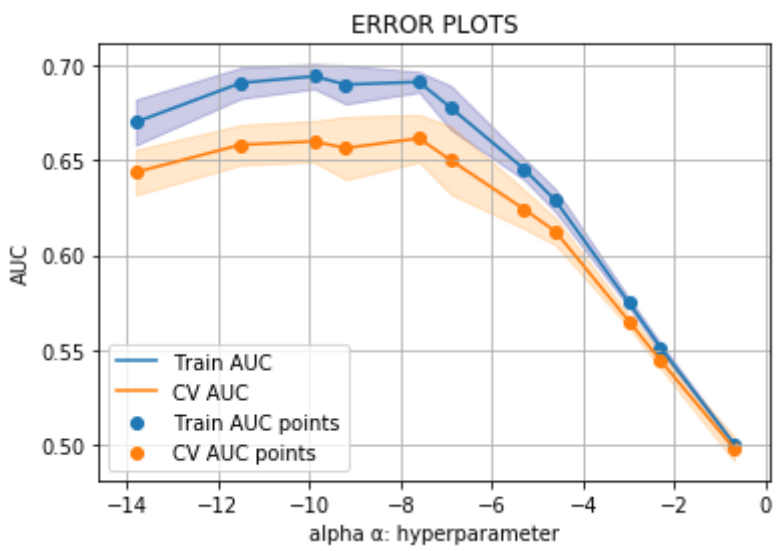
In [50]:
```
print('Training DATA\n')
print('ESSAY : ', train_tfidf_w2v_essays.shape)
print('Title : ', train_tfidf_w2v_titles.shape)
print('Categorical Data : ', (X_train_clean_category.shape + X_train_clean_subcategories.shape + X_train_project_grade.s
                              X_train_school_state.shape + X_train_teacher_prefix.shape))
print('Numerical Data : ', (X_train_previous_projects.shape + X_train_price.shape + X_train_quantity.shape))

print('\n','='*120)

print('CV DATA\n')
print('ESSAY : ', cv_tfidf_w2v_essays.shape)
print('Title : ', cv_tfidf_w2v_titles.shape)
print('Categorical Data : ', (X_cv_clean_category.shape + X_cv_clean_subcategories.shape + X_cv_project_grade.shape + \
                              X_cv_school_state.shape + X_cv_teacher_prefix.shape))
print('Numerical Data : ', (X_cv_previous_projects.shape + X_cv_price.shape + X_cv_quantity.shape))

print('\n','='*120)

print('Test DATA\n')
print('ESSAY : ', test_tfidf_w2v_essays.shape)
print('Title : ', test_tfidf_w2v_titles.shape)
print('Categorical Data : ', (X_test_clean_category.shape + X_test_clean_subcategories.shape + X_test_project_grade.shap
                              X_test_school_state.shape + X_test_teacher_prefix.shape))
print('Numerical Data : ', (X_test_previous_projects.shape + X_test_price.shape + X_test_quantity.shape))

print('\n','='*120)
```

```
Training DATA

ESSAY :  (49039, 300)
Title :  (49039, 300)
Categorical Data :  (49039, 9, 49039, 30, 49039, 4, 49039, 51, 49039, 5)
Numerical Data :  (49039, 1, 49039, 1, 49039, 1)

 ========================================================================================================================
==
CV DATA

ESSAY :  (24155, 300)
Title :  (24155, 300)
Categorical Data :  (24155, 9, 24155, 30, 24155, 4, 24155, 51, 24155, 5)
Numerical Data :  (24155, 1, 24155, 1, 24155, 1)

 ========================================================================================================================
==
Test DATA

ESSAY :  (36051, 300)
Title :  (36051, 300)
Categorical Data :  (36051, 9, 36051, 30, 36051, 4, 36051, 51, 36051, 5)
Numerical Data :  (36051, 1, 36051, 1, 36051, 1)

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

Hyper paramter tuning to find best α (alpha) (Using GridSearchCV)

Using penalty = 'L2'

In [52]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating SVM regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l2', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 8min 22s, sys: 11.2 s, total: 8min 33s
Wall time: 8min 34s
```

In [53]:
```
clf.best_estimator_
```

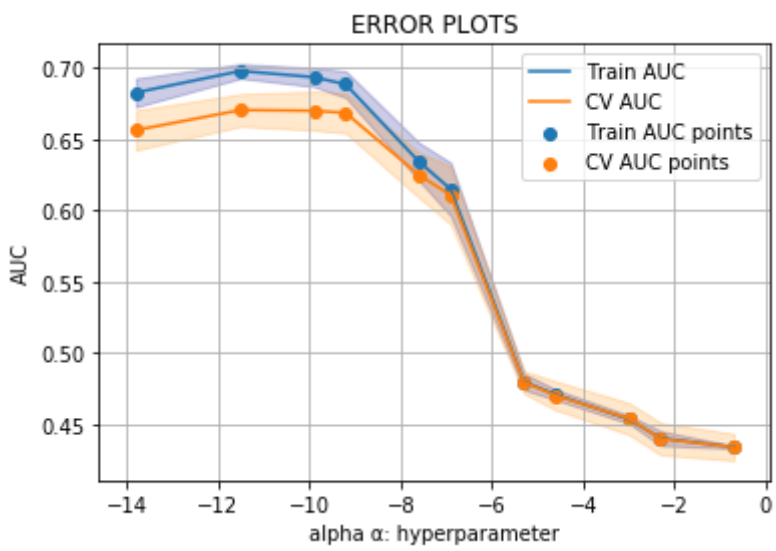
Out[53]:
```
SGDClassifier(alpha=0.0005, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

In [54]:
```
clf.best_params_
```

Out[54]:
```
{'alpha': 0.0005}
```

Using penalty = 'L1'

In [51]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating SVM regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l1', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 10min 35s, sys: 10 s, total: 10min 45s
Wall time: 10min 46s
```

In [52]:
```
clf.best_estimator_
```

Out[52]:
```
SGDClassifier(alpha=1e-05, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l1',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

In [53]:
```
clf.best_params_
```

Out[53]:
```
{'alpha': 1e-05}
```

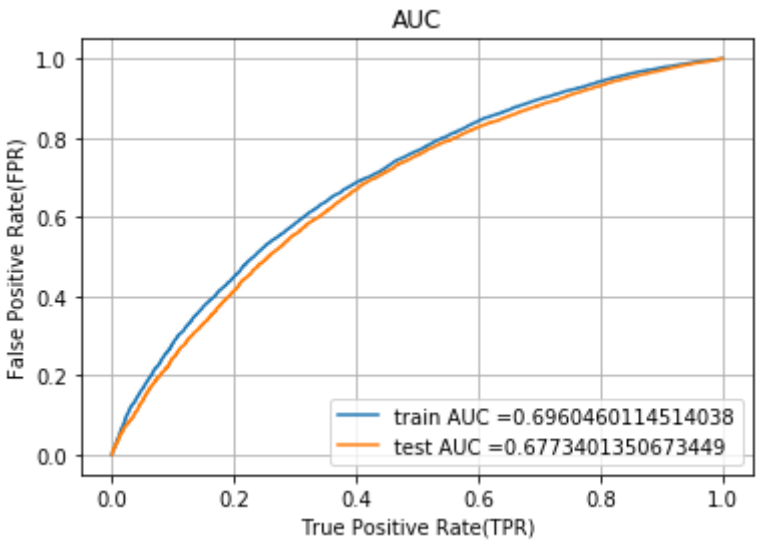
NOTE:

- As we can see that the L2 parameter gives the best results.
- L1 regularization yields a comparitively lower AUC score and the range seems to be more thicker, making it difficult to choose an appropriate value.

Now creating the model with best α and penalty

In [59]:
```
# From the error plot we choose α such that, we will have maximum AUC on cv data and gap between the train and cv is les

# Here we are choosing the best_α based on GridSearchCV results

best_α = 0.0005
```

In [62]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

# Creating the classifier with best α
classifier = SGDClassifier(loss = 'hinge', alpha = best_α, penalty='l2', max_iter = 100000, tol = 1e-3)
classifier.fit(X_tr, y_train)

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

# Getting the Predict confidence scores for test and train values
y_train_pred = classifier.decision_function(X_tr)
y_test_pred = classifier.decision_function(X_te)

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

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




```
CPU times: user 2.15 s, sys: 0 ns, total: 2.15 s
Wall time: 2.15 s
```

NOTE:

- As we can see from the graph.The AUC curve is lower for the test set than the train set.
- The AUC scores for the Train and Test data are : 69% and 67% respectively
- We choose the α value equal to 0.0005 because it has maximum AUC on the CV data

In [63]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshold, fpr, tpr):

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

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

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

In [64]:
```
%%time
# https://scikit-learn.org/stable/modules/classes.html#module-sklearn.metrics
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = classifier.predict(X_te)
print("Accuracy on test set: {}".format(accuracy_score(y_test, y_pred_new)))
print("Precision on test set: {}".format(precision_score(y_test, y_pred_new)))
print("Recall on test set: {}".format(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: {}".format(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 0.8485756289700702
Precision on test set: 0.8485756289700702
Recall on test set: 1.0
F1-Score on test set: 0.9180859205017782
CPU times: user 91.5 ms, sys: 3.92 ms, total: 95.4 ms
Wall time: 93.6 ms
```

In [65]:
```
from sklearn.metrics import confusion_matrix

print("="*120)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*120)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr)))
```

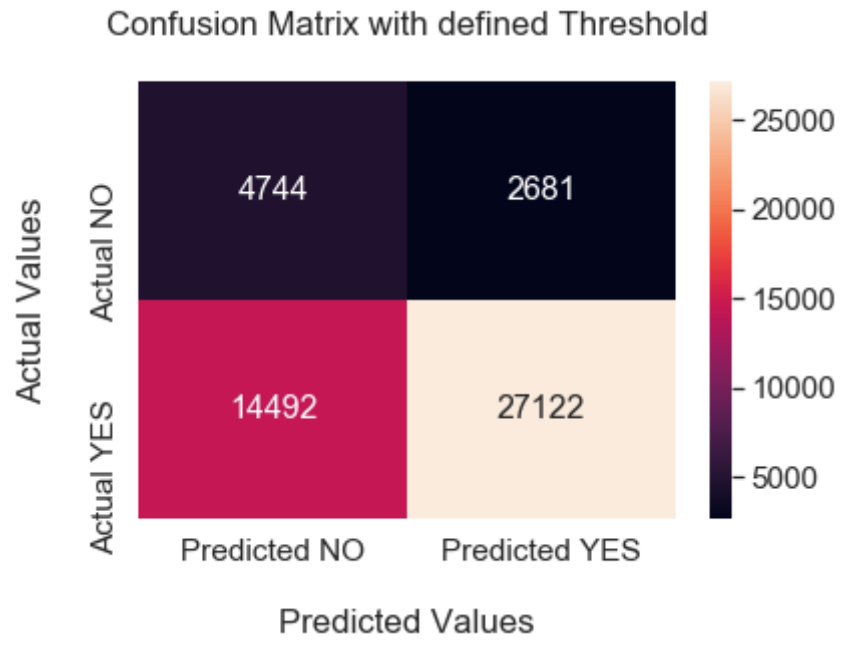
```
========================================================================================================================
=
Train confusion matrix
[[ 4744  2681]
 [14492 27122]]
========================================================================================================================
=
Test confusion matrix
[[ 3321  2138]
 [10343 20249]]
```

Function to create the confusion matrix

In [66]:
```
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

def get_confusion_matrix(y_tr_ts, y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr):

    """Function to get heatmap confusion matrix"""

    # Creating the confusion matrix dataframe
    df_cm = pd.DataFrame(confusion_matrix(y_tr_ts, predict(y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr))
                         , range(2),range(2))

    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})

    plt.title('Confusion Matrix with defined Threshold\n ')

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

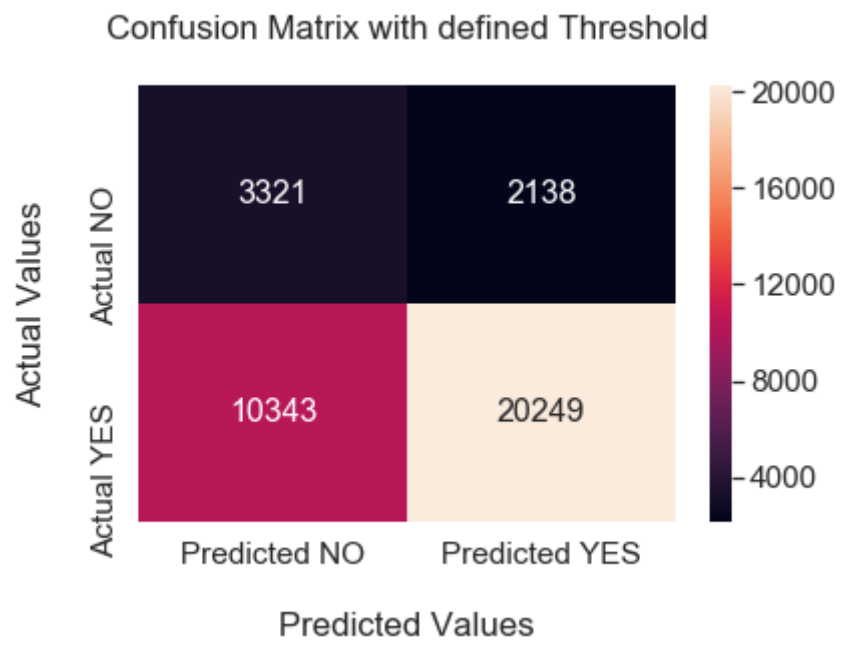
Confusion Matrix on train data

In [68]:
```
get_confusion_matrix(y_train, y_train_pred, tr_thresholds, train_fpr, train_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



Confusion Matrix on test data

In [69]:
```
get_confusion_matrix(y_test, y_test_pred, te_thresholds, test_fpr, test_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



NOTE:

1. The model predicts the test set correctly with a AUC score of 67%
2. The F1 score obtained is 0.9180859205017782
3. The alpha value that we got after GridSearchCV is 0.0005

[Task-2] Apply SVM on the below feature set 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

Applying TruncatedSVD on TfidfVectorizer - `Essay_text`

In [46]:
```
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
```

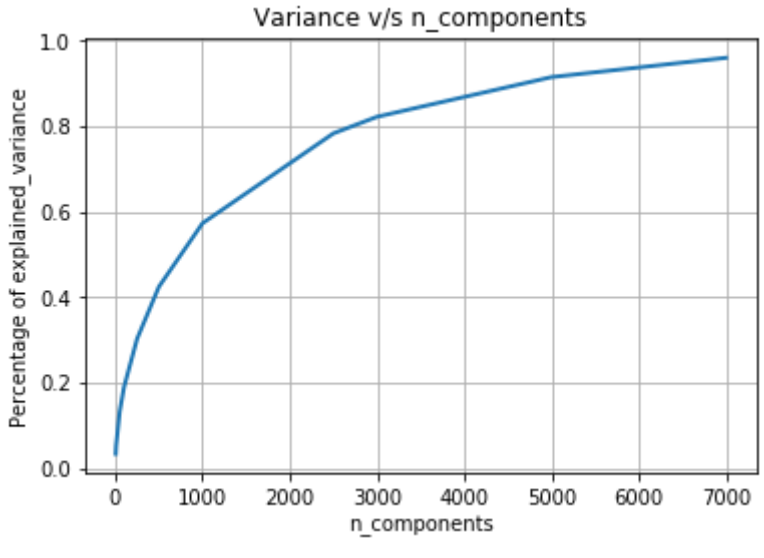
```
(49039, 12036) (49039,)
(24155, 12036) (24155,)
(36051, 12036) (36051,)
```

NOTE:

- Applying TruncatedSVD on the above features
- Using elbow method to determine the best features

In [49]:
```
from sklearn.decomposition import TruncatedSVD

_range = [5,10,50,100,250,500,1000,2500,3000,5000,7000]
cum_var_explained = []

for i in tqdm(_range):
    svd = TruncatedSVD(n_components = i)
    svd.fit(X_train_essay_tfidf)
    cum_var_explained.append(svd.explained_variance_ratio_.sum())


plt.plot(_range, cum_var_explained, linewidth=2)
plt.grid()
plt.title('Variance v/s n_components')
plt.xlabel('n_components')
plt.ylabel('Percentage of explained_variance')
plt.show()
```

```
100%|██████████| 11/11 [43:27<00:00, 589.55s/it]
```



NOTE:

- The variance explained by 6000 features is more than 95%.
- We will take n_components as 3000 because 80% of the variance is explained by it.

If we take n_components as 6000, the memory required is more than 16G. So to avoid any memory shortage I am taking 3000 features.

TF-IDF - text_essay

In [47]:
```
%%time
# Vectorizing the essay column
from sklearn.decomposition import TruncatedSVD

# Creating the vectorizer with bi-grams
svd = TruncatedSVD(n_components = 3000)

# We will fit the train data only
svd.fit(X_train_essay_tfidf)

# we use the fitted TfidfVectorizer to convert the text to vector
X_train_essay_svd = svd.transform(X_train_essay_tfidf)
X_cv_essay_svd = svd.transform(X_cv_essay_tfidf)
X_test_essay_svd = svd.transform(X_test_essay_tfidf)


print("Essay vectorized")
print(X_train_essay_svd.shape, y_train.shape)
print(X_cv_essay_svd.shape, y_cv.shape)
print(X_test_essay_svd.shape, y_test.shape)
```

```
Essay vectorized
(49039, 3000) (49039,)
(24155, 3000) (24155,)
(36051, 3000) (36051,)
CPU times: user 6min 58s, sys: 21.6 s, total: 7min 20s
Wall time: 5min 28s
```

In [48]:
```
del project_data, X, y
```

Merging the categorical, numerical and text features

In [49]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
# https://stackoverflow.com/questions/54226138/constructing-sparse-csr-matrix-directly-vs-using-coo-tocsr-scipy
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)

from scipy.sparse import hstack

# Training data
X_tr = hstack((X_train_essay_svd, X_train_words_in_essay, X_train_words_in_title, X_train_clean_category, X_train_clean_
               X_train_project_grade, X_train_school_state, X_train_teacher_prefix,
               X_train_neg, X_train_pos, X_train_neu, X_train_compound,
               X_train_previous_projects, X_train_price, X_train_quantity)).tocsr()
# CV data
X_cr = hstack((X_cv_essay_svd, X_cv_words_in_essay, X_cv_words_in_title, X_cv_clean_category, X_cv_clean_subcategories,
               X_cv_project_grade, X_cv_school_state, X_cv_teacher_prefix,
               X_cv_neg, X_cv_pos, X_cv_neu, X_cv_compound,
               X_cv_previous_projects, X_cv_price, X_cv_quantity)).tocsr()
# Test data
X_te = hstack((X_test_essay_svd, X_test_words_in_essay, X_test_words_in_title, X_test_clean_category, X_test_clean_subca
               X_test_project_grade, X_test_school_state, X_test_teacher_prefix,
               X_test_neg, X_test_pos, X_test_neu, X_test_compound,
               X_test_previous_projects, X_test_price, X_test_quantity)).tocsr()


## Print the final data matrix

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49039, 3108) (49039,)
(24155, 3108) (24155,)
(36051, 3108) (36051,)
```

Dimensions of the hstacked features

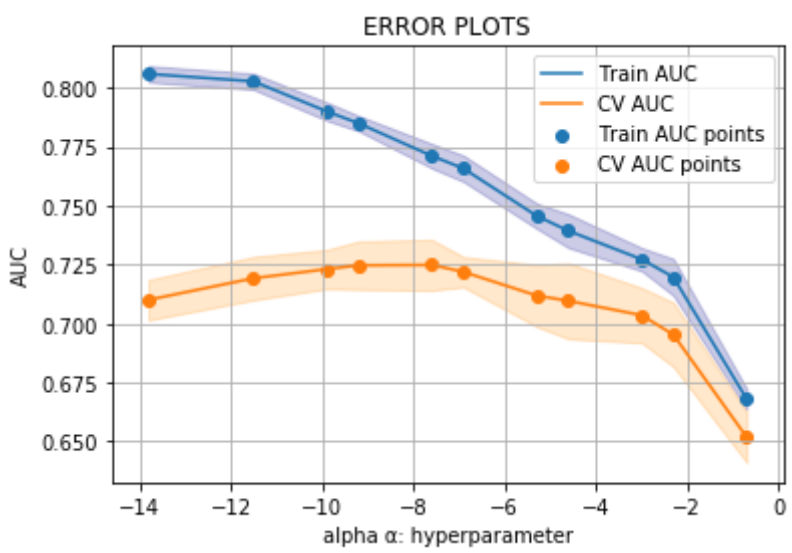
In [50]:
```
print('Training DATA\n')
print('ESSAY (n_components) : ', X_train_essay_svd.shape)
print('ESSAY : ', X_train_words_in_essay.shape)
print('Title : ', X_train_words_in_title.shape)
print('Categorical Data : ', (X_train_clean_category.shape + X_train_clean_subcategories.shape + X_train_project_grade.s
                              X_train_school_state.shape + X_train_teacher_prefix.shape))
print('Numerical Data : ', (X_train_previous_projects.shape + X_train_price.shape + X_train_quantity.shape +\
                            X_train_pos.shape + X_train_neg.shape + X_train_neu.shape + X_train_compound.shape))

print('\n','='*120)

print('CV DATA\n')
print('ESSAY (n_components) : ', X_cv_essay_svd.shape)
print('ESSAY : ', X_cv_words_in_essay.shape)
print('Title : ', X_cv_words_in_title.shape)
print('Categorical Data : ', (X_cv_clean_category.shape + X_cv_clean_subcategories.shape + X_cv_project_grade.shape + \
                              X_cv_school_state.shape + X_cv_teacher_prefix.shape))
print('Numerical Data : ', (X_cv_previous_projects.shape + X_cv_price.shape + X_cv_quantity.shape +\
                            X_cv_pos.shape + X_cv_neg.shape + X_cv_neu.shape + X_cv_compound.shape))

print('\n','='*120)

print('Test DATA\n')
print('ESSAY (n_components) : ', X_test_essay_svd.shape)
print('ESSAY : ', X_test_words_in_essay.shape)
print('Title : ', X_test_words_in_title.shape)
print('Categorical Data : ', (X_test_clean_category.shape + X_test_clean_subcategories.shape + X_test_project_grade.shap
                              X_test_school_state.shape + X_test_teacher_prefix.shape))
print('Numerical Data : ', (X_test_previous_projects.shape + X_test_price.shape + X_test_quantity.shape +\
                            X_test_pos.shape + X_test_neg.shape + X_test_neu.shape + X_test_compound.shape))

print('\n','='*120)
```

```
Training DATA

ESSAY (n_components) :  (49039, 3000)
ESSAY :  (49039, 1)
Title :  (49039, 1)
Categorical Data :  (49039, 9, 49039, 30, 49039, 4, 49039, 51, 49039, 5)
Numerical Data :  (49039, 1, 49039, 1, 49039, 1, 49039, 1, 49039, 1, 49039, 1, 49039, 1)

 ============================================================================================================================
==
CV DATA

ESSAY (n_components) :  (24155, 3000)
ESSAY :  (24155, 1)
Title :  (24155, 1)
Categorical Data :  (24155, 9, 24155, 30, 24155, 4, 24155, 51, 24155, 5)
Numerical Data :  (24155, 1, 24155, 1, 24155, 1, 24155, 1, 24155, 1, 24155, 1, 24155, 1)

 ============================================================================================================================
==
Test DATA

ESSAY (n_components) :  (36051, 3000)
ESSAY :  (36051, 1)
Title :  (36051, 1)
Categorical Data :  (36051, 9, 36051, 30, 36051, 4, 36051, 51, 36051, 5)
Numerical Data :  (36051, 1, 36051, 1, 36051, 1, 36051, 1, 36051, 1, 36051, 1, 36051, 1)

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

Hyper paramter tuning to find best α (alpha) (Using GridSearchCV)

Using penalty = 'L2'

In [53]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating SVM regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l2', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 39min 16s, sys: 54.1 s, total: 40min 10s
Wall time: 40min 10s
```

In [54]:
```
clf.best_estimator_
```

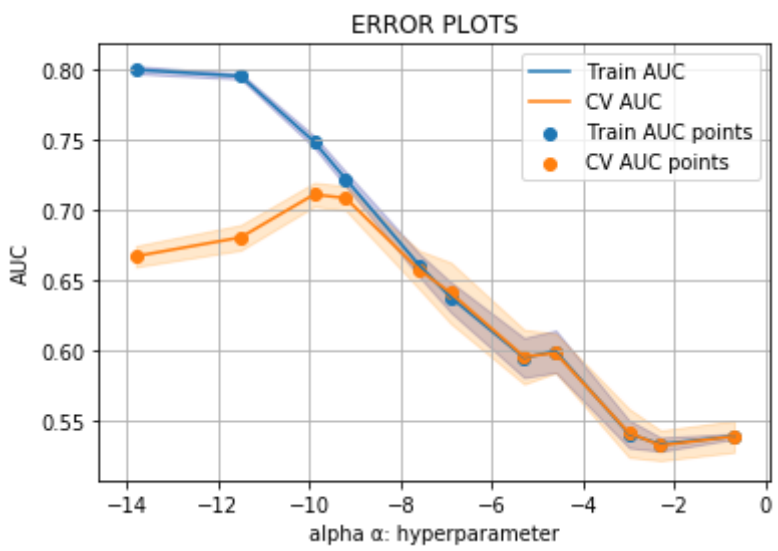
Out[54]:
```
SGDClassifier(alpha=0.0005, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l2',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

In [55]:
```
clf.best_params_
```

Out[55]:
```
{'alpha': 0.0005}
```

Using penalty = 'L1'

In [51]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
# https://stackoverflow.com/questions/52640386/how-do-i-solve-the-future-warning-min-groups-self-n-splits-warning-in
# https://stackoverflow.com/questions/48643181/please-what-is-the-meaning-of-the-deprecation-warning-message

from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_curve, auc

# creating SVM regression classifier using SGDclassifier
classifier = SGDClassifier(loss = 'hinge', penalty='l1', max_iter = 100000, tol = 1e-3)

# Alpha values
parameters = {'alpha':[0.5, 0.1, 0.05, 0.01, 0.005, 0.001, 0.0005, 0.0001, 0.00005, 0.00001, 0.000001]}

# Finding the best parameter using gridsearchcv and 10-folds
clf = GridSearchCV(classifier, parameters, cv=10, scoring='roc_auc', return_train_score=True)
clf.fit(X_tr, y_train)

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

# We use log(alpha) values so as to get a more distinguishable graph because log is monotonous function
# and it won't affect our results

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

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


plt.legend()
plt.xlabel("alpha α: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```




```
CPU times: user 1h 22min 33s, sys: 55.6 s, total: 1h 23min 28s
Wall time: 1h 23min 29s
```

In [52]:
```
clf.best_estimator_
```

Out[52]:
```
SGDClassifier(alpha=5e-05, average=False, class_weight=None,
              early_stopping=False, epsilon=0.1, eta0=0.0, fit_intercept=True,
              l1_ratio=0.15, learning_rate='optimal', loss='hinge',
              max_iter=100000, n_iter_no_change=5, n_jobs=None, penalty='l1',
              power_t=0.5, random_state=None, shuffle=True, tol=0.001,
              validation_fraction=0.1, verbose=0, warm_start=False)
```

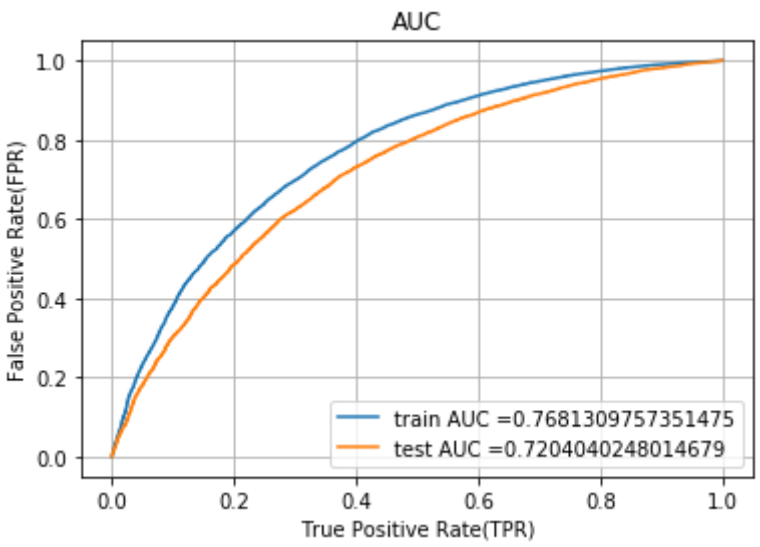
In [53]:
```
clf.best_params_
```

Out[53]:
```
{'alpha': 5e-05}
```

Now creating the model with best α penalty

In [56]:
```
# From the error plot we choose α such that, we will have maximum AUC on cv data and gap between the train and cv is les

# Here we are choosing the best_α based on GridSearchCV results

best_α = 0.0005
```

In [57]:
```
%%time
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc
from sklearn.linear_model import SGDClassifier

# Creating the classifier with best α
classifier = SGDClassifier(loss = 'hinge', alpha = best_α, penalty='l2', max_iter = 100000, tol = 1e-3)
classifier.fit(X_tr, y_train)

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

# Getting the Predict confidence scores for test and train values
y_train_pred = classifier.decision_function(X_tr)
y_test_pred = classifier.decision_function(X_te)

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

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




```
CPU times: user 13.4 s, sys: 0 ns, total: 13.4 s
Wall time: 13.4 s
```

NOTE:

- As we can see from the graph.The difference in the AUC curve is very less between the train data and test data.
- The AUC scores for the Train and Test data are : 76% and 72% respectively
- We choose the α value equal to 0.005 because it has maximum AUC on the CV data

In [58]:
```
# we are writing our own function for predict, with defined threshold
# we will pick a threshold that will give the least fpr
def predict(proba, threshold, fpr, tpr):

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

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

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

In [59]:
```
%%time
# https://scikit-learn.org/stable/modules/classes.html#module-sklearn.metrics
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = classifier.predict(X_te)
print("Accuracy on test set: {}".format(accuracy_score(y_test, y_pred_new)))
print("Precision on test set: {}".format(precision_score(y_test, y_pred_new)))
print("Recall on test set: {}".format(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: {}".format(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 0.8485756289700702
Precision on test set: 0.8485756289700702
Recall on test set: 1.0
F1-Score on test set: 0.9180859205017782
CPU times: user 258 ms, sys: 56 µs, total: 258 ms
Wall time: 256 ms
```

In [60]:
```
from sklearn.metrics import confusion_matrix

print("="*120)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_tpr)))
print("="*120)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, te_thresholds, test_fpr, test_tpr)))
```

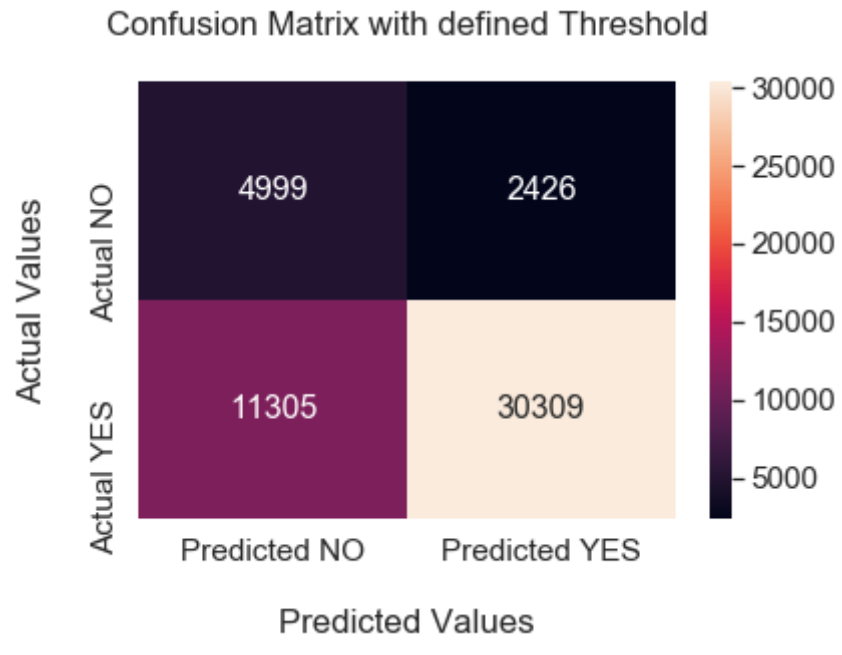
```
========================================================================================================================
=
Train confusion matrix
[[ 4999  2426]
 [11305 30309]]
========================================================================================================================
=
Test confusion matrix
[[ 3417  2042]
 [ 8897 21695]]
```

Function to create the confusion matrix

In [61]:
```
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix

def get_confusion_matrix(y_tr_ts, y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr):

    """Function to get heatmap confusion matrix"""

    # Creating the confusion matrix dataframe
    df_cm = pd.DataFrame(confusion_matrix(y_tr_ts, predict(y_tr_ts_pred, tr_ts_thresholds, tr_ts_fpr, tr_ts_tpr))
                         , range(2),range(2))

    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})

    plt.title('Confusion Matrix with defined Threshold\n ')

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

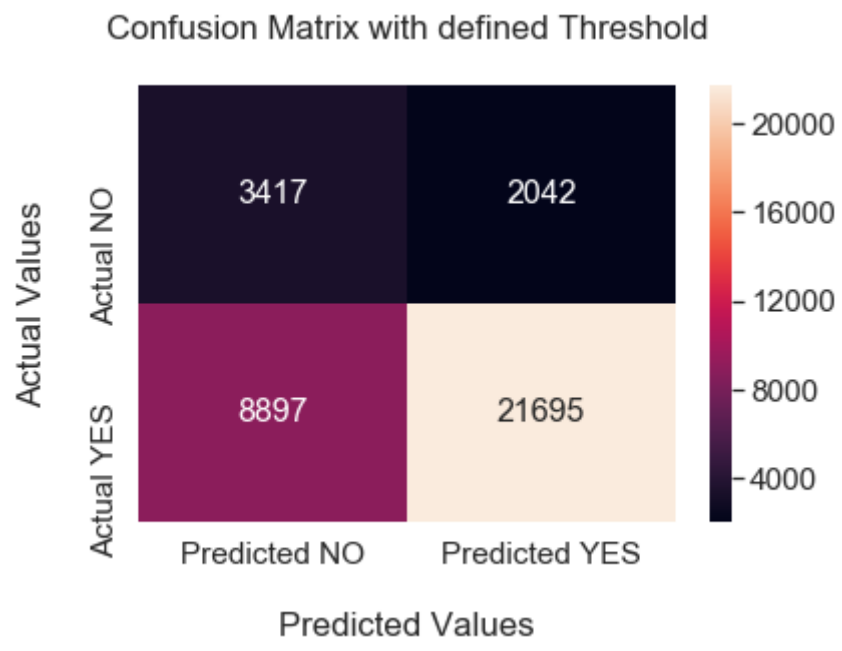
Confusion Matrix on train data

In [63]:
```
get_confusion_matrix(y_train, y_train_pred, tr_thresholds, train_fpr, train_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



Confusion Matrix on test data

In [64]:
```
get_confusion_matrix(y_test, y_test_pred, te_thresholds, test_fpr, test_tpr)
plt.xlabel('\nPredicted Values')
plt.ylabel('Actual Values\n')
plt.show()
```



NOTE:

1. The model predicts the test set correctly with a AUC score of 72%
2. The F1 score obtained is 0.9180859205017782
3. The alpha value that we got after GridSearchCV is 0.0005

CONCLUSION

In [3]:
```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model[LOSS='hinge']" , "Hyper parameter [α], [penalty]", "AUC Score [train]", "AUC Score
x.add_row(["Bag of Words", "SGDClassifier", '0.005 , l2', 0.78, 0.64])
x.add_row(["TF-IDF", "SGDClassifier", '0.0001 , l2', 0.83, 0.70])
x.add_row(["AVG W2V", "SGDClassifier", '0.0001 , l2', 0.71, 0.68])
x.add_row(["TFIDF weighted W2V", "SGDClassifier", '0.0005 , l2', 0.70, 0.67])
x.add_row(["TF-IDF (TruncatedSVD)", "SGDClassifier", '0.0005 , l2', 0.76, 0.72])

print(x)
```

```
+----------------------+---------------------+--------------------------------+-------------------+------------------+
|      Vectorizer      | Model[LOSS='hinge'] | Hyper parameter [α], [penalty] | AUC Score [train] | AUC Score [test] |
+----------------------+---------------------+--------------------------------+-------------------+------------------+
|     Bag of Words     |    SGDClassifier    |          0.005 , l2            |        0.78       |       0.64       |
|        TF-IDF        |    SGDClassifier    |         0.0001 , l2            |        0.83       |       0.7        |
|       AVG W2V        |    SGDClassifier    |         0.0001 , l2            |        0.71       |       0.68       |
|   TFIDF weighted W2V |    SGDClassifier    |         0.0005 , l2            |        0.7        |       0.67       |
| TF-IDF (TruncatedSVD) |    SGDClassifier    |         0.0005 , l2            |        0.76       |       0.72       |
+----------------------+---------------------+--------------------------------+-------------------+------------------+
```

NOTE:

1. As we can see from the results that, converting the test features (essays and titles) into numerical values does make a upgrade in the AUC scores.
2. It is clearly visible that Text data contained in the Essays and Essay Titles indeed play a major role in predicting the outcome of the project. Hence, it cannot be neglected as most of the models containing them proved to have a better AUC score.
3. After doing dimension reduction using TruncatedSVD, we got 6000 features as the best n_components that explained 100% of the variance. But due to lack of hardware comaptability (I only have 16GB ram), I had to take 3000 components which explained more than 80% of the variance.
4. After dimension reduction also we are able to get more AUC score on both test and train set.

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