Donors Choose - Using SGD Classifier with hinge loss

Objective : Predict whether teachers' project proposals are accepted

Importing packages

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

Reading the data

In [2]:

```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

Project data

In [3]:

```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("Attributes :", project_data.columns.values)
project_data.head(2)
```

```
Number of data points in train data (109248, 17)
--------------------------------------------------
Attributes : ['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']
```

Out[3]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	

Sampling out the data points: Considering 50k Random samples

In [5]:

```
approved_project=project_data[project_data["project_is_approved"]==1].sample(n=35000,random
rejected_project=project_data[project_data["project_is_approved"]==0].sample(n=15000,random
project_data=pd.concat([approved_project,rejected_project] )
```

Handling Missing Value in "Teacher prefix" column

In [6]:

```
a = project_data['teacher_prefix'].mode().values
```

In [7]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].fillna(a[0])
```

Total number of null values in each column

In [8]:

```
#Total number of null values in each column
project_data.isnull().sum(axis = 0)
```

Out[8]:

```
Unnamed: 0                                          0
id                                                  0
teacher_id                                          0
teacher_prefix                                      0
school_state                                        0
project_submitted_datetime                          0
project_grade_category                              0
project_subject_categories                          0
project_subject_subcategories                       0
project_title                                       0
project_essay_1                                     0
project_essay_2                                     0
project_essay_3                                 48346
project_essay_4                                 48346
project_resource_summary                            0
teacher_number_of_previously_posted_projects        0
project_is_approved                                 0
dtype: int64
```

Resource data

In [9]:

```
print("Number of data points in train data", resource_data.shape)
print('-'*50)
print("Attributes: ", resource_data.columns.values)
resource_data.head(2)
```

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

Out[9]:

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

Replacing date-time with date

In [10]:

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


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


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


project_data.head(2)
```

Out[10]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	00:
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	00:

In [11]:

```
# https://matplotlib.org/gallery/pie_and_polar_charts/pie_and_donut_labels.html#sphx-glr-ga

y_value_counts = project_data['project_is_approved'].value_counts()
print("Number of projects than are approved for funding ", y_value_counts[1], ", (", (y_val
print("Number of projects than are not approved for funding ", y_value_counts[0], ", (", (y
```

```
Number of projects than are approved for funding  35000 , ( 70.0 %)
Number of projects than are not approved for funding  15000 , ( 30.0 %)
```

NOTE: This is an imbalance dataset that containes 85% approved project's data and 15% not approved project's data

Preprocessing Categorical Data

Project Subject Categories

In [12]:

```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

# 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", '
        if 'The' in j.split(): # this will split each of the catogory based on space "Math
            j=j.replace('The','') # if we have the words "The" we are going to replace it w
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math
        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 Sub-Categories

In [13]:

```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

# 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", '
        if 'The' in j.split(): # this will split each of the catogory based on space "Math
            j=j.replace('The','') # if we have the words "The" we are going to replace it w
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

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

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

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

Preprocessing Text Data

Project Essay

In [14]:

```
# 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)
```

Compound Sentiment score of Project essay

In [15]:

```
#https://medium.com/analytics-vidhya/simplifying-social-media-sentiment-analysis-using-vade

import nltk
nltk.download('vader_lexicon')
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()

essays = project_data['essay']
essays_sentiments = []

for essay in tqdm(essays):
    res = sid.polarity_scores(essay)
    essays_sentiments.append(res['compound']) #Considering compound as a criteria.

project_data['essay_sentiment'] = essays_sentiments
```

```
[nltk_data] Error loading vader_lexicon: <urlopen error [SSL:
[nltk_data]     CERTIFICATE_VERIFY_FAILED] certificate verify failed:
[nltk_data]     self signed certificate in certificate chain
[nltk_data]     (_ssl.c:1056)>
100%|████████████████████████████████████████████████████████████████████████
████| 50000/50000 [04:40<00:00, 178.38it/s]
```

In [16]:

```
# 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
```

Word count of project essay and title

In [17]:

```
#https://www.geeksforgeeks.org/python-program-to-count-words-in-a-sentence/
for col_type, new_col in [('project_title', 'title_size'), ('essay', 'essay_size')]:
    col_data = project_data[col_type]
    col_size = []
    for sen in col_data:
        sen = decontracted(sen)
        col_size.append(len(sen.split()))
    project_data[new_col] = col_size
```

In [18]:

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

Out[18]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	00:
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	00:

2 rows × 21 columns

In [19]:

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


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 = sent.lower()
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split(" ") if e not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████████
████| 50000/50000 [01:02<00:00, 800.84it/s]
```

In [20]:

```
# placing the preprocessed essay into the dataframe
project_data['clean_essays'] = preprocessed_essays
project_data.drop(['essay'], axis=1, inplace=True)
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)
```

In [21]:

```
#Printing random cleaned essay
project_data['clean_essays'].values[23]
```

Out[21]:

```
'teach science technology 3 8 grades recently middle schoolers told would go
od idea real technology stem classes students since third grade seen grow ph
ysically mature emotionally students school encouraged lead example inspire
creativity voice opinions actions master academics working project alone evi
dence desire master academics working team 2014 ten percent jobs us required
stem skills hope continued support encouragement students begin see stem car
eer option future students needed scan print park designs third term enginee
ring project design paper park also share work others students believed acce
ss color printer scanner sharing work would easier students trying visualize
work better even design something computers actually would take things home
continue working printer class not extra one period stem classroom lower gra
des hands science classroom resources learn technology engineering need tech
nology classroom order good stem classroom'
```

Project title

In [22]:

```
from tqdm import tqdm
preprocessed_titles = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = sent.lower()
    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%|███████████████████████████████████████████████████████████████████████
██| 50000/50000 [00:02<00:00, 17950.05it/s]
```

In [23]:

```
# placing the preprocessed essay into the dataframe
project_data['clean_titles'] = preprocessed_titles
project_data.drop(['project_title'], axis=1, inplace=True)
```

In [24]:

```
#Printing random cleaned title
project_data['clean_titles'].values[12]
```

Out[24]:

```
'duct duct craft spring inspiration'
```

Merging Price and quantity data to Project data (left joining price data)

Merging Price and quantity data to Project data (left joining price data)

In [25]:

```
# reference : https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexe
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index
price_data.head(2)
```

Out[25]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [26]:

```
# join two dataframes(project_data and price_data) in python
# reference : https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.m
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

Splitting Data and Starifying the sampling

In [27]:

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

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

```
(50000, 18)
(50000,)
```

In [28]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_spli
#https://stackoverflow.com/questions/34842405/parameter-stratify-from-method-train-test-spl
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, shuffle=Flase)#
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify = y) # t
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify

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

```
(22445, 18) (22445,)
(11055, 18) (11055,)
(16500, 18) (16500,)
```

Vectorizing Categorical Data

Clean Categories

In [29]:

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

# Vectorizing "clean_categories"
from sklearn.feature_extraction.text import CountVectorizer
vectorizer_sbj = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False,
vectorizer_sbj.fit(X_train['clean_categories'].values)

X_train_categories_one_hot = vectorizer_sbj.transform(X_train['clean_categories'].values)
X_cv_categories_one_hot = vectorizer_sbj.transform(X_cv['clean_categories'].values)
X_test_categories_one_hot = vectorizer_sbj.transform(X_test['clean_categories'].values)

print("After verctorizing")
print(X_train_categories_one_hot.shape, y_train.shape)
print(X_cv_categories_one_hot.shape, y_cv.shape)
print(X_test_categories_one_hot.shape, y_test.shape)

print(vectorizer_sbj.get_feature_names())
```

```
After verctorizing
(22445, 9) (22445,)
(11055, 9) (11055,)
(16500, 9) (16500,)
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning',
'SpecialNeeds', 'Health_Sports', 'Math_Science', 'Literacy_Language']
```

Clean sub Categories

In [30]:

```
# Vectorizing "clean_subcategories"
vectorizer_sub_sbj = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase
vectorizer_sub_sbj.fit(X_train['clean_subcategories'].values)

X_train_sub_categories_one_hot = vectorizer_sub_sbj.transform(X_train['clean_subcategories'
X_cv_sub_categories_one_hot = vectorizer_sub_sbj.transform(X_cv['clean_subcategories'].valu
X_test_sub_categories_one_hot = vectorizer_sub_sbj.transform(X_test['clean_subcategories'].

print("After verctorizing")
print(X_train_sub_categories_one_hot.shape, y_train.shape)
print(X_cv_sub_categories_one_hot.shape, y_cv.shape)
print(X_test_sub_categories_one_hot.shape, y_test.shape)

print(vectorizer_sub_sbj.get_feature_names())
```

```
After verctorizing
(22445, 30) (22445,)
(11055, 30) (11055,)
(16500, 30) (16500,)
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement',
'Civics_Government', 'Extracurricular', 'ForeignLanguages', 'Warmth', 'Care_
Hunger', 'NutritionEducation', 'SocialSciences', 'PerformingArts', 'Characte
rEducation', 'TeamSports', 'Other', 'College_CareerPrep', 'Music', 'History_
Geography', 'EarlyDevelopment', 'ESL', 'Health_LifeScience', 'Gym_Fitness',
'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
```

Teacher Prefix

Teacher Prefix

In [31]:

```
# Vectorizing "teacher_prefix"
prefix = list(set(X_train['teacher_prefix'].values))

vectorizer_teacher = CountVectorizer(vocabulary=prefix, lowercase=False, binary=True)
vectorizer_teacher.fit(X_train['teacher_prefix'].values)

X_train_prefix_one_hot = vectorizer_teacher.transform(X_train['teacher_prefix'])
X_cv_prefix_one_hot = vectorizer_teacher.transform(X_cv['teacher_prefix'])
X_test_prefix_one_hot = vectorizer_teacher.transform(X_test['teacher_prefix'])

print("After verctorizing")
print(X_train_prefix_one_hot.shape, y_train.shape)
print(X_cv_prefix_one_hot.shape, y_cv.shape)
print(X_test_prefix_one_hot.shape, y_test.shape)

print(vectorizer_teacher.get_feature_names())
```

```
After verctorizing
(22445, 5) (22445,)
(11055, 5) (11055,)
(16500, 5) (16500,)
['Mrs.', 'Teacher', 'Mr.', 'Ms.', 'Dr.']
```

school state

In [32]:

```
# Vectorizing "school_state"
from collections import Counter
my_counter = Counter()
for word in X_train['school_state'].values:
    my_counter.update(word.split())

state_dict = dict(my_counter)
sorted_state_dict = dict(sorted(state_dict.items(), key=lambda kv: kv[1]))

vectorizer_state = CountVectorizer(vocabulary=list(sorted_state_dict.keys()), lowercase=Fal
vectorizer_state.fit(X_train['school_state'].values)

X_train_state_one_hot = vectorizer_state.transform(X_train['school_state'].values)
X_cv_state_one_hot = vectorizer_state.transform(X_cv['school_state'].values)
X_test_state_one_hot = vectorizer_state.transform(X_test['school_state'].values)

print("After verctorizing")
print(X_train_state_one_hot.shape, y_train.shape)
print(X_cv_state_one_hot.shape, y_cv.shape)
print(X_test_state_one_hot.shape, y_test.shape)

print(vectorizer_state.get_feature_names())
```

```
After verctorizing
(22445, 51) (22445,)
(11055, 51) (11055,)
(16500, 51) (16500,)
['WY', 'VT', 'ND', 'SD', 'RI', 'MT', 'NE', 'NH', 'DE', 'AK', 'ME', 'WV', 'H
I', 'NM', 'DC', 'IA', 'KS', 'ID', 'CO', 'AR', 'MN', 'OR', 'NV', 'KY', 'MS',
'AL', 'MD', 'TN', 'CT', 'UT', 'WI', 'AZ', 'VA', 'NJ', 'WA', 'OK', 'OH', 'M
O', 'MA', 'LA', 'IN', 'MI', 'PA', 'SC', 'GA', 'IL', 'NC', 'FL', 'NY', 'TX',
'CA']
```

Project Grade Category

In [33]:

```
# Vectorizing "project_grade_category"
prefix = list(set(X_train["project_grade_category"].values))

vectorizer_grade = CountVectorizer(vocabulary=prefix, lowercase=False, binary=True)
vectorizer_grade.fit(X_train['project_grade_category'])

X_train_grade_one_hot = vectorizer_grade.transform(X_train['project_grade_category'])
X_cv_grade_one_hot = vectorizer_grade.transform(X_cv['project_grade_category'])
X_test_grade_one_hot = vectorizer_grade.transform(X_test['project_grade_category'])

print("After verctorizing")
print(X_train_grade_one_hot.shape, y_train.shape)
print(X_cv_grade_one_hot.shape, y_cv.shape)
print(X_test_grade_one_hot.shape, y_test.shape)

print(vectorizer_grade.get_feature_names())
```

```
After verctorizing
(22445, 4) (22445,)
(11055, 4) (11055,)
(16500, 4) (16500,)
['Grades 6-8', 'Grades 9-12', 'Grades 3-5', 'Grades PreK-2']
```

Normalizing Numerical values

Number of previously posted assignments by Teacher

In [34]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Normalizer.html
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

number_projects_train = normalizer.transform(X_train['teacher_number_of_previously_posted_p
number_projects_cv = normalizer.transform(X_cv['teacher_number_of_previously_posted_project
number_projects_test = normalizer.transform(X_test['teacher_number_of_previously_posted_pro

print("After vectorizations")
print(number_projects_train.shape, y_train.shape)
print(number_projects_cv.shape, y_cv.shape)
print(number_projects_test.shape, y_test.shape)
```

```
After vectorizations
(1, 22445) (22445,)
(1, 11055) (11055,)
(1, 16500) (16500,)
```

In [35]:

```
number_projects_train
```

Out[35]:

```
array([[0.        , 0.        , 0.00357224, ..., 0.00071445, 0.00142889,
        0.        ]])
```

In [36]:

```
number_projects_train = np.reshape(number_projects_train, (-1, 1))
number_projects_cv = np.reshape(number_projects_cv, (-1, 1))
number_projects_test = np.reshape(number_projects_test, (-1, 1))
```

Price

In [37]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Normalizer.html
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

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

print("After vectorizations")
print(price_train.shape, y_train.shape)
print(price_cv.shape, y_cv.shape)
print(price_test.shape, y_test.shape)
```

```
After vectorizations
(1, 22445) (22445,)
(1, 11055) (11055,)
(1, 16500) (16500,)
```

In [38]:

```
price_train
```

Out[38]:

```
array([[0.00700088, 0.0013403 , 0.00522195, ..., 0.00353458, 0.00247662,
        0.00438217]])
```

In [39]:

```
price_train=np.reshape(price_train, (-1, 1))
price_cv=np.reshape(price_cv, (-1, 1))
price_test=np.reshape(price_test, (-1, 1))
```

Resource quantity

In [40]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Normalizer.html
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

quantity_train = normalizer.transform(X_train['quantity'].values.reshape(1,-1))
quantity_cv = normalizer.transform(X_cv['quantity'].values.reshape(1,-1))
quantity_test = normalizer.transform(X_test['quantity'].values.reshape(1,-1))

print("After vectorizations")
print(quantity_train.shape, y_train.shape)
print(quantity_cv.shape, y_cv.shape)
print(quantity_test.shape, y_test.shape)
```

```
After vectorizations
(1, 22445) (22445,)
(1, 11055) (11055,)
(1, 16500) (16500,)
```

In [41]:

```
quantity_train
```

Out[41]:

```
array([[0.00020764, 0.00145346, 0.00456802, ..., 0.00083055, 0.0033222 ,
        0.02927687]])
```

In [42]:

```
quantity_train =np.reshape(quantity_train, (-1, 1))
quantity_cv =np.reshape(quantity_cv, (-1, 1))
quantity_test =np.reshape(quantity_test, (-1, 1))
```

Sentiment score

In [43]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Normalizer.html

essay_sentiment_train = X_train['essay_sentiment'].values.reshape(1,-1)
essay_sentiment_cv = X_cv['essay_sentiment'].values.reshape(1,-1)
essay_sentiment_test = X_test['essay_sentiment'].values.reshape(1,-1)

essay_sentiment_train = np.reshape(essay_sentiment_train, (-1, 1))
essay_sentiment_cv = np.reshape(essay_sentiment_cv, (-1, 1))
essay_sentiment_test = np.reshape(essay_sentiment_test, (-1, 1))

print(essay_sentiment_train.shape,y_train.shape)
print(essay_sentiment_cv.shape ,y_cv.shape)
print(essay_sentiment_test.shape,  y_test.shape)
```

```
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
```

Number of words in Project title

In [44]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Normalizer.html
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

title_size_train = normalizer.transform(X_train['title_size'].values.reshape(1,-1))
title_size_cv = normalizer.transform(X_cv['title_size'].values.reshape(1,-1))
title_size_test = normalizer.transform(X_test['title_size'].values.reshape(1,-1))

print("After normalization")
print(title_size_train.shape, y_train.shape)
print(title_size_cv.shape, y_cv.shape)
print(title_size_test.shape, y_test.shape)
```

```
After normalization
(1, 22445) (22445,)
(1, 11055) (11055,)
(1, 16500) (16500,)
```

In [45]:

```
title_size_train =np.reshape(title_size_train, (-1, 1))
title_size_cv =np.reshape(title_size_cv, (-1, 1))
title_size_test =np.reshape(title_size_test, (-1, 1))

print(title_size_train.shape, y_train.shape)
print(title_size_cv.shape, y_cv.shape)
print(title_size_test.shape, y_test.shape)
```

```
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
```

Number of words in combined Essay

In [46]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.preprocessing.Normalizer.html
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

essay_size_train = normalizer.transform(X_train['essay_size'].values.reshape(1,-1))
essay_size_cv = normalizer.transform(X_cv['essay_size'].values.reshape(1,-1))
essay_size_test = normalizer.transform(X_test['essay_size'].values.reshape(1,-1))

essay_size_train =np.reshape(essay_size_train, (-1, 1))
essay_size_cv =np.reshape(essay_size_cv, (-1, 1))
essay_size_test =np.reshape(essay_size_test, (-1, 1))


print(essay_size_train.shape, y_train.shape)
print(essay_size_cv.shape, y_cv.shape)
print(essay_size_test.shape, y_test.shape)
```

```
(22445, 1) (22445,)
(11055, 1) (11055,)
(16500, 1) (16500,)
```

Text Vectorization: Making data ready for models

BoW on Clean Essay

In [47]:

```
# We are considering only the words which appeared in at least 10 documents(rows or project
vectorizer_bow_essay = CountVectorizer(min_df=10)
vectorizer_bow_essay.fit(X_train['clean_essays'].values)

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("After vectorizing")
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)
```

```
After vectorizing
(22445, 8723) (22445,)
(11055, 8723) (11055,)
(16500, 8723) (16500,)
```

BoW on Clean Title

In [48]:

```
vectorizer_bow_title = CountVectorizer(min_df=10)
vectorizer_bow_title.fit(X_train['clean_titles'].values)

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("After vectorizing")
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)
```

```
After vectorizing
(22445, 1150) (22445,)
(11055, 1150) (11055,)
(16500, 1150) (16500,)
```

Tfidf on Clean Essay

In [49]:

```
from sklearn.feature_extraction.text import TfidfVectorizer


vectorizer_tfidf_essay = TfidfVectorizer(min_df=10)
vectorizer_tfidf_essay.fit(X_train['clean_essays'].values)

X_train_essay_tfidf = vectorizer_tfidf_essay.transform(X_train['clean_essays'])
X_cv_essay_tfidf = vectorizer_tfidf_essay.transform(X_cv['clean_essays'])
X_test_essay_tfidf = vectorizer_tfidf_essay.transform(X_test['clean_essays'])

print("After vectorizing")
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)
```

```
After vectorizing
(22445, 8723) (22445,)
(11055, 8723) (11055,)
(16500, 8723) (16500,)
```

Tfidf on Clean Title

In [50]:

```
vectorizer_tfidf_title = TfidfVectorizer(min_df=10)
vectorizer_tfidf_title.fit(X_train['clean_titles'].values)

X_train_title_tfidf = vectorizer_tfidf_title.transform(X_train['clean_titles'])
X_cv_title_tfidf = vectorizer_tfidf_title.transform(X_cv['clean_titles'])
X_test_title_tfidf = vectorizer_tfidf_title.transform(X_test['clean_titles'])

print("After vectorizing")
print(X_train_title_tfidf.shape, y_train.shape)
print(X_cv_title_tfidf.shape, y_cv.shape)
print(X_test_title_tfidf.shape, y_test.shape)
```

```
After vectorizing
(22445, 1150) (22445,)
(11055, 1150) (11055,)
(16500, 1150) (16500,)
```

Avg W2V on Clean Essay

In [51]:

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


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

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

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

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


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

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

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

```
Loading Glove Model

1917495it [09:18, 3430.49it/s]

Done. 1917495  words loaded!
all the words in the coupus 7030520
the unique words in the coupus 43523
The number of words that are present in both glove vectors and our coupus 39
639 ( 91.076 %)
word 2 vec length 39639
```

In [52]:

```
train_essay_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in words_glove:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_essay_avg_w2v.append(vector)

print(len(train_essay_avg_w2v))
print(len(train_essay_avg_w2v[0]))


cv_essay_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in words_glove:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    cv_essay_avg_w2v.append(vector)

print(len(cv_essay_avg_w2v))
print(len(cv_essay_avg_w2v[0]))


test_essay_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in words_glove:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    test_essay_avg_w2v.append(vector)

print(len(test_essay_avg_w2v))
print(len(test_essay_avg_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████████████
███| 22445/22445 [00:17<00:00, 1273.17it/s]

22445
300

100%|████████████████████████████████████████████████████████████████████████
███| 11055/11055 [00:06<00:00, 1591.71it/s]

11055
300

100%|██████████████████████████████████████████████████████████████████████
```

```
█████| 16500/16500 [00:10<00:00, 1596.10it/s]

16500
300
```

In [53]:

```
# Changing list to numpy arrays
train_essay_avg_w2v = np.array(train_essay_avg_w2v)
cv_essay_avg_w2v = np.array(cv_essay_avg_w2v)
test_essay_avg_w2v = np.array(test_essay_avg_w2v)
```

Avg W2V on Clean Title

In [54]:

```
train_title_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    train_title_avg_w2v.append(vector)

print(len(train_title_avg_w2v))
print(len(train_title_avg_w2v[0]))


cv_title_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    cv_title_avg_w2v.append(vector)

print(len(cv_title_avg_w2v))
print(len(cv_title_avg_w2v[0]))


test_title_avg_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    test_title_avg_w2v.append(vector)

print(len(test_title_avg_w2v))
print(len(test_title_avg_w2v[0]))
```

```
100%|███████████████████████████████████████████████████████████████████████
██| 22445/22445 [00:00<00:00, 29415.06it/s]

22445
300

100%|███████████████████████████████████████████████████████████████████████
██| 11055/11055 [00:00<00:00, 30225.26it/s]

11055
300
```

```
100%|██████████████████████████████████████████████████████████████████████
████| 16500/16500 [00:00<00:00, 28742.81it/s]

16500
300
```

In [55]:

```
# Changing list to numpy arrays
train_title_avg_w2v = np.array(train_title_avg_w2v)
cv_title_avg_w2v = np.array(cv_title_avg_w2v)
test_title_avg_w2v = np.array(test_title_avg_w2v)
```

Tfidf W2V on Clean essay

In [56]:

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

In [57]:

```
train_essay_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    train_essay_tfidf_w2v.append(vector)

print(len(train_essay_tfidf_w2v))
print(len(train_essay_tfidf_w2v[0]))


cv_essay_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    cv_essay_tfidf_w2v.append(vector)

print(len(cv_essay_tfidf_w2v))
print(len(cv_essay_tfidf_w2v[0]))


test_essay_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_essays']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    test_essay_tfidf_w2v.append(vector)

print(len(test_essay_tfidf_w2v))
print(len(test_essay_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████
████| 22445/22445 [01:34<00:00, 236.80it/s]
```

```
22445
300

100%|████████████████████████████████████████████████████████████████████
████| 11055/11055 [00:45<00:00, 242.48it/s]

11055
300

100%|████████████████████████████████████████████████████████████████████
████| 16500/16500 [01:06<00:00, 247.91it/s]

16500
300
```

In [58]:

```
# Changing list to numpy arrays
train_essay_tfidf_w2v = np.array(train_essay_tfidf_w2v)
cv_essay_tfidf_w2v = np.array(cv_essay_tfidf_w2v)
test_essay_tfidf_w2v = np.array(test_essay_tfidf_w2v)
```

Tfidf W2V on Clean Title

In [59]:

```
train_title_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_train['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    train_title_tfidf_w2v.append(vector)

print(len(train_title_tfidf_w2v))
print(len(train_title_tfidf_w2v[0]))


cv_title_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_cv['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    cv_title_tfidf_w2v.append(vector)

print(len(cv_title_tfidf_w2v))
print(len(cv_title_tfidf_w2v[0]))



test_title_tfidf_w2v = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['clean_titles']): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettir
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    test_title_tfidf_w2v.append(vector)

print(len(test_title_tfidf_w2v))
print(len(test_title_tfidf_w2v[0]))
```

```
100%|████████████████████████████████████████████████████████████████
█| 22445/22445 [00:01<00:00, 17376.94it/s]
```

```
22445
300

100%|███████████████████████████████████████████████████████████████████████
█| 11055/11055 [00:00<00:00, 14402.80it/s]

11055
300

100%|███████████████████████████████████████████████████████████████████████
█| 16500/16500 [00:01<00:00, 15657.36it/s]

16500
300
```

In [60]:

```
# Changing list to numpy arrays
train_title_tfidf_w2v = np.array(train_title_tfidf_w2v)
cv_title_tfidf_w2v = np.array(cv_title_tfidf_w2v)
test_title_tfidf_w2v = np.array(test_title_tfidf_w2v)
```

Applying SGD with Hinge loss || Linear Support vector machine

Set 1: categorical, numerical features + project_title(BOW) + preprocessed_eassay(BOW)

Hstacking features

In [61]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train_bow = hstack((X_train_categories_one_hot, X_train_sub_categories_one_hot, X_train_e
X_cv_bow = hstack((X_cv_categories_one_hot, X_cv_sub_categories_one_hot, X_cv_essay_bow, qu
X_test_bow = hstack((X_test_categories_one_hot, X_test_sub_categories_one_hot, X_test_essay

print('Final matrix')
print(X_train_bow.shape, y_train.shape)
print(X_cv_bow.shape, y_cv.shape)
print(X_test_bow.shape, y_test.shape)
```

```
Final matrix
(22445, 9975) (22445,)
(11055, 9975) (11055,)
(16500, 9975) (16500,)
```

Hyperparameter tuning using simple for loop

In [62]:

```
#https://datascience.stackexchange.com/questions/22762/understanding-predict-proba-from-mul
def batch_predict(clf, data):
    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000  #Iter untill last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

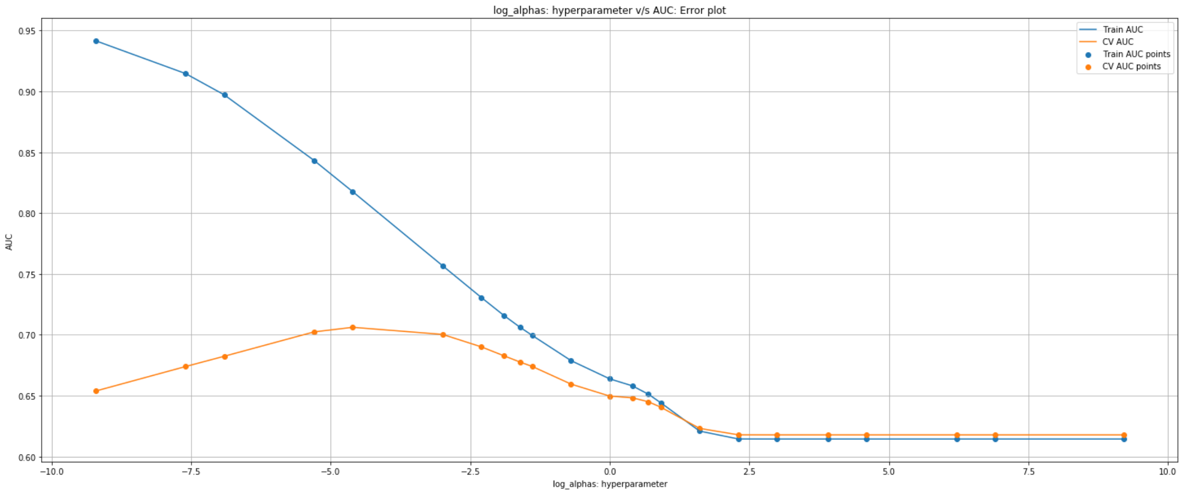
In [63]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.calibration.CalibratedClassifier
from sklearn.linear_model import SGDClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
import math
from sklearn.calibration import CalibratedClassifierCV

train_auc = []
cv_auc = []
log_alphas = []


alphas = [0.0001, 0.0005, 0.001,0.005, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.5, 1.0, 1.5, 2.0

for i in (alphas):
    sgd_bow = SGDClassifier(alpha=i, loss='hinge', penalty='l2',class_weight='balanced',tol
    cal_bow = CalibratedClassifierCV(sgd_bow, method='sigmoid', cv=5)
    cal_bow.fit(X_train_bow, y_train)


    y_train_pred = batch_predict(cal_bow, X_train_bow )
    y_cv_pred = batch_predict(cal_bow, X_cv_bow)


    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

for a in (alphas):
    b = math.log(a)
    log_alphas.append(b)
```

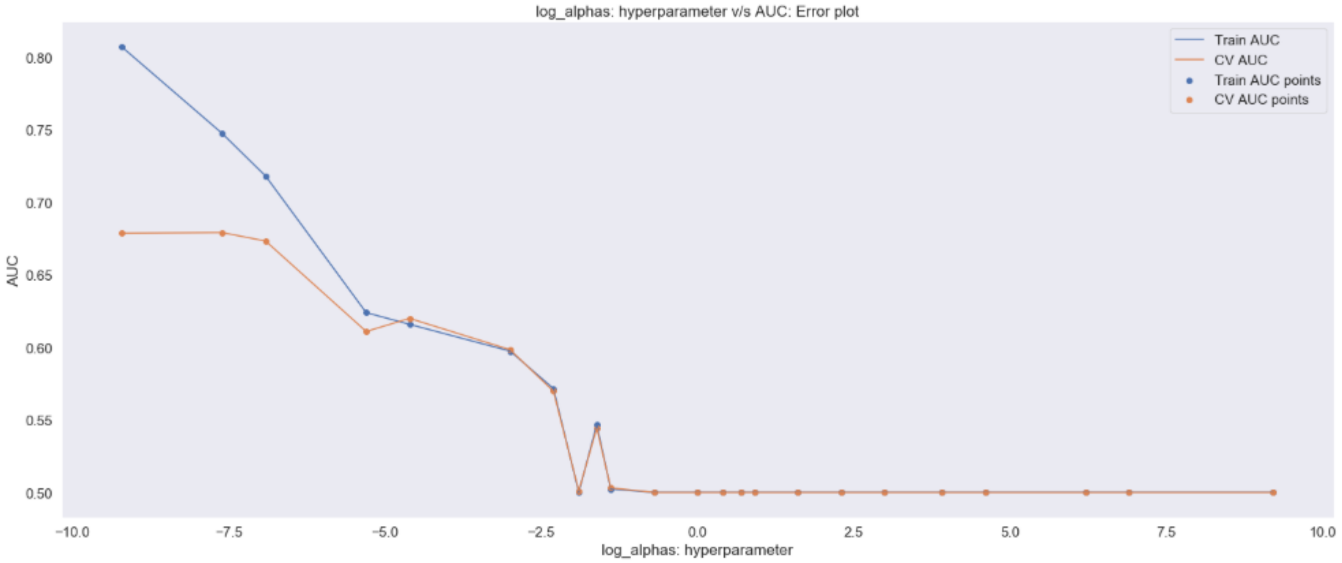
log_alphas vs AUC

In [64]:

```
plt.figure(figsize=(25,10))

plt.plot(log_alphas, train_auc, label='Train AUC')
plt.plot(log_alphas, cv_auc, label='CV AUC')

plt.scatter(log_alphas, train_auc, label='Train AUC points')
plt.scatter(log_alphas, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("log_alphas: hyperparameter")
plt.ylabel("AUC")
plt.title("log_alphas: hyperparameter v/s AUC: Error plot")
plt.grid()
plt.show()
```



With L1 penalty:



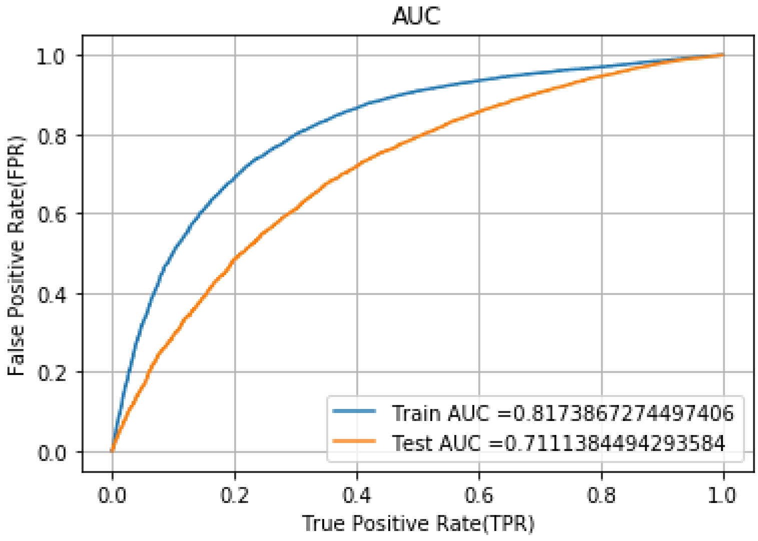
In [65]:

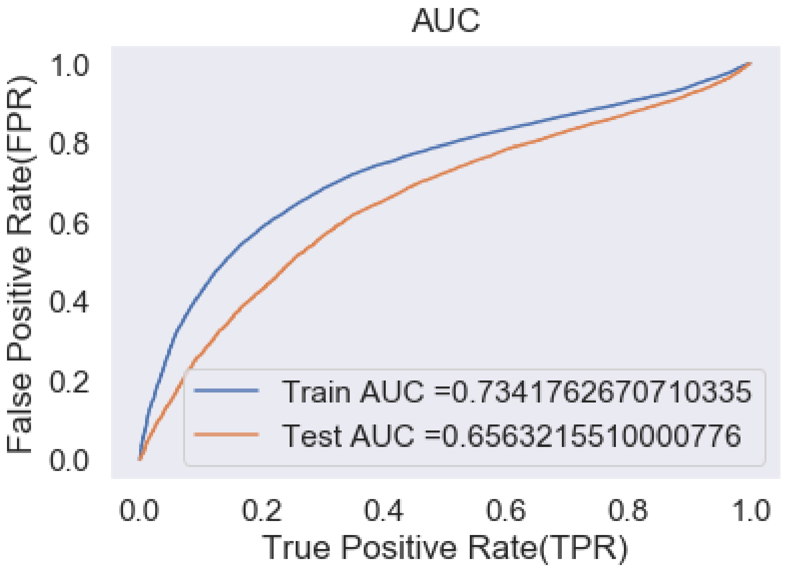
```
optimal_alpha = 0.01
```

Training model with optimal value of hyperparameter

In [66]:

```
from sklearn.metrics import roc_curve, auc

sgd_bow = SGDClassifier(alpha=0.01, class_weight='balanced', loss='hinge', penalty='l2',max
cal_bow = CalibratedClassifierCV(sgd_bow, method='sigmoid', cv=5)
cal_bow.fit(X_train_bow, y_train)

# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the p
# not the predicted outputs
y_train_pred = batch_predict(cal_bow, X_train_bow)
y_test_pred = batch_predict(cal_bow, X_test_bow)


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()
```





NOTE: As per the obeservation, L2 penalty with alpha 0.01 gave better AUC than l1 penalty with alpha 0.0005

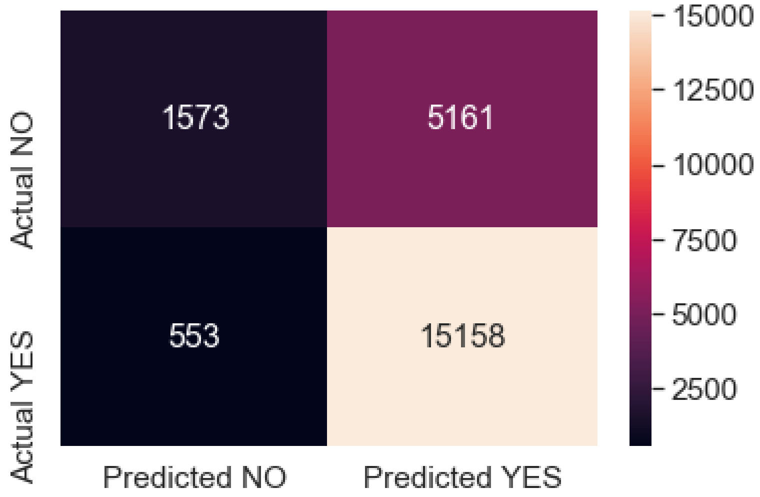
Getting confusion metrix for both train and test set

In [67]:

```
def get_confusion_matrix(clf,X_te,y_te):
    y_pred = clf.predict(X_te)
    df_cm = pd.DataFrame(confusion_matrix(y_te, y_pred), range(2),range(2))
    df_cm.columns = ['Predicted NO','Predicted YES']
    df_cm = df_cm.rename({0: 'Actual NO', 1: 'Actual YES'})
    sns.set(font_scale=1.4)#for label size
    sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')
```

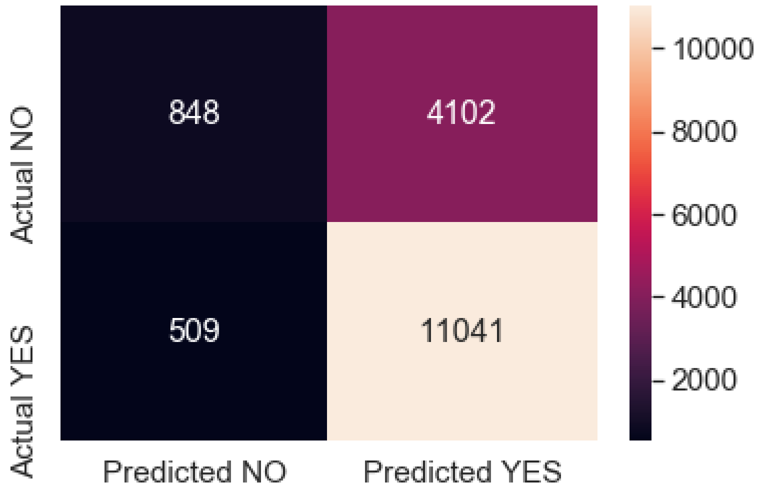
In [68]:

```
get_confusion_matrix(cal_bow,X_train_bow,y_train)
```



In [69]:

```
get_confusion_matrix(cal_bow,X_test_bow,y_test)
```



Evaluating model performance

In [70]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = cal_bow.predict(X_test_bow)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(y_test, y_pred_new)*100))
print("Precision on test set: %0.3f"%(precision_score(y_test, y_pred_new)))
print("Recall on test set: %0.3f"%(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: %0.3f"%(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 72.055%
Precision on test set: 0.729
Recall on test set: 0.956
F1-Score on test set: 0.827
```

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

Hstacking features

In [71]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train_tfidf = hstack((X_train_categories_one_hot, X_train_sub_categories_one_hot, X_trair
X_cv_tfidf = hstack((X_cv_categories_one_hot, X_cv_sub_categories_one_hot, X_cv_essay_tfidf
X_test_tfidf = hstack((X_test_categories_one_hot, X_test_sub_categories_one_hot, X_test_ess

print('Final matrix')
print(X_train_tfidf.shape, y_train.shape)
print(X_cv_tfidf.shape, y_cv.shape)
print(X_test_tfidf.shape, y_test.shape)
```

```
Final matrix
(22445, 9975) (22445,)
(11055, 9975) (11055,)
(16500, 9975) (16500,)
```

Hyperparameter tuning

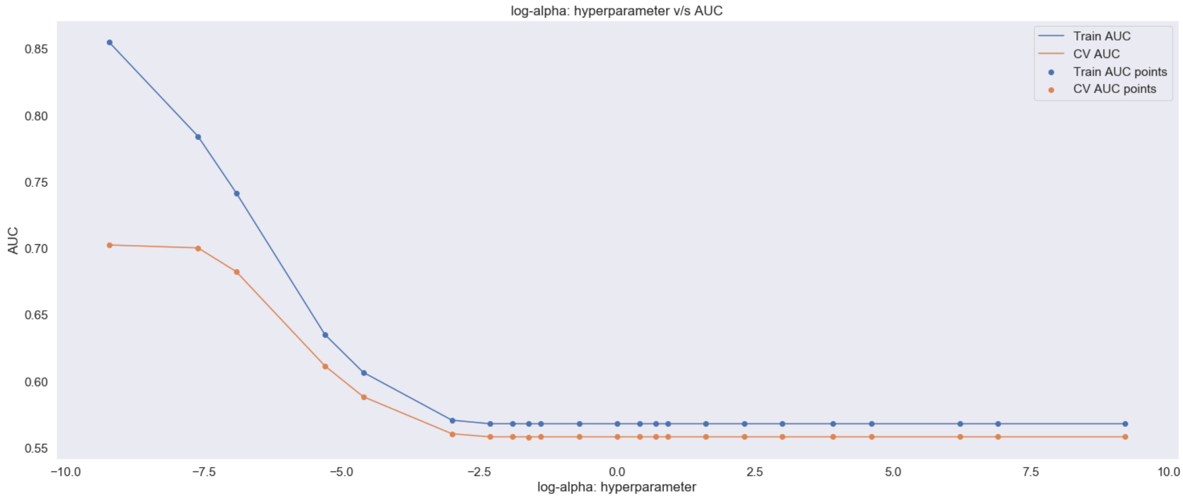
In [72]:

```
from sklearn.linear_model import SGDClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
import math

train_auc = []
cv_auc = []
log_alphas = []

alphas = [0.0001, 0.0005, 0.001,0.005, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.5, 1.0, 1.5, 2.0

for i in (alphas):
    sgd_tfidf = SGDClassifier(alpha=i, class_weight='balanced', loss='hinge', penalty='l2',
    cal_tfidf = CalibratedClassifierCV(sgd_tfidf, method='sigmoid', cv='warn')
    cal_tfidf.fit(X_train_tfidf, y_train)

    y_train_pred = batch_predict(cal_tfidf, X_train_tfidf )
    y_cv_pred = batch_predict(cal_tfidf, X_cv_tfidf)


    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

for a in tqdm(alphas):
    b = math.log(a)
    log_alphas.append(b)
```

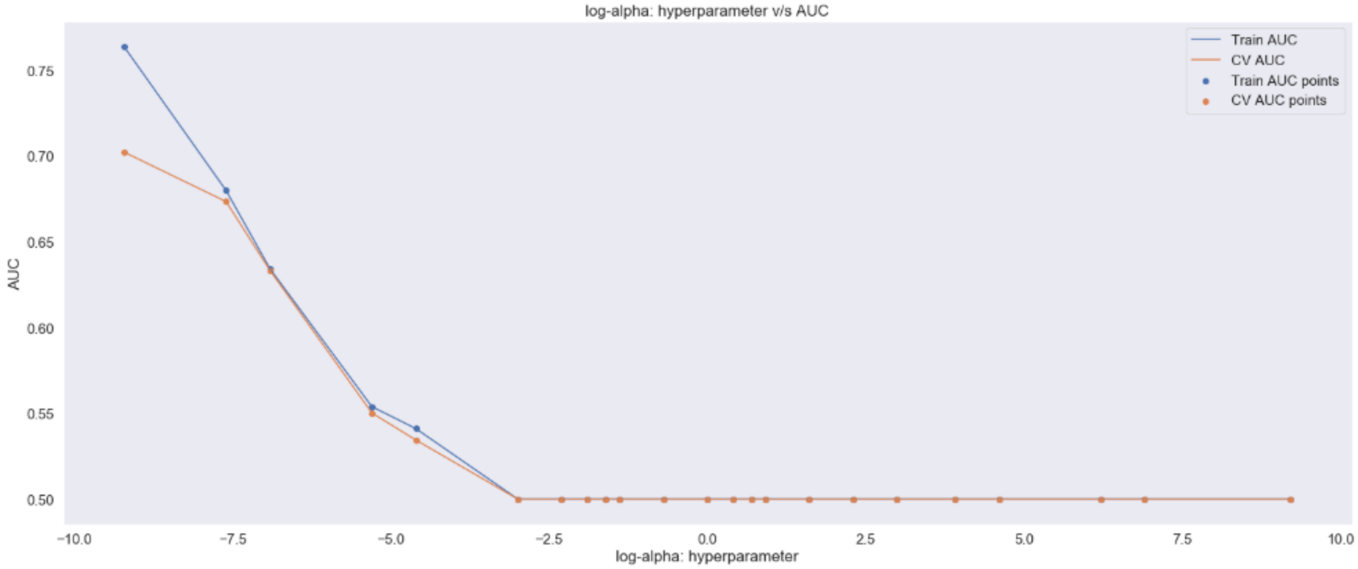
```
100%|████████████████████████████████████████████████████████
███████████████| 23/23 [00:00<?, ?it/s]
```

In [73]:

```
plt.figure(figsize=(25,10))
plt.plot(log_alphas, train_auc, label='Train AUC')
plt.plot(log_alphas, cv_auc, label='CV AUC')

plt.scatter(log_alphas, train_auc, label='Train AUC points')
plt.scatter(log_alphas, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("log-alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("log-alpha: hyperparameter v/s AUC")
plt.grid()
plt.show()
```



With L1 penalty:

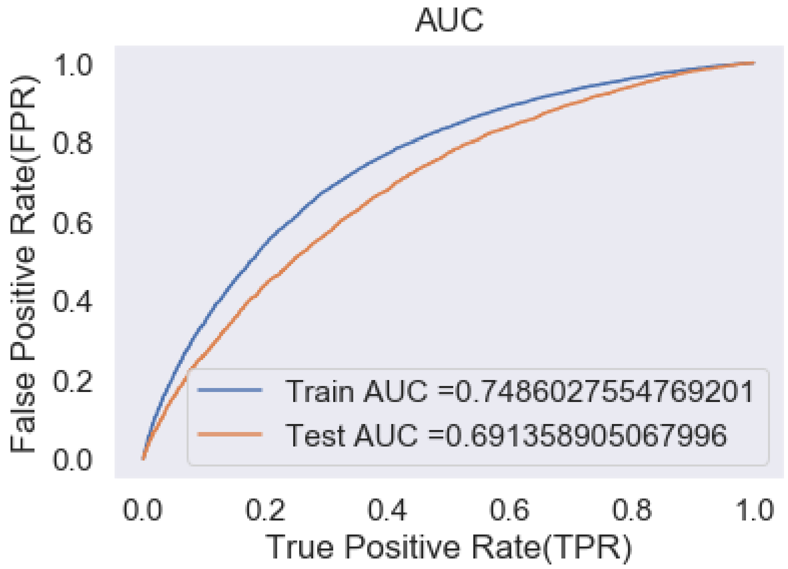


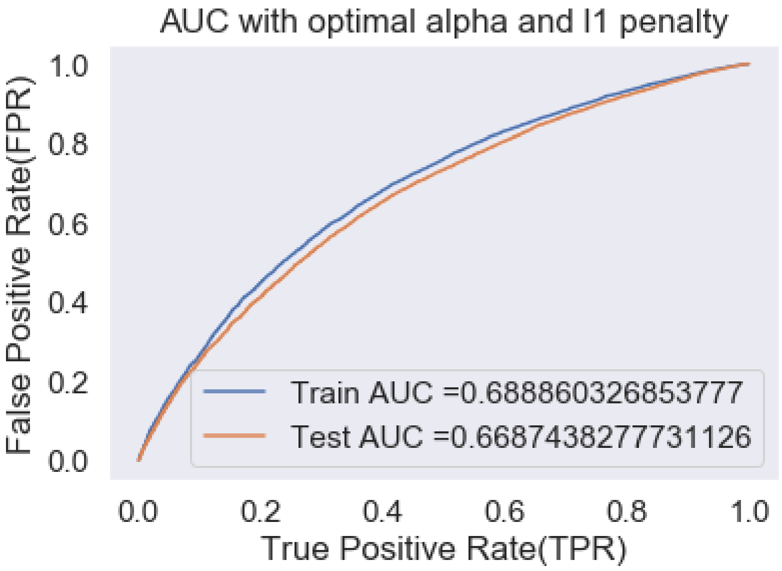
In [74]:

```
optimal_alpha  = 0.001
```

In [75]:

```
from sklearn.metrics import roc_curve, auc

sgd_tfidf = SGDClassifier(alpha=0.001, class_weight='balanced', loss='hinge', penalty='l2')

cal_tfidf = CalibratedClassifierCV(sgd_tfidf, method='sigmoid', cv='warn')
cal_tfidf.fit(X_train_tfidf, y_train)

y_train_pred = batch_predict(cal_tfidf, X_train_tfidf)
y_test_pred = batch_predict(cal_tfidf, X_test_tfidf)

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()
```



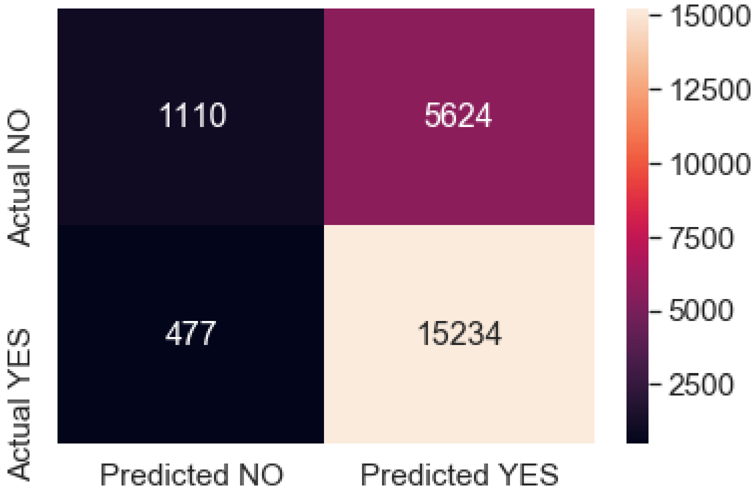


NOTE: As per the obeservation, L2 penalty with alpha 0.001 gave better AUC than l1 penalty with alpha 0.0005

Confusion matrix

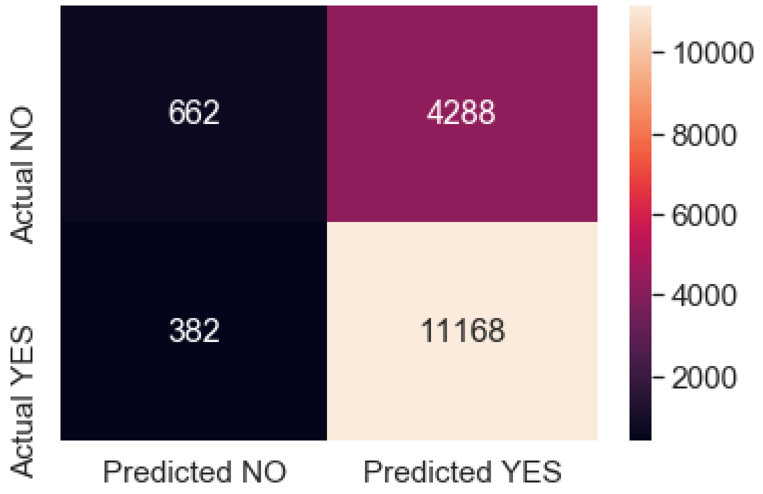
In [76]:

```
get_confusion_matrix(cal_tfidf,X_train_tfidf,y_train)
```



In [77]:

```
get_confusion_matrix(cal_tfidf,X_test_tfidf,y_test)
```



Evaluating model performance

In [78]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = cal_tfidf.predict(X_test_tfidf)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(y_test, y_pred_new)*100))
print("Precision on test set: %0.3f"%(precision_score(y_test, y_pred_new)))
print("Recall on test set: %0.3f"%(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: %0.3f"%(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 71.697%
Precision on test set: 0.723
Recall on test set: 0.967
F1-Score on test set: 0.827
```

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

Hstacking features

In [79]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train_avg = hstack((X_train_categories_one_hot, X_train_sub_categories_one_hot, train_ess
X_cv_avg = hstack((X_cv_categories_one_hot, X_cv_sub_categories_one_hot, cv_essay_avg_w2v,
X_test_avg = hstack((X_test_categories_one_hot, X_test_sub_categories_one_hot, test_essay_a

print('Final matrix')
print(X_train_avg.shape, y_train.shape)
print(X_cv_avg.shape, y_cv.shape)
print(X_test_avg.shape, y_test.shape)
```

```
Final matrix
(22445, 702) (22445,)
(11055, 702) (11055,)
(16500, 702) (16500,)
```

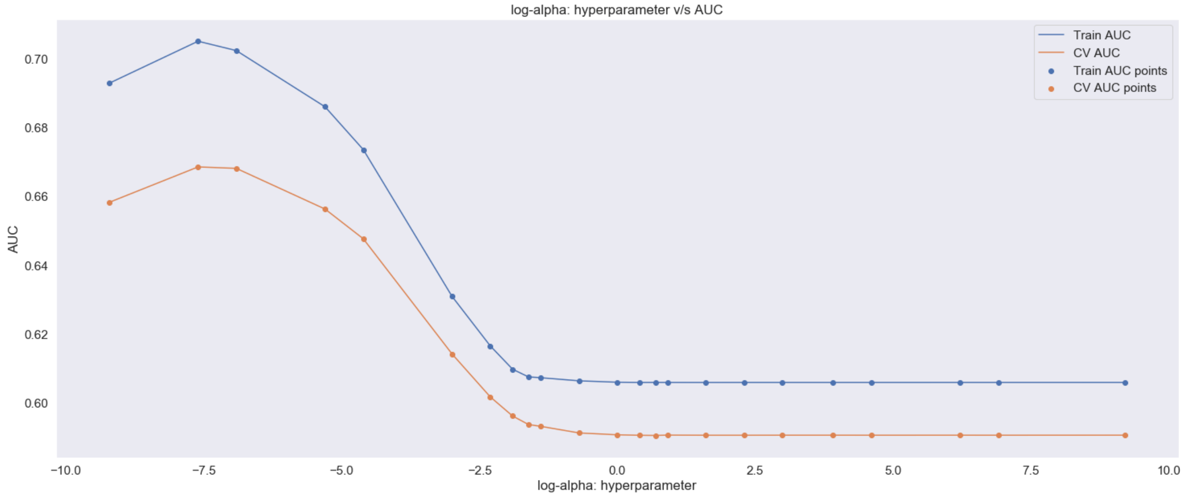
Hyperparameter Tuning

In [80]:

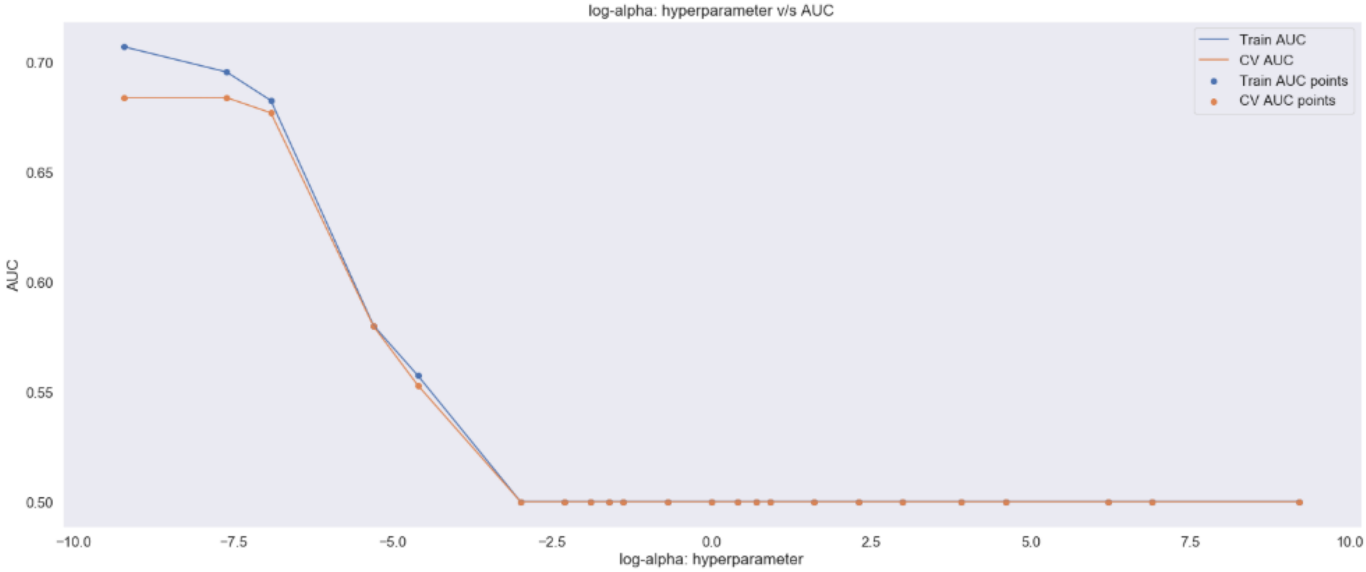
```
from sklearn.linear_model import SGDClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
import math

train_auc = []
cv_auc = []
log_alphas = []

alphas = [0.0001, 0.0005, 0.001,0.005, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.5, 1.0, 1.5, 2.0

for i in (alphas):
    sgd_avg = SGDClassifier(alpha=i, class_weight='balanced', loss='hinge', penalty='l2')
    cal_avg = CalibratedClassifierCV(sgd_avg, method='sigmoid', cv='warn')
    cal_avg.fit(X_train_avg, y_train)


    y_train_pred = batch_predict(cal_avg, X_train_avg )
    y_cv_pred = batch_predict(cal_avg, X_cv_avg)


    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

for a in (alphas):
    b = math.log(a)
    log_alphas.append(b)
```

In [81]:

```
plt.figure(figsize=(25,10))
plt.plot(log_alphas, train_auc, label='Train AUC')
plt.plot(log_alphas, cv_auc, label='CV AUC')

plt.scatter(log_alphas, train_auc, label='Train AUC points')
plt.scatter(log_alphas, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("log-alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("log-alpha: hyperparameter v/s AUC")
plt.grid()
plt.show()
```



With L1 penalty:

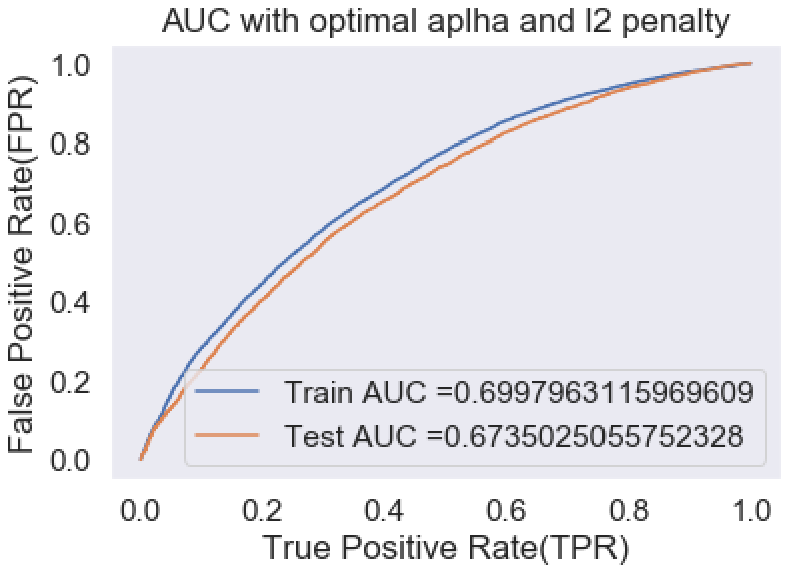


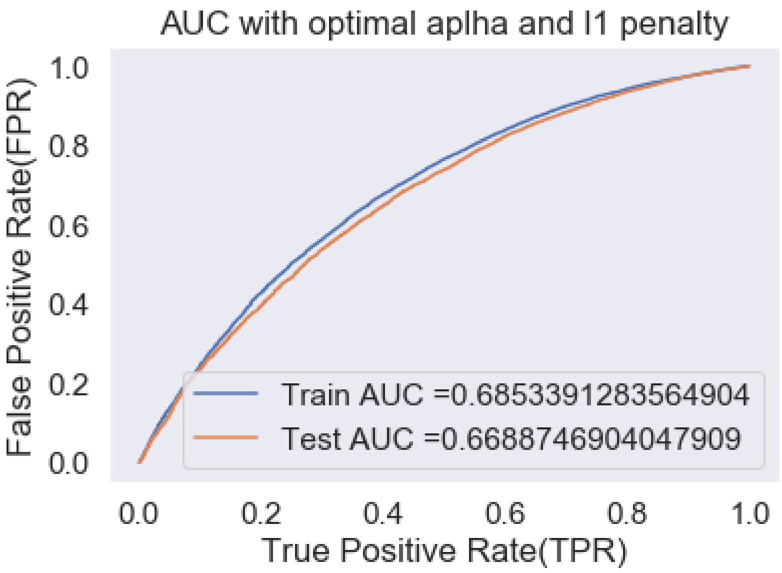
In [82]:

```
optimal_alpha = 0.001
```

In [83]:

```
from sklearn.metrics import roc_curve, auc

sgd_avg = SGDClassifier(alpha=0.001, class_weight='balanced', loss='hinge', penalty='l2')
cal_avg = CalibratedClassifierCV(sgd_avg, method='sigmoid', cv='warn')
cal_avg.fit(X_train_avg, y_train)

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

y_train_pred = batch_predict(cal_avg, X_train_avg)
y_test_pred = batch_predict(cal_avg, X_test_avg)

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 with optimal aplha and l2 penalty")
plt.grid()
plt.show()
```



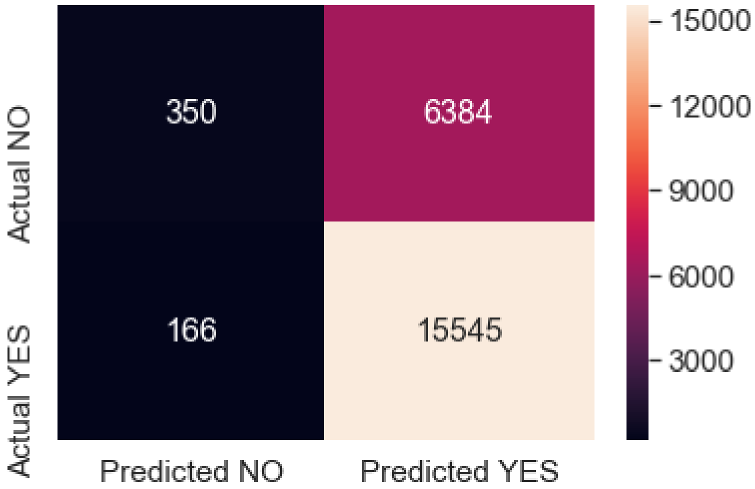


NOTE: As per the obeservation, L2 penalty with alpha 0.001 give better AUC than l1 penalty with alpha 0.001

Confusion matrix

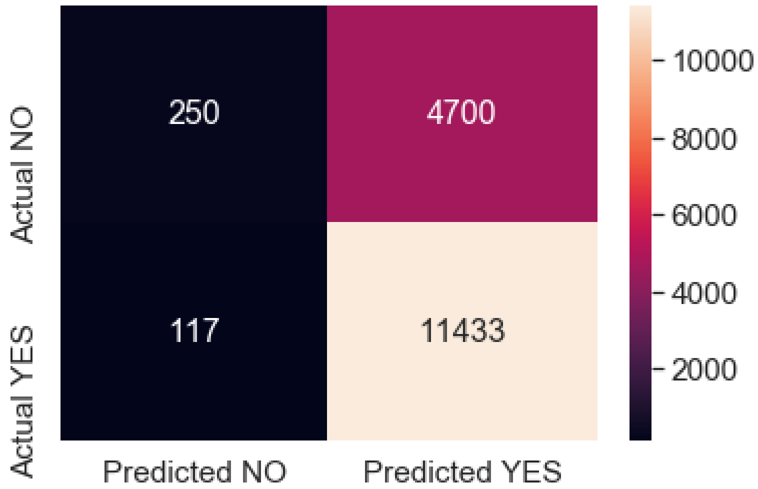
In [84]:

```
get_confusion_matrix(cal_avg,X_train_avg,y_train)
```



In [85]:

```
get_confusion_matrix(cal_avg,X_test_avg,y_test)
```



Evaluating model performance

In [86]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = cal_avg.predict(X_test_avg)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(y_test, y_pred_new)*100))
print("Precision on test set: %0.3f"%(precision_score(y_test, y_pred_new)))
print("Recall on test set: %0.3f"%(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: %0.3f"%(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 70.806%
Precision on test set: 0.709
Recall on test set: 0.990
F1-Score on test set: 0.826
```

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

Hstacking features

In [87]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train_tfidf_w2v = hstack((X_train_categories_one_hot, X_train_sub_categories_one_hot, tra
X_cv_tfidf_w2v = hstack((X_cv_categories_one_hot, X_cv_sub_categories_one_hot, cv_essay_tfi
X_test_tfidf_w2v = hstack((X_test_categories_one_hot, X_test_sub_categories_one_hot, test_e

print('Final matrix')
print(X_train_tfidf_w2v.shape, y_train.shape)
print(X_cv_tfidf_w2v.shape, y_cv.shape)
print(X_test_tfidf_w2v.shape, y_test.shape)
```

```
Final matrix
(22445, 702) (22445,)
(11055, 702) (11055,)
(16500, 702) (16500,)
```

Hyperparameter tuning

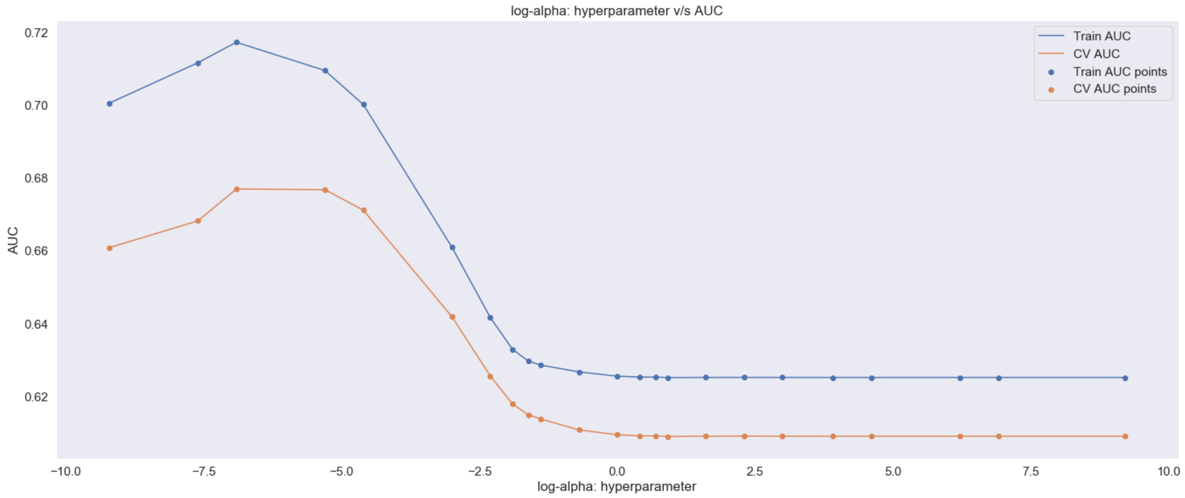
In [88]:

```
from sklearn.linear_model import SGDClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
import math

train_auc = []
cv_auc = []
log_alphas = []

alphas = [0.0001, 0.0005, 0.001,0.005, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.5, 1.0, 1.5, 2.0

for i in tqdm(alphas):
    sgd_tfidf_w2v = SGDClassifier(alpha=i, class_weight='balanced', loss='hinge', penalty='
    cal_tfidf_w2v = CalibratedClassifierCV(sgd_tfidf_w2v, method='sigmoid', cv='warn')
    cal_tfidf_w2v.fit(X_train_tfidf_w2v, y_train)

    y_train_pred = batch_predict(cal_tfidf_w2v, X_train_tfidf_w2v )
    y_cv_pred = batch_predict(cal_tfidf_w2v, X_cv_tfidf_w2v)


    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

for a in tqdm(alphas):
    b = math.log(a)
    log_alphas.append(b)
```

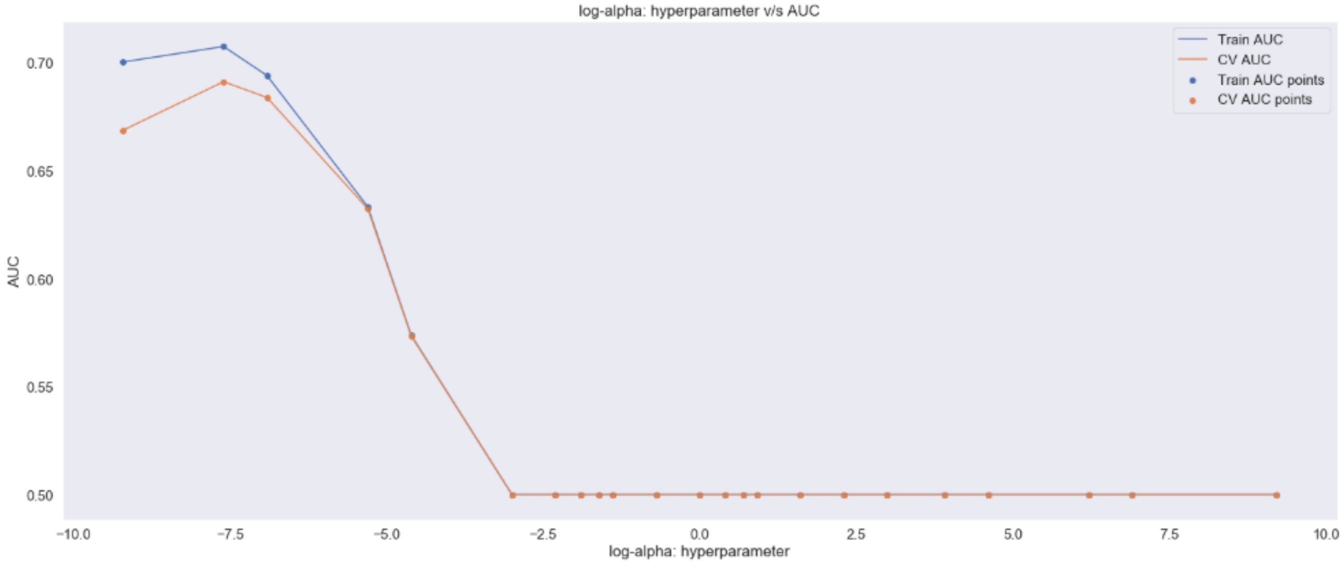
```
100%|██████████████████████████████████████████████████████████████████████
██████████| 23/23 [00:56<00:00,  2.52s/it]
100%|██████████████████████████████████████████████████████████████████████
███████████████████| 23/23 [00:00<?, ?it/s]
```

In [89]:

```
plt.figure(figsize=(25,10))
plt.plot(log_alphas, train_auc, label='Train AUC')
plt.plot(log_alphas, cv_auc, label='CV AUC')

plt.scatter(log_alphas, train_auc, label='Train AUC points')
plt.scatter(log_alphas, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("log-alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("log-alpha: hyperparameter v/s AUC")
plt.grid()
plt.show()
```



With L1 penalty:

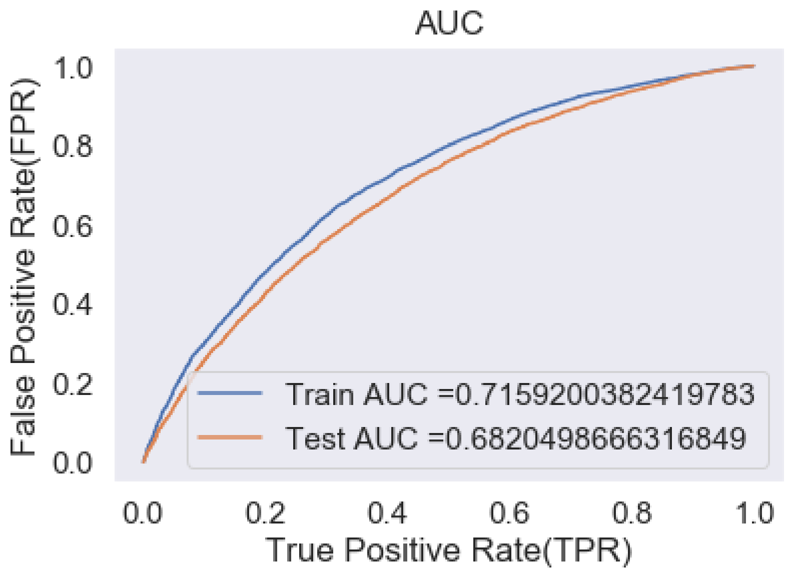


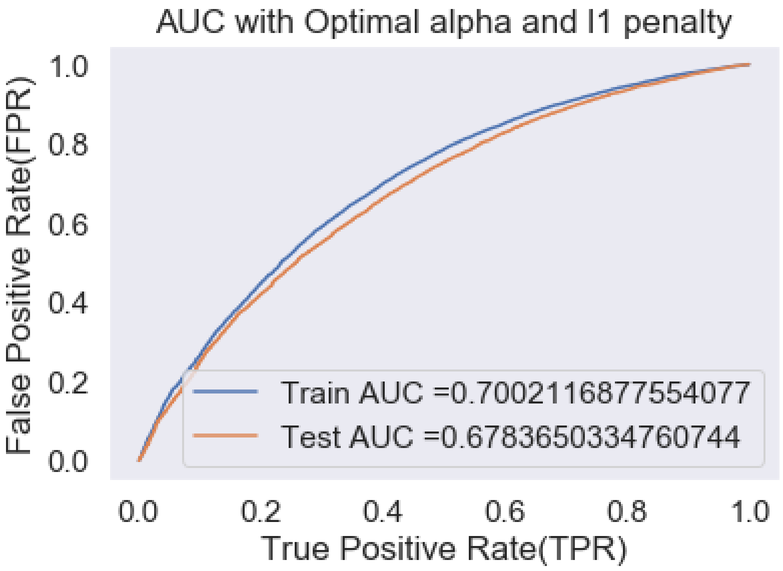
In [90]:

```
optimal_alpha = 0.001
```

In [91]:

```
from sklearn.metrics import roc_curve, auc

sgd_tfidf_w2v = SGDClassifier(alpha=0.001, class_weight='balanced', loss='hinge', penalty='
cal_tfidf_w2v = CalibratedClassifierCV(sgd_tfidf_w2v, method='sigmoid', cv='warn')
cal_tfidf_w2v.fit(X_train_tfidf_w2v, y_train)

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

y_train_pred = batch_predict(cal_tfidf_w2v, X_train_tfidf_w2v)
y_test_pred = batch_predict(cal_tfidf_w2v, X_test_tfidf_w2v)

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()
```



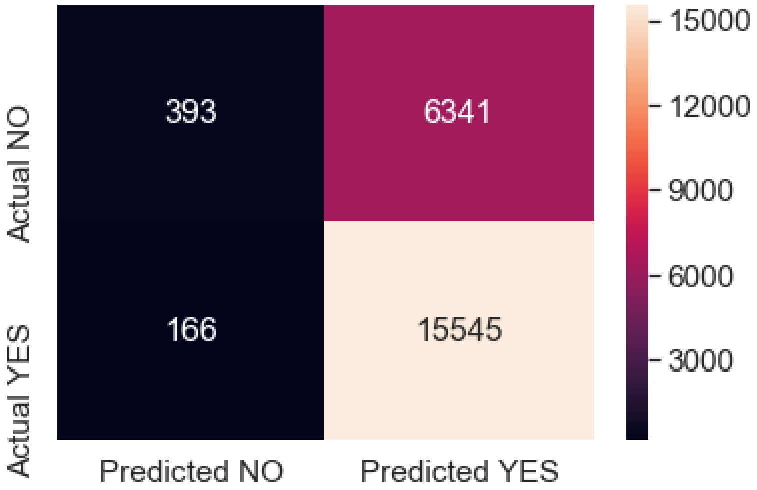


NOTE: As per the obeservation, L2 penalty with alpha 0.001 give better AUC than l1 penalty with alpha 0.001

Confusion matrix

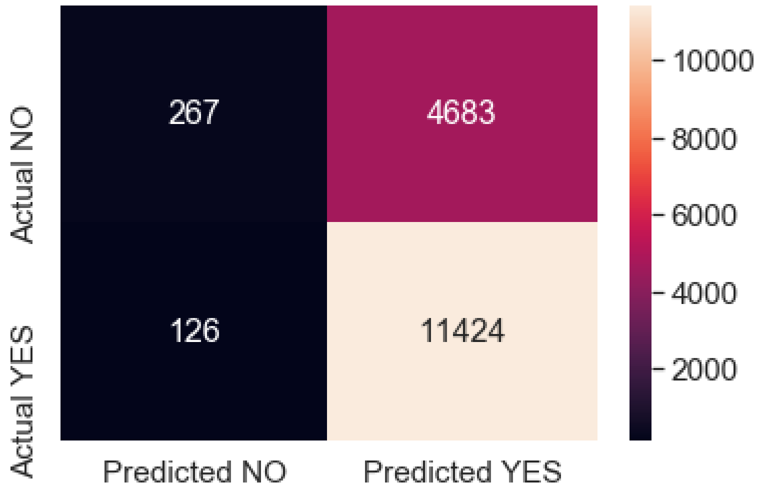
In [92]:

```
get_confusion_matrix(cal_tfidf_w2v,X_train_tfidf_w2v,y_train)
```



In [93]:

```
get_confusion_matrix(cal_tfidf_w2v,X_test_tfidf_w2v,y_test)
```



Evaluating Model performance

In [94]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = cal_tfidf_w2v.predict(X_test_tfidf_w2v)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(y_test, y_pred_new)*100))
print("Precision on test set: %0.3f"%(precision_score(y_test, y_pred_new)))
print("Recall on test set: %0.3f"%(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: %0.3f"%(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 70.855%
Precision on test set: 0.709
Recall on test set: 0.989
F1-Score on test set: 0.826
```

Set 5: categorical, numerical features + Sentiment score + Number of words in title and combined essay+ TruncatedSVD on Essay tfidf

In [95]:

```
from sklearn.feature_extraction.text import TfidfVectorizer


vectorizer_tfidf_essay = TfidfVectorizer(min_df=10, max_features=3000)
vectorizer_tfidf_essay.fit(X_train['clean_essays'].values)

X_train = vectorizer_tfidf_essay.transform(X_train['clean_essays'])
X_cv = vectorizer_tfidf_essay.transform(X_cv['clean_essays'])
X_test = vectorizer_tfidf_essay.transform(X_test['clean_essays'])

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

```
After vectorizing
(22445, 3000) (22445,)
(11055, 3000) (11055,)
(16500, 3000) (16500,)
```

In [96]:

```
X_train.tocsr()
```

Out[96]:

```
<22445x3000 sparse matrix of type '<class 'numpy.float64'>'
        with 2043378 stored elements in Compressed Sparse Row format>
```

In [97]:

```
type(X_train)
```

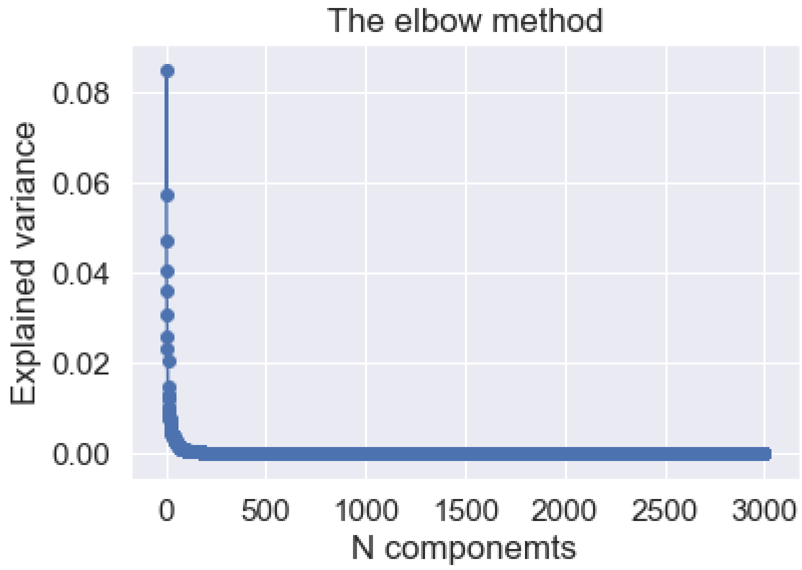
Out[97]:

```
scipy.sparse.csr.csr_matrix
```

Hstacking features

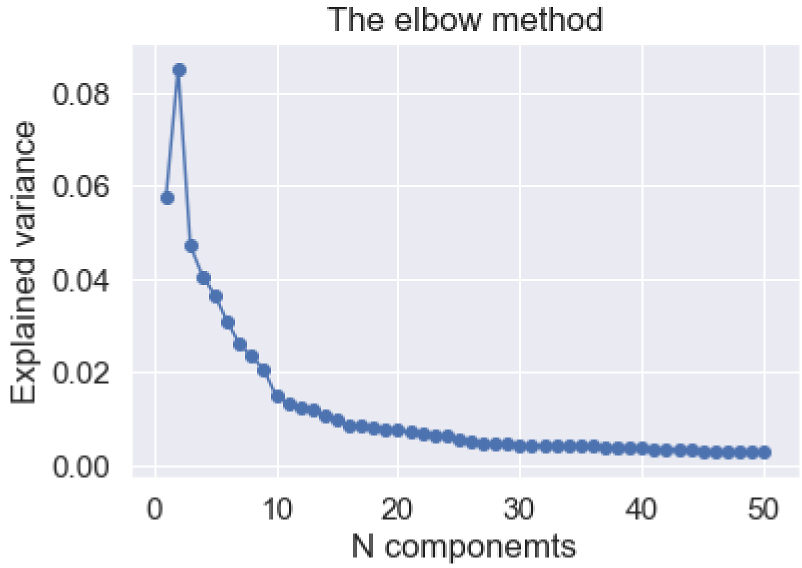
In [98]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.TruncatedSVD.html
#https://chrisalbon.com/machine_learning/feature_engineering/select_best_number_of_componen
from sklearn.decomposition import TruncatedSVD
n_comp = list(range(1,3000))

tsvd = TruncatedSVD(n_components=2999, algorithm='randomized', n_iter=5, random_state=None,
tsvd.fit(X_train_tfidf)
tsvd_var_ratio = tsvd.explained_variance_ratio_

tsvd_var_ratio = tsvd_var_ratio.tolist()
plt.plot(n_comp,tsvd_var_ratio, label='N component plot')
plt.scatter(n_comp,tsvd_var_ratio, label='N component points')
plt.title("The elbow method")
plt.xlabel("N componemts")
plt.ylabel("Explained variance")
plt.show()
```



In [99]:

```
#Plotting for n components 0-50
plt.plot(n_comp[0:50],tsvd_var_ratio[0:50], label='N component plot')
plt.scatter(n_comp[0:50],tsvd_var_ratio[0:50], label='N component points')
plt.title("The elbow method")
plt.xlabel("N componemts")
plt.ylabel("Explained variance")
plt.show()
```



In [100]:

```
tsvd = TruncatedSVD(n_components=10, algorithm='randomized', n_iter=5, random_state=None,tc
tsvd.fit(X_train)
tsvd_train = tsvd.transform(X_train)
tsvd_test = tsvd.transform(X_test)
tsvd_cv = tsvd.transform(X_cv)
```

In [101]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X_train = hstack((X_train_categories_one_hot, X_train_sub_categories_one_hot,quantity_trair
X_cv = hstack((X_cv_categories_one_hot, X_cv_sub_categories_one_hot, quantity_cv, X_cv_stat
X_test = hstack((X_test_categories_one_hot, X_test_sub_categories_one_hot,quantity_test, X_

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

```
Final matrix
(22445, 115) (22445,)
(11055, 115) (11055,)
(16500, 115) (16500,)
```

Hyperparameter tuning

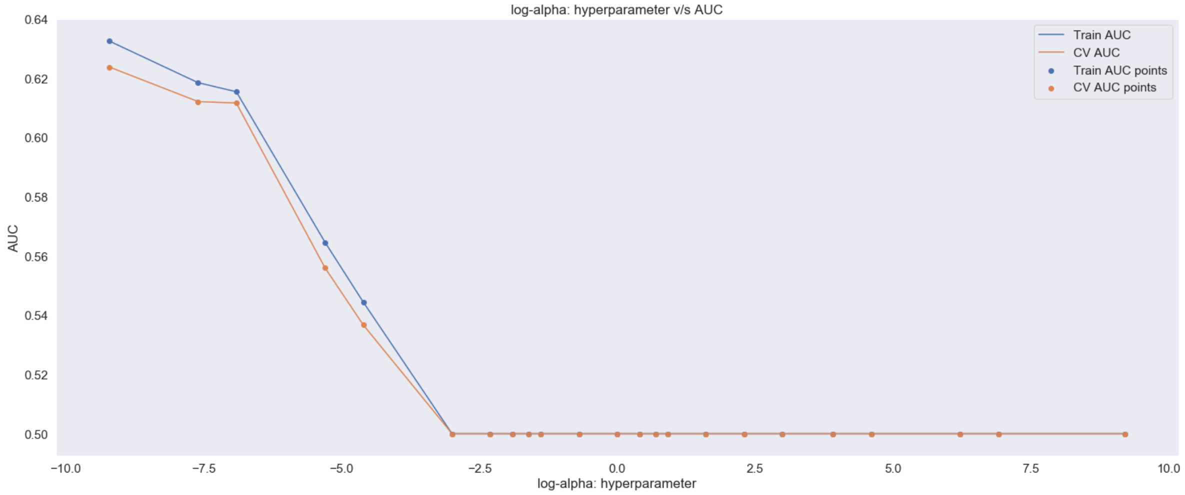
In [134]:

```
from sklearn.linear_model import SGDClassifier
import matplotlib.pyplot as plt
from sklearn.metrics import roc_auc_score
import math

train_auc = []
cv_auc = []
log_alphas = []

alphas = [0.0001, 0.0005, 0.001,0.005, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.5, 1.0, 1.5, 2.0

for i in (alphas):
    sgd_tfidf = SGDClassifier(alpha=i, loss='hinge', penalty='l1',tol=0.001, class_weight='
    cal_tfidf = CalibratedClassifierCV(sgd_tfidf, method='sigmoid', cv='warn')
    cal_tfidf.fit(X_train, y_train)

    y_train_pred = batch_predict(cal_tfidf, X_train)
    y_cv_pred = batch_predict(cal_tfidf, X_cv)


    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of t
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

for a in tqdm(alphas):
    b = math.log(a)
    log_alphas.append(b)
```

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

In [135]:

```
plt.figure(figsize=(25,10))
plt.plot(log_alphas, train_auc, label='Train AUC')
plt.plot(log_alphas, cv_auc, label='CV AUC')

plt.scatter(log_alphas, train_auc, label='Train AUC points')
plt.scatter(log_alphas, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("log-alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("log-alpha: hyperparameter v/s AUC")
plt.grid()
plt.show()
```

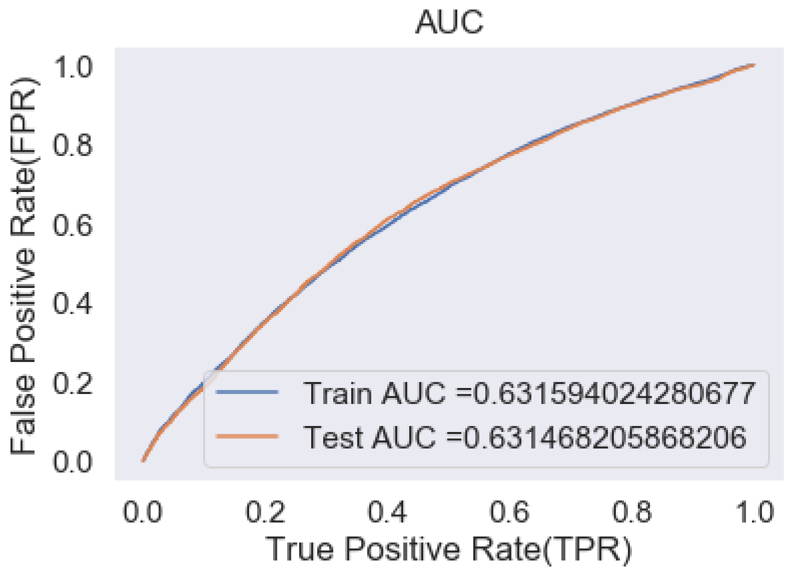


In [136]:

```
optimal_alpha = 0.0001
```

In [147]:

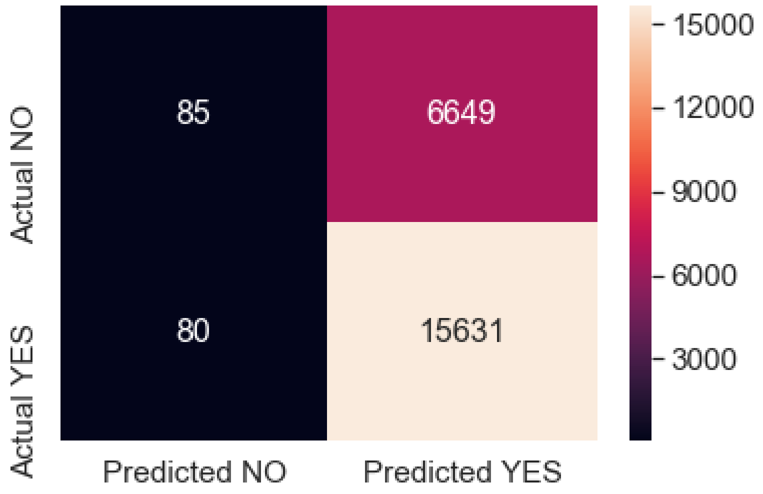
```
from sklearn.metrics import roc_curve, auc

sgd_tfidf = SGDClassifier(alpha=0.0001, loss='hinge', penalty='l1',tol=0.001)
cal_tfidf = CalibratedClassifierCV(sgd_tfidf, method='sigmoid', cv='warn')
cal_tfidf.fit(X_train, y_train)

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

y_train_pred = batch_predict(cal_tfidf, X_train)
y_test_pred = batch_predict(cal_tfidf, X_test)

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()
```



Confusion matrix

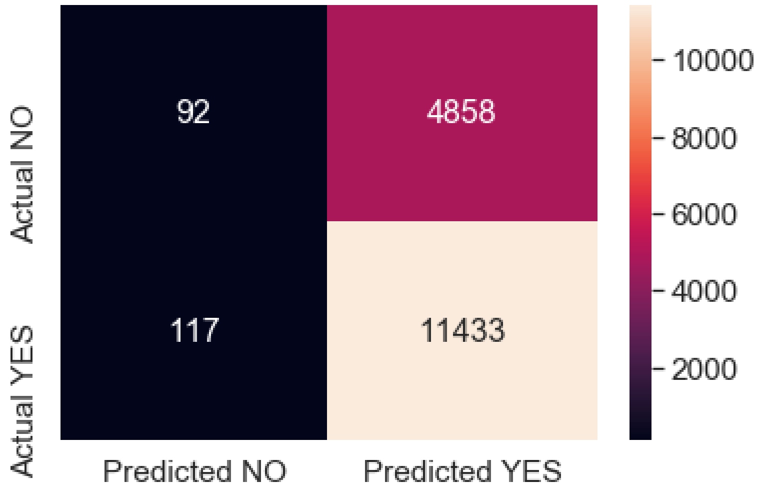
In [148]:

```
get_confusion_matrix(cal_tfidf,X_train,y_train)
```



In [149]:

```
get_confusion_matrix(cal_tfidf,X_test,y_test)
```



Evaluating Model performance

In [150]:

```
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score

y_pred_new = cal_tfidf.predict(X_test)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(y_test, y_pred_new)*100))
print("Precision on test set: %0.3f"%(precision_score(y_test, y_pred_new)))
print("Recall on test set: %0.3f"%(recall_score(y_test, y_pred_new)))
print("F1-Score on test set: %0.3f"%(f1_score(y_test, y_pred_new)))
```

```
Accuracy on test set: 69.848%
Precision on test set: 0.702
Recall on test set: 0.990
F1-Score on test set: 0.821
```

In [151]:

```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Hyperparameter","Penalty", "Train AUC","Test AUC","F1 Score

x.add_row(["BoW (set 1)",0.01,"l2", 0.81, 0.71,0.827,"72.055%"])
x.add_row(["TFIDF (set 2)",0.001,"l2", 0.74, 0.69,0.827,"71.697%"])
x.add_row(["AVG W2V (set 3)",0.001,"l2", 0.69, 0.67,0.826,"70.806%"])
x.add_row(["TFIDF W2V (set 4)",0.001,"l2", 0.71, 0.68, 0.826,"70.855%"])
x.add_row(["TFIDF TruncatedSVD",0.0001,"l2", 0.63, 0.63,0.821,"69.848%"])

print(x)
```

```
+--------------------+----------------+---------+-----------+----------+----
------+----------------------+
|     Vectorizer     | Hyperparameter | Penalty | Train AUC | Test AUC | F1
Score | Accuracy on test set |
+--------------------+----------------+---------+-----------+----------+----
------+----------------------+
|    BoW (set 1)     |      0.01      |    l2   |    0.81   |   0.71   |  0.
827   |       72.055%        |
|   TFIDF (set 2)    |     0.001      |    l2   |    0.74   |   0.69   |  0.
827   |       71.697%        |
|  AVG W2V (set 3)   |     0.001      |    l2   |    0.69   |   0.67   |  0.
826   |       70.806%        |
| TFIDF W2V (set 4)  |     0.001      |    l2   |    0.71   |   0.68   |  0.
826   |       70.855%        |
| TFIDF TruncatedSVD |     0.0001     |    l2   |    0.63   |   0.63   |  0.
821   |       69.848%        |
+--------------------+----------------+---------+-----------+----------+----
------+----------------------+
```

Conclusion:

1. L2 penalty gave better AUC scores than L1 penalty.
2. All the model has more than 84% accuracy on test set.
3. BoW and Tfidf W2V model has performed slightly better than other models.
4. Linear SVM has performed better than any other models so far.

5. Slight decrease in accuracy has been obeserved in the model 5.