In [1]:
```
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
```

```
/Library/Frameworks/Python.framework/Versions/3.7/lib/python3.7/site-pa
ckages/statsmodels/tools/_testing.py:19: FutureWarning: pandas.util.tes
ting is deprecated. Use the functions in the public API at pandas.testi
ng instead.
  import pandas.util.testing as tm
```

In [2]:
```
cd Donor_Naive_bAYES
```

```
/Users/hiralparmar/Downloads/Donor_Naive_bAYES
```

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

In [4]:
```
print("Number of data points in train data", project_data.shape)
print('-'*50)
print("The attributes of data :", project_data.columns.values)
```

```
Number of data points in train data (109248, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefi
x' '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 [5]:
```
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

Out[5]:

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

In [6]:
```
project_data.head()
```

Out[6]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	project_
0	160221	p253737	c90749f5d961ff158d4b4d1e7dc665fc	Mrs.	IN	
1	140945	p258326	897464ce9ddc600bced1151f324dd63a	Mr.	FL	
2	21895	p182444	3465aaf82da834c0582ebd0ef8040ca0	Ms.	AZ	
3	45	p246581	f3cb9bffbba169bef1a77b243e620b60	Mrs.	KY	
4	172407	p104768	be1f7507a41f8479dc06f047086a39ec	Mrs.	TX	

Univariate analysis for featureteacher_number_of_previously_posted_projects

In [7]:
```
#stacked bar plots matplotlib: https://matplotlib.org/gallery/lines_bars_and_markers/bar_stacked.html
def stack_plot(data, xtick, col2='project_is_approved', col3='total'):
    ind = np.arange(data.shape[0])

    plt.figure(figsize=(20,5))
    p1 = plt.bar(ind, data[col3].values)
    p2 = plt.bar(ind, data[col2].values)

    plt.ylabel('Projects')
    plt.title('% of projects aproved state wise')
    plt.xticks(ind, list(data[xtick].values))
    plt.legend((p1[0], p2[0]), ('total', 'accepted'))
    plt.show()
```

In [8]:
```
def univariate_barplots(data, col1, col2='project_is_approved', top=False):
    # Count number of zeros in dataframe python: https://stackoverflow.com/a/51540521/4084039
    temp = pd.DataFrame(project_data.groupby(col1)[col2].agg(lambda x: x.eq(1).sum())).reset_index()

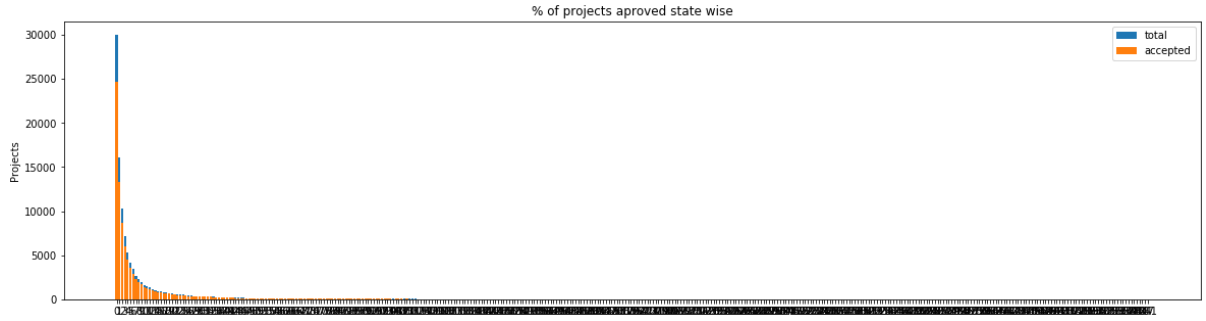
    # Pandas dataframe grouby count: https://stackoverflow.com/a/19385591/4084039
    temp['total'] = pd.DataFrame(project_data.groupby(col1)[col2].agg(total='count')).reset_index()['total']
    temp['Avg'] = pd.DataFrame(project_data.groupby(col1)[col2].agg(Avg='mean')).reset_index()['Avg']

    temp.sort_values(by=['total'],inplace=True, ascending=False)

    if top:
        temp = temp[0:top]

    stack_plot(temp, xtick=col1, col2=col2, col3='total')
    print(temp.head(5))
    print("="*50)
    print(temp.tail(5))
```

In [9]:
```
univariate_barplots(project_data, 'teacher_number_of_previously_posted_projects', 'project_is_approved' , top=False)
```



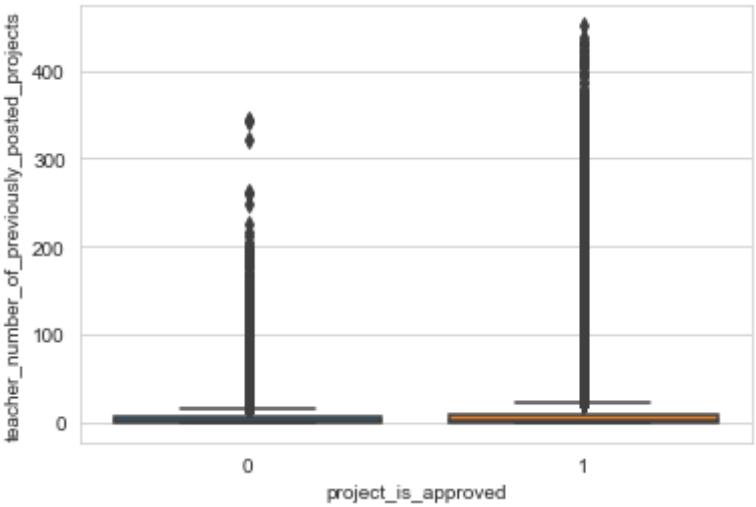

```
   teacher_number_of_previously_posted_projects  project_is_approved  t
otal  \
0                                             0                24652  3
0014
1                                             1                13329  1
6058
2                                             2                 8705  1
0350
3                                             3                 5997
7110
4                                             4                 4452
5266

        Avg
0  0.821350
1  0.830054
2  0.841063
3  0.843460
4  0.845423
==================================================
     teacher_number_of_previously_posted_projects  project_is_approved
total  \
242                                           242                   1
1
268                                           270                   1
1
234                                           234                   1
1
335                                           347                   1
1
373                                           451                   1
1

     Avg
242  1.0
268  1.0
234  1.0
335  1.0
373  1.0
```

In [10]:
```
sns.set_style("whitegrid")
sns.boxplot(x = 'project_is_approved', y = 'teacher_number_of_previously
_posted_projects', data = project_data)
```

Out[10]: <matplotlib.axes._subplots.AxesSubplot at 0x118266b00>



we find more number of projected previsouly posted in project approved

Univariate analysis for feature resource summary

In [11]:
```
sub_catogories = list(project_data['project_resource_summary'].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","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())
```

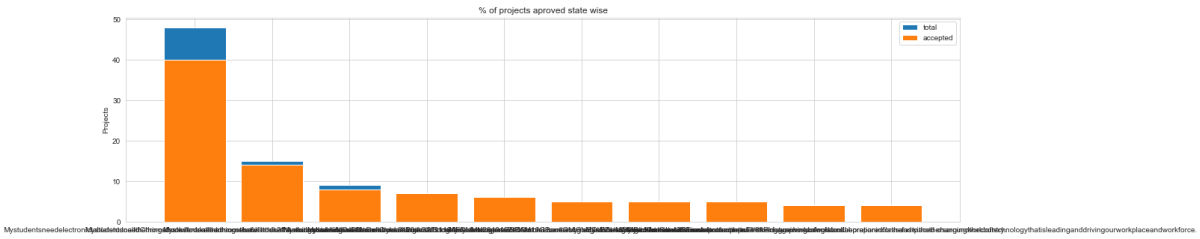
In [12]:
```
project_data['project_resource_summary'] = sub_cat_list

project_data.head(2)
```

Out[12]:

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

In [13]:
```
univariate_barplots(project_data, 'project_resource_summary', 'project_is_approved', top=10)
```




```
                                     project_resource_summary  project_is_ap
proved  \
56503  Mystudentsneedelectronictabletstodoallthething...
40
10221  MystudentsneedChromebookstodoallthethingsthatw...
14
51318  Mystudentsneedchromebookstodoallthethingsthatw...
8
18711  MystudentsneedaDellChromebook3120andaGoogleEDU...
7
18707  MystudentsneedaDellChromebook3120116CeleronN28...
6

       total       Avg
56503     48  0.833333
10221     15  0.933333
51318      9  0.888889
18711      7  1.000000
18707      6  1.000000
==================================================
                                     project_resource_summary  project_is_ap
proved  \
18713  MystudentsneedaDellChromebookandGoogleEDUManag...
5
4340   Mystudentsneed3\"iPad\"minisandcasestoprotectt...
5
4327   Mystudentsneed3TexasInstrumentsTI-84Plusgraphi...
5
3863   Mystudentsneed3Chromebookcomputerstoengageinme...
4
51121  Mystudentsneedchromebooksinordertocompetewitht...
4

       total  Avg
18713      5  1.0
4340       5  1.0
4327       5  1.0
3863       4  1.0
51121      4  1.0
```

In [14]:
```
project_data = pd.read_csv('train_data.csv')
```

In [15]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import pandas as pd
import numpy as np
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer


import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/

from nltk.corpus import stopwords
import pickle

from tqdm import tqdm
import os
```

In [16]:
```
# https://stackoverflow.com/questions/36383821/pandas-dataframe-apply-function-to-column-strings-based-on-other-column-value
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(' ','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace('-','_')
project_data['project_grade_category'] = project_data['project_grade_category'].str.lower()
project_data['project_grade_category'].value_counts()
```

Out[16]:
```
grades_prek_2    44225
grades_3_5       37137
grades_6_8       16923
grades_9_12      10963
Name: project_grade_category, dtype: int64
```

In [17]:
```
project_data['project_subject_categories'] = project_data['project_subject_categories'].str.replace(' The ','')
project_data['project_subject_categories'] = project_data['project_subject_categories'].str.replace(' ','')
project_data['project_subject_categories'] = project_data['project_subject_categories'].str.replace('&','_')
project_data['project_subject_categories'] = project_data['project_subject_categories'].str.replace(',','_')
project_data['project_subject_categories'] = project_data['project_subject_categories'].str.lower()
#project_data['project_subject_categories'].value_counts()
```

In [18]:
```
project_data['teacher_prefix'].value_counts()
# check if we have any nan values are there
print(project_data['teacher_prefix'].isnull().values.any())
print("number of nan values",project_data['teacher_prefix'].isnull().values.sum())
```

```
True
number of nan values 3
```

In [19]:
```
project_data['teacher_prefix']=project_data['teacher_prefix'].fillna('Mrs.')
#project_data['teacher_prefix'].value_counts()
```

In [20]:
```
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace('.','')
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.lower()
#project_data['teacher_prefix'].value_counts()
```

In [21]:
```
project_data['project_subject_subcategories'].value_counts()
```

Out[21]:
```
Literacy                                    9486
Literacy, Mathematics                       8325
Literature & Writing, Mathematics           5923
Literacy, Literature & Writing              5571
Mathematics                                 5379
                                            ...
Economics, Nutrition Education                 1
Economics, Music                               1
Gym & Fitness, Parent Involvement              1
Civics & Government, Nutrition Education       1
Community Service, Gym & Fitness               1
Name: project_subject_subcategories, Length: 401, dtype: int64
```

In [22]:
```
project_data['project_subject_subcategories'] = project_data['project_su
bject_subcategories'].str.replace(' The ','')
project_data['project_subject_subcategories'] = project_data['project_su
bject_subcategories'].str.replace(' ','')
project_data['project_subject_subcategories'] = project_data['project_su
bject_subcategories'].str.replace('&','_')
project_data['project_subject_subcategories'] = project_data['project_su
bject_subcategories'].str.replace(',','_')
project_data['project_subject_subcategories'] = project_data['project_su
bject_subcategories'].str.lower()
project_data['project_subject_subcategories'].value_counts()
```

Out[22]:
```
literacy                                9486
literacy_mathematics                    8325
literature_writing_mathematics          5923
literacy_literature_writing             5571
mathematics                             5379
                                        ...
gym_fitness_warmth_care_hunger             1
gym_fitness_parentinvolvement              1
extracurricular_financialliteracy          1
economics_foreignlanguages                 1
college_careerprep_warmth_care_hunger      1
Name: project_subject_subcategories, Length: 401, dtype: int64
```

In [23]:
```
project_data['school_state'].value_counts()
```

Out[23]:
```
CA    15388
TX     7396
NY     7318
FL     6185
NC     5091
IL     4350
GA     3963
SC     3936
MI     3161
PA     3109
IN     2620
MO     2576
OH     2467
LA     2394
MA     2389
WA     2334
OK     2276
NJ     2237
AZ     2147
VA     2045
WI     1827
AL     1762
UT     1731
TN     1688
CT     1663
MD     1514
NV     1367
MS     1323
KY     1304
OR     1242
MN     1208
CO     1111
AR     1049
ID      693
IA      666
KS      634
NM      557
DC      516
HI      507
ME      505
WV      503
NH      348
AK      345
DE      343
NE      309
SD      300
RI      285
MT      245
ND      143
WY       98
VT       80
Name: school_state, dtype: int64
```

In [24]:
```
project_data['school_state'] = project_data['school_state'].str.lower()
project_data['school_state'].value_counts()
```

Out[24]:
```
ca    15388
tx     7396
ny     7318
fl     6185
nc     5091
il     4350
ga     3963
sc     3936
mi     3161
pa     3109
in     2620
mo     2576
oh     2467
la     2394
ma     2389
wa     2334
ok     2276
nj     2237
az     2147
va     2045
wi     1827
al     1762
ut     1731
tn     1688
ct     1663
md     1514
nv     1367
ms     1323
ky     1304
or     1242
mn     1208
co     1111
ar     1049
id      693
ia      666
ks      634
nm      557
dc      516
hi      507
me      505
wv      503
nh      348
ak      345
de      343
ne      309
sd      300
ri      285
mt      245
nd      143
wy       98
vt       80
Name: school_state, dtype: int64
```

In [25]:
```
# https://stackoverflow.com/a/47091490/4084039
import re

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

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

In [26]:
```
# 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", 'it
s', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'thi
s', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'ha
ve', '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', 'i
nto', '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', 'ho
w', '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", 'd
idn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "is
n't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn',
"shouldn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [27]:
```
project_data['project_title'].head(5)
```

Out[27]:
```
0     Educational Support for English Learners at Home
1                Wanted: Projector for Hungry Learners
2    Soccer Equipment for AWESOME Middle School Stu...
3                                Techie Kindergarteners
4                                Interactive Math Tools
Name: project_title, dtype: object
```

In [28]:
```
print("printing some random reviews")
print(9, project_data['project_title'].values[9])
print(34, project_data['project_title'].values[34])
print(147, project_data['project_title'].values[147])
```

```
printing some random reviews
9 Just For the Love of Reading--\r\nPure Pleasure
34 \"Have A Ball!!!\"
147 Who needs a Chromebook?\r\nWE DO!!
```

In [29]:
```
# Combining all the above stundents
from tqdm import tqdm
def preprocess_text(text_data):
    preprocessed_text = []
    # tqdm is for printing the status bar
    for sentance in tqdm(text_data):
        sent = decontracted(sentance)
        sent = sent.replace('\\r', ' ')
        sent = sent.replace('\\n', ' ')
        sent = sent.replace('\\"', ' ')
        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 stop
words)
        preprocessed_text.append(sent.lower().strip())
    return preprocessed_text
```

In [30]:
```
preprocessed_titles = preprocess_text(project_data['project_title'].valu
es)
```

```
100%|██████████| 109248/109248 [00:03<00:00, 27661.83it/s]
```

In [31]:
```
print("printing some random reviews")
print(9, preprocessed_titles[9])
print(34, preprocessed_titles[34])
print(147, preprocessed_titles[147])
```

```
printing some random reviews
9 love reading pure pleasure
34 ball
147 needs chromebook
```

In [32]:
```
# 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 [33]:
```
print("printing some random essay")
print(9, project_data['essay'].values[9])
print('-'*50)
print(34, project_data['essay'].values[34])
print('-'*50)
print(147, project_data['essay'].values[147])
```

printing some random essay
9 Over 95% of my students are on free or reduced lunch. I have a few w
ho are homeless, but despite that, they come to school with an eagernes
s to learn. My students are inquisitive eager learners who embrace th
e challenge of not having great books and other resources every day.
Many of them are not afforded the opportunity to engage with these big
colorful pages of a book on a regular basis at home and they don't trav
el to the public library. \r\nIt is my duty as a teacher to do all I c
an to provide each student an opportunity to succeed in every aspect of
life. \r\nReading is Fundamental! My students will read these books ove
r and over again while boosting their comprehension skills. These books
will be used for read alouds, partner reading and for Independent readi
ng. \r\nThey will engage in reading to build their \"Love for Reading\"
by reading for pure enjoyment. They will be introduced to some new auth
ors as well as some old favorites. I want my students to be ready for t
he 21st Century and know the pleasure of holding a good hard back book
in hand. There's nothing like a good book to read! \r\nMy students wil
l soar in Reading, and more because of your consideration and generous
funding contribution. This will help build stamina and prepare for 3rd
grade. Thank you so much for reading our proposal!nannan
---
34 My students mainly come from extremely low-income families, and the
majority of them come from homes where both parents work full time. Mos
t of my students are at school from 7:30 am to 6:00 pm (2:30 to 6:00 pm
in the after-school program), and they all receive free and reduced mea
ls for breakfast and lunch. \r\n\r\n\r\nI want my students to feel as
comfortable in my classroom as they do at home. Many of my students tak
e on multiple roles both at home as well as in school. They are sometim
es the caretakers of younger siblings, cooks, babysitters, academics, f
riends, and most of all, they are developing who they are going to beco
me as adults. I consider it an essential part of my job to model helpi
ng others gain knowledge in a positive manner. As a result, I have a co
mmunity of students who love helping each other in and outside of the c
lassroom. They consistently look for opportunities to support each othe
r's learning in a kind and helpful way.I am excited to be experimenting
with alternative seating in my classroom this school year. Studies have
shown that giving students the option of where they sit in a classroom
increases focus as well as motivation. \r\n\r\nBy allowing students ch
oice in the classroom, they are able to explore and create in a welcomi
ng environment. Alternative classroom seating has been experimented wit
h more frequently in recent years. I believe (along with many others),
that every child learns differently. This does not only apply to how mu
ltiplication is memorized, or a paper is written, but applies to the sp
ace in which they are asked to work. I have had students in the past as
k \"Can I work in the library? Can I work on the carpet?\" My answer wa
s always, \"As long as you're learning, you can work wherever you want!
\" \r\n\r\nWith the yoga balls and the lap-desks, I will be able to inc
rease the options for seating in my classroom and expand its imaginable
space.nannan
---
147 My students are eager to learn and make their mark on the world.\r
\n\r\nThey come from a Title 1 school and need extra love.\r\n\r\nMy fo
urth grade students are in a high poverty area and still come to school
every day to get their education. I am trying to make it fun and educat
ional for them so they can get the most out of their schooling. I creat
ed a caring environment for the students to bloom! They deserve the bes
t.\r\nThank you!\r\nI am requesting 1 Chromebook to access online inter

```
ventions, differentiate instruction, and get extra practice. The Chrome
book will be used to supplement ELA and math instruction. Students will
play ELA and math games that are engaging and fun, as well as participa
te in assignments online. This in turn will help my students improve th
eir skills. Having a Chromebook in the classroom would not only allow s
tudents to use the programs at their own pace, but would ensure more st
udents are getting adequate time to use the programs. The online progra
ms have been especially beneficial to my students with special needs. T
hey are able to work at their level as well as be challenged with some
different materials. This is making these students more confident in th
eir abilities.\r\n\r\nThe Chromebook would allow my students to have da
ily access to computers and increase their computing skills.\r\nThis wi
ll change their lives for the better as they become more successful in
school. Having access to technology in the classroom would help bridge
the achievement gap.nannan
```

In [34]:
```
preprocessed_essays = preprocess_text(project_data['essay'].values)
```

```
100%|██████████| 109248/109248 [01:34<00:00, 1153.38it/s]
```

In [35]:
```
project_data['preprocessed_essays'] = preprocessed_essays
```

In [36]:
```
project_data['preprocessed_titles']=preprocessed_titles
```

In [37]:
```
project_data.drop(['project_essay_1','project_essay_2','project_essay_3'
,'project_essay_4','project_resource_summary','project_title','essay'],
axis=1, inplace=True)
```

In [38]:
```
project_data.drop(['Unnamed: 0'], axis=1, inplace=True)
```

In [39]:
```
# 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()
price_data.head(2)
```

Out[39]:

	id	price	quantity
0	p000001	459.56	7
1	p000002	515.89	21

In [40]:
```
# join two dataframes in python:
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [41]:
```
project_data['price'].head()
```

Out[41]:
```
0    154.60
1    299.00
2    516.85
3    232.90
4     67.98
Name: price, dtype: float64
```

In [42]:
```
project_data.drop(['quantity'], axis=1, inplace=True)
```

count word in title

In [44]:
```
#https://www.geeksforgeeks.org/python-program-to-count-words-in-a-sentence/
title_word_count = []
for i in project_data["preprocessed_titles"] :
    find_length = len(i.split())
    title_word_count.append(find_length)
project_data["title_word_count"] = title_word_count
```

In [45]:
```
#count essay word length
#https://www.geeksforgeeks.org/python-program-to-count-words-in-a-sentence/
essay_word_count = []
for i in project_data["preprocessed_essays"] :
    find_length = len(i.split())
    essay_word_count.append(find_length)
project_data["essay_word_count"] = essay_word_count
```

In [46]:
```
project_data.drop(['project_submitted_datetime'], axis=1, inplace=True)
```

train test split

In [47]:
```
y = project_data['project_is_approved'].values
X = project_data.drop(['project_is_approved'], axis=1)
X.head(1)
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)
```

Calculate Bag of Words

In [48]:
```
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)


vectorizer_essay_bow = CountVectorizer(min_df=10,ngram_range=(1,4), max_
features=5000)
vectorizer_essay_bow.fit(X_train['preprocessed_essays'].values) # fit ha
s to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer_essay_bow.transform(X_train['preprocessed
_essays'].values)
X_cv_essay_bow = vectorizer_essay_bow.transform(X_cv['preprocessed_essay
s'].values)
X_test_essay_bow = vectorizer_essay_bow.transform(X_test['preprocessed_e
ssays'].values)

print("After vectorizations")
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)
print("="*100)
```

```
(49041, 13) (49041,)
(24155, 13) (24155,)
(36052, 13) (36052,)
============================================================================
============================
After vectorizations
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
============================================================================
============================
```

Bag of words for project_title feature

In [49]:
```
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)


vectorizer_project_title_bow = CountVectorizer(min_df=10,ngram_range=(1,
4), max_features=5000)
vectorizer_project_title_bow.fit(X_train['preprocessed_titles'].values)
# fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_project_title_bow = vectorizer_project_title_bow.transform(X_tra
in['preprocessed_titles'].values)
X_cv_project_title_bow = vectorizer_project_title_bow.transform(X_cv['pr
eprocessed_titles'].values)
X_test_project_title_bow = vectorizer_project_title_bow.transform(X_test
['preprocessed_titles'].values)

print("After vectorizations")
print(X_train_project_title_bow.shape, y_train.shape)
print(X_cv_project_title_bow.shape, y_cv.shape)
print(X_test_project_title_bow.shape, y_test.shape)
print("="*100)
```

```
(49041, 13) (49041,)
(24155, 13) (24155,)
(36052, 13) (36052,)
====================================================================
============================
After vectorizations
(49041, 3410) (49041,)
(24155, 3410) (24155,)
(36052, 3410) (36052,)
====================================================================
============================
```

One hot encoding for other categorical features

for school state feature

In [50]:
```
vectorizer_school_state = CountVectorizer()
vectorizer_school_state.fit(X_train['school_state'].values) # fit has to
happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_state_ohe = vectorizer_school_state.transform(X_train['school_st
ate'].values)
X_cv_state_ohe = vectorizer_school_state.transform(X_cv['school_state'].
values)
X_test_state_ohe = vectorizer_school_state.transform(X_test['school_stat
e'].values)

print("After vectorizations")
print(X_train_state_ohe.shape, y_train.shape)
print(X_cv_state_ohe.shape, y_cv.shape)
print(X_test_state_ohe.shape, y_test.shape)
print(vectorizer_school_state.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'h
i', 'ia', 'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi',
'mn', 'mo', 'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny',
'oh', 'ok', 'or', 'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt',
'wa', 'wi', 'wv', 'wy']
====================================================================
============================
```

for teacher_prefix feature

In [51]:
```
vectorizer_teacher_prefix = CountVectorizer()
vectorizer_teacher_prefix.fit(X_train['teacher_prefix'].values) # fit ha
s to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer_teacher_prefix.transform(X_train['teach
er_prefix'].values)
X_cv_teacher_ohe = vectorizer_teacher_prefix.transform(X_cv['teacher_pre
fix'].values)
X_test_teacher_ohe = vectorizer_teacher_prefix.transform(X_test['teacher
_prefix'].values)

print("After vectorizations")
print(X_train_teacher_ohe.shape, y_train.shape)
print(X_cv_teacher_ohe.shape, y_cv.shape)
print(X_test_teacher_ohe.shape, y_test.shape)
print(vectorizer_teacher_prefix.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 5) (49041,)
(24155, 5) (24155,)
(36052, 5) (36052,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================
============================
```

for project_grade_Category feature

In [52]:
```
vectorizer_project_grade_category = CountVectorizer()
vectorizer_project_grade_category.fit(X_train['project_grade_category'].
values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_grade_ohe = vectorizer_project_grade_category.transform(X_train[
'project_grade_category'].values)
X_cv_grade_ohe = vectorizer_project_grade_category.transform(X_cv['proje
ct_grade_category'].values)
X_test_grade_ohe =vectorizer_project_grade_category.transform(X_test['pr
oject_grade_category'].values)

print("After vectorizations")
print(X_train_grade_ohe.shape, y_train.shape)
print(X_cv_grade_ohe.shape, y_cv.shape)
print(X_test_grade_ohe.shape, y_test.shape)
print(vectorizer_project_grade_category.get_feature_names())
print("="*100)
```

```
After vectorizations
(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
============================================================================
==============================
```

for project_subject_categories and project_subject_subcategories

In [53]:
```
vectorizer_project_subject_category = CountVectorizer()
vectorizer_project_subject_category.fit(X_train['project_subject_categor
ies'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_subject_ohe = vectorizer_project_subject_category.transform(X_tr
ain['project_subject_categories'].values)
X_cv_subject_ohe = vectorizer_project_subject_category.transform(X_cv['p
roject_subject_categories'].values)
X_test_subject_ohe =vectorizer_project_subject_category.transform(X_test
['project_subject_categories'].values)

print("After vectorizations")
print(X_train_subject_ohe.shape, y_train.shape)
print(X_cv_subject_ohe.shape, y_cv.shape)
print(X_test_subject_ohe.shape, y_test.shape)

print("="*100)
```

```
After vectorizations
(49041, 50) (49041,)
(24155, 50) (24155,)
(36052, 50) (36052,)
============================================================================
==============================
```

In [54]:
```
vectorizer_project_subject_subcategories = CountVectorizer()
vectorizer_project_subject_subcategories.fit(X_train['project_subject_su
bcategories'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_sub_subject_ohe = vectorizer_project_subject_subcategories.trans
form(X_train['project_subject_subcategories'].values)
X_cv_sub_subject_ohe = vectorizer_project_subject_subcategories.transfor
m(X_cv['project_subject_subcategories'].values)
X_test_sub_subject_ohe =vectorizer_project_subject_subcategories.transfo
rm(X_test['project_subject_subcategories'].values)

print("After vectorizations")
print(X_train_sub_subject_ohe .shape, y_train.shape)
print(X_cv_sub_subject_ohe.shape, y_cv.shape)
print(X_test_sub_subject_ohe.shape, y_test.shape)

print("="*100)
```

```
After vectorizations
(49041, 377) (49041,)
(24155, 377) (24155,)
(36052, 377) (36052,)
====================================================================
============================
```

encoding numerical features: Price

price feature

In [55]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

X_train_price_norm = normalizer.transform(X_train['price'].values.reshap
e(1,-1)).reshape(-1,1)
X_cv_price_norm = normalizer.transform(X_cv['price'].values.reshape(1,-1
)).reshape(-1,1)
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(
1,-1)).reshape(-1,1)



print("After vectorizations")
print(X_train_price_norm.shape, y_train.shape)
print(X_cv_price_norm.shape, y_cv.shape)
print(X_test_price_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

normalize title word count feature

In [56]:
```
normalizer = Normalizer()

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

X_train_title_word_count_norm = normalizer.transform(X_train['title_word
_count'].values.reshape(1,-1)).reshape(-1,1)
X_cv_title_word_count_norm = normalizer.transform(X_cv['title_word_coun
t'].values.reshape(1,-1)).reshape(-1,1)
X_test_title_word_count_norm = normalizer.transform(X_test['title_word_c
ount'].values.reshape(1,-1)).reshape(-1,1)



print("After vectorizations")
print(X_train_title_word_count_norm.shape, y_train.shape)
print(X_cv_title_word_count_norm.shape, y_cv.shape)
print(X_test_title_word_count_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================================
```

normalize essay_word_count

In [57]:
```
normalizer = Normalizer()

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

X_train_essay_word_count_norm = normalizer.transform(X_train['essay_word
_count'].values.reshape(1,-1)).reshape(-1,1)
X_cv_essay_word_count_norm = normalizer.transform(X_cv['essay_word_coun
t'].values.reshape(1,-1)).reshape(-1,1)
X_test_essay_word_count_norm = normalizer.transform(X_test['essay_word_c
ount'].values.reshape(1,-1)).reshape(-1,1)



print("After vectorizations")
print(X_train_essay_word_count_norm.shape, y_train.shape)
print(X_cv_essay_word_count_norm.shape, y_cv.shape)
print(X_test_essay_word_count_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================================
============================
```

In [58]:
```
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.

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

X_train_project_submit_count_norm = normalizer.transform(X_train['teache
r_number_of_previously_posted_projects'].values.reshape(-1,1))
X_cv_project_submit_count_norm = normalizer.transform(X_cv['teacher_numb
er_of_previously_posted_projects'].values.reshape(-1,1))
X_test_project_submit_count_norm = normalizer.transform(X_test['teacher_
number_of_previously_posted_projects'].values.reshape(-1,1))

print("After vectorizations")
print(X_train_project_submit_count_norm.shape, y_train.shape)
print(X_cv_project_submit_count_norm.shape, y_cv.shape)
print(X_test_project_submit_count_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
====================================================================
============================
```

Concatinating all the features

In [59]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/408403
9
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_bow,X_train_project_title_bow,X_train_state
_ohe,X_train_teacher_ohe,X_train_grade_ohe,X_train_subject_ohe,X_train_s
ub_subject_ohe,X_train_price_norm,X_train_title_word_count_norm,X_train_
essay_word_count_norm,X_train_project_submit_count_norm)).tocsr()
X_cr = hstack((X_cv_essay_bow,X_cv_project_title_bow,X_cv_state_ohe,X_cv
_teacher_ohe,X_cv_grade_ohe,X_cv_subject_ohe,X_cv_sub_subject_ohe,X_cv_p
rice_norm,X_cv_title_word_count_norm,X_cv_essay_word_count_norm,X_cv_pro
ject_submit_count_norm)).tocsr()
X_te = hstack((X_test_essay_bow,X_test_project_title_bow,X_test_state_oh
e,X_test_teacher_ohe,X_test_grade_ohe,X_test_subject_ohe,X_test_sub_subj
ect_ohe,X_test_price_norm,X_test_title_word_count_norm,X_test_essay_word
_count_norm,X_test_project_submit_count_norm)).tocsr()

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)
print("="*100)
```

```
Final Data matrix
(49041, 8901) (49041,)
(24155, 8901) (24155,)
(36052, 8901) (36052,)
====================================================================
============================
```

Applying Multinomial Naive Bayes: BOW featurization

In [60]:
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probabi
lity estimates of the positive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your tr_loop will be 49041
 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [62]:
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
import math
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive clas
s, confidence values, or non-thresholded measure of
decisions (as returned by “decision_function” on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with
greater label.

"""

train_auc = []
cv_auc = []
log_alpha=[]
#alpha value taken from course case study
alpha = [0.00001,0.0005, 0.0001,0.005,0.001,0.05,0.01,0.1,0.5,1,5,10,50,
100]
for i in tqdm(alpha):
    print("for alpha =", i)
    naive_bayes = MultinomialNB(alpha=i, class_prior = [0.5, 0.5])
    naive_bayes.fit(X_tr, y_train)

    y_train_pred = batch_predict(naive_bayes, X_tr)
    y_cv_pred = batch_predict(naive_bayes, X_cr)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probabi
lity estimates of the positive class
    # 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))

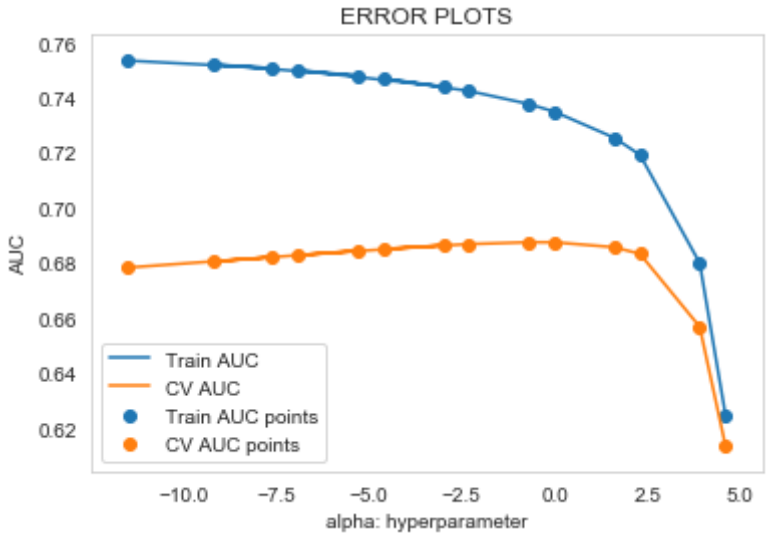
for j in tqdm(alpha):
    k=math.log(j)
    log_alpha.append(k)

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

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

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

```
  0%|          | 0/14 [00:00<?, ?it/s]
for alpha = 1e-05
  7%|▋         | 1/14 [00:00<00:05,  2.38it/s]
for alpha = 0.0005
 14%|█▍        | 2/14 [00:01<00:05,  2.01it/s]
for alpha = 0.0001
 21%|██        | 3/14 [00:01<00:05,  2.01it/s]
for alpha = 0.005
 29%|██▊       | 4/14 [00:01<00:04,  2.34it/s]
for alpha = 0.001
 36%|███▌      | 5/14 [00:02<00:03,  2.56it/s]
for alpha = 0.05
 43%|████▎     | 6/14 [00:02<00:02,  2.79it/s]
for alpha = 0.01
 50%|█████     | 7/14 [00:02<00:02,  2.91it/s]
for alpha = 0.1
 57%|█████▋    | 8/14 [00:03<00:02,  3.00it/s]
for alpha = 0.5
 64%|██████▍   | 9/14 [00:03<00:01,  3.13it/s]
for alpha = 1
 71%|███████▏  | 10/14 [00:03<00:01,  3.19it/s]
for alpha = 5
 79%|███████▊  | 11/14 [00:03<00:00,  3.29it/s]
for alpha = 10
 86%|████████▌ | 12/14 [00:04<00:00,  3.25it/s]
for alpha = 50
 93%|█████████▎| 13/14 [00:04<00:00,  3.43it/s]
for alpha = 100
100%|██████████| 14/14 [00:04<00:00,  2.92it/s]
100%|██████████| 14/14 [00:00<00:00, 21446.40it/s]
```


ERROR PLOTS
AUC
0.76
0.74
0.72
0.70
0.68
0.66
0.64
0.62
Train AUC
CV AUC
Train AUC points
CV AUC points
−10.0
−7.5
−5.0
−2.5
0.0
2.5
5.0
alpha: hyperparameter

Gridsearch

In [63]:
```
#https://scikit-learn.org/stable/modules/grid_search.html
#Gridsearchcv
from sklearn.model_selection import GridSearchCV
naive_bayes = MultinomialNB(class_prior=[0.5,0.5])
#alpha value taken from course case study problem
parameters = {'alpha':[0.00001,0.0005, 0.0001,0.005,0.001,0.05,0.01,0.1,
0.5,1,5,10,50,100]}

clf = GridSearchCV(naive_bayes, parameters, cv= 10, scoring='roc_auc',re
turn_train_score=True,verbose=2)

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']
```

```
Fitting 10 folds for each of 14 candidates, totalling 140 fits
[CV] alpha=1e-05 .....................................................

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent
workers.

[CV] ..................................... alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .....................................................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.3s remaining:
0.0s
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[CV] ...................................... alpha=1e-05, total=   0.4s
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[Parallel(n_jobs=1)]: Done 140 out of 140 | elapsed:   19.5s finished
```

In [65]:
```
alpha = [0.00001,0.0005, 0.0001,0.005,0.001,0.05,0.01,0.1,0.5,1,5,10,50,
100]
log_alpha=[]
for j in tqdm(alpha):
    k = math.log(j)
    log_alpha.append(k)

plt.figure(figsize=(20,10))

plt.plot(log_alpha, train_auc, label='Train AUC')

# this code is copied from here: https://stackoverflow.com/a/48803361/40
84039
# plt.gca().fill_between(K, train_auc - train_auc_std,train_auc + train_
auc_std,alpha=0.2,color='darkblue')

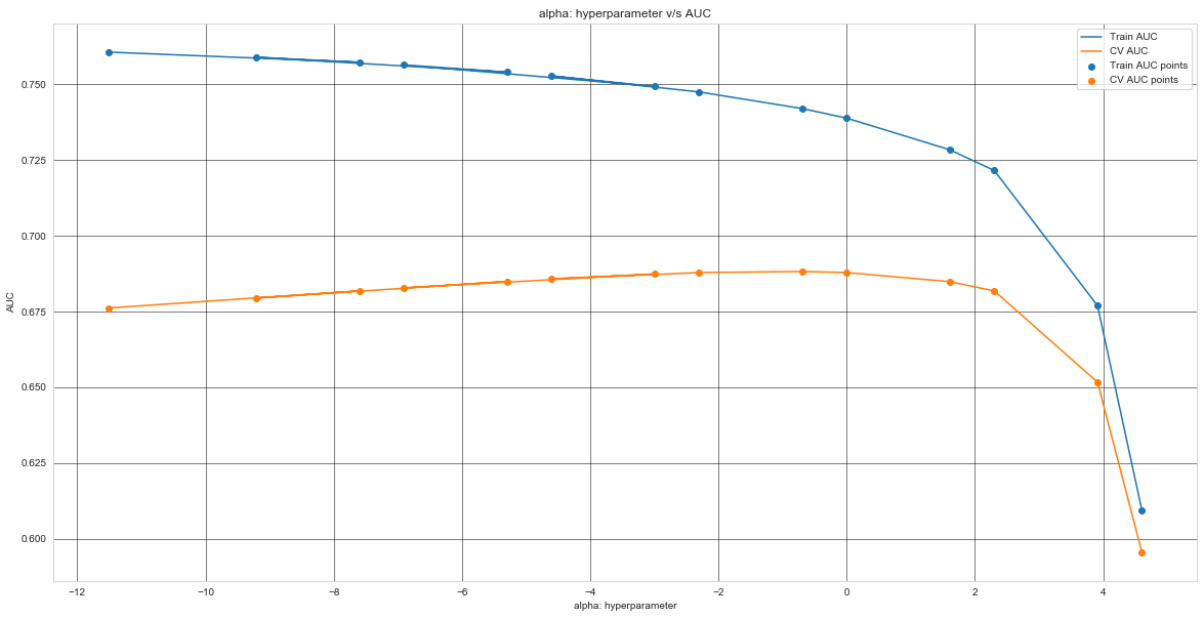


plt.plot(log_alpha, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/40
84039
#plt.gca().fill_between(alpha,cv_auc - cv_auc_std,cv_auc + cv_auc_std,al
pha=0.3,color='darkorange')

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


plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC")
plt.grid(color='black', linestyle='-', linewidth=0.5)
plt.show()
```

```
100%|██████████| 14/14 [00:00<00:00, 5472.53it/s]
```



In [66]:
```
#Output of GridSearchCV
print('Best score: ',clf.best_score_)
print('Bset alpha value : ',clf.best_params_)
```

```
Best score:  0.688214401808872
Bset alpha value :  {'alpha': 0.5}
```

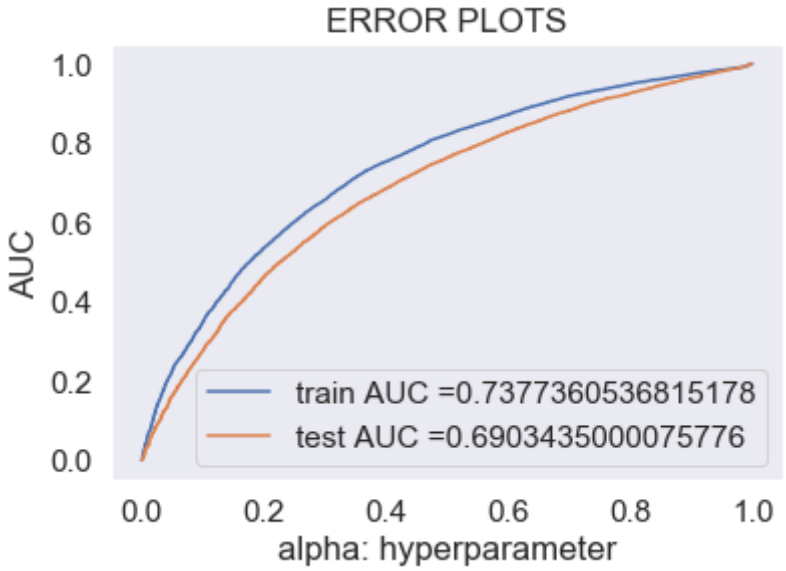
In [82]:
```
best_alpha=0.5
from sklearn.metrics import roc_curve, auc


naive_bayes_bow = MultinomialNB(alpha=0.5,class_prior = [0.5, 0.5])
naive_bayes_bow.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

y_train_pred = batch_predict(naive_bayes_bow, X_tr)
y_test_pred = batch_predict(naive_bayes_bow, 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, tr
ain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_t
pr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [83]:
```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is v
ery high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for thr
eshold", np.round(t,3))
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
print("="*100)

best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t
)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t
)))
```

```
====================================================================
============================
the maximum value of tpr*(1-fpr) 0.4641284479045425 for threshold 0.339
Train confusion matrix
[[ 4869  2557]
 [12157 29458]]
Test confusion matrix
[[ 3214  2245]
 [ 9361 21232]]
```

calculate confusion matrix for train data

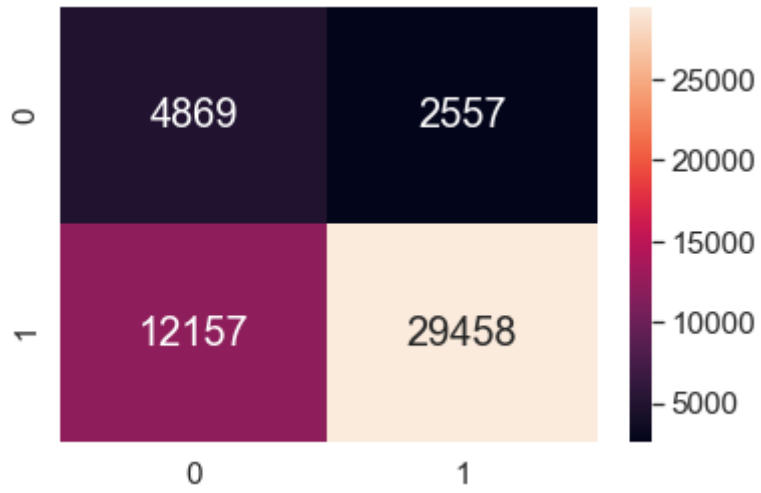
In [84]:
```
#https://stackoverflow.com/questions/61748441/how-to-fix-the-values-displayed-in-a-confusion-matrix-in-exponential-form-to-nor
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix/35572520#35572520
from sklearn.metrics import confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt

print("Train data confusion matrix")

confusion_matrix_train_data = pd.DataFrame(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_train_data, annot=True,annot_kws={"size": 20}, fmt='g')
```

```
Train data confusion matrix
```

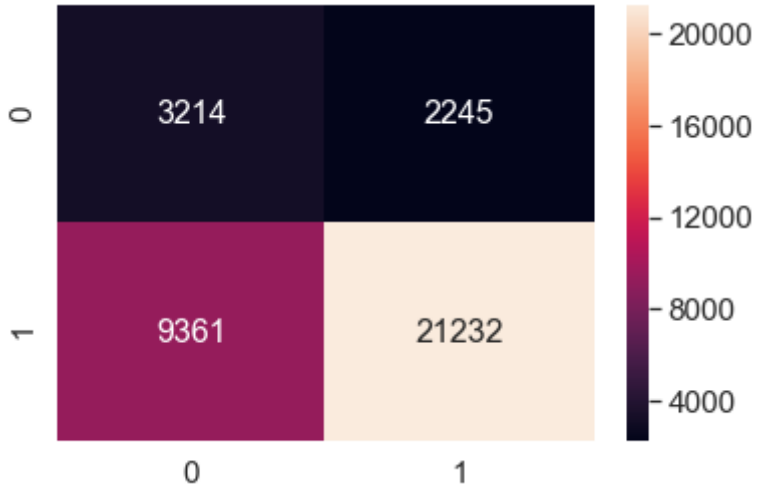
Out[84]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1677beeb8>
```



calculate confusion matrix for test data

In [85]:
```
confusion_matrix_test_data = pd.DataFrame(confusion_matrix(y_test, predi
ct_with_best_t(y_test_pred, best_t)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_test_data, annot=True,annot_kws={"size": 16
}, fmt='g')
```

Out[85]: <matplotlib.axes._subplots.AxesSubplot at 0x143ce7e80>



top20 feature Bow of project_title and essay

In [86]:
```
#https://www.geeksforgeeks.org/python-ways-to-concatenate-two-lists/
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfVectorizer.html
bow_features=[]
for f1 in vectorizer_essay_bow.get_feature_names():
    bow_features.append(f1)

for f2 in vectorizer_project_title_bow.get_feature_names():
    bow_features.append(f2)

for f3 in vectorizer_school_state.get_feature_names():
    bow_features.append(f3)

for f4 in vectorizer_teacher_prefix.get_feature_names():
    bow_features.append(f4)

for f5 in  vectorizer_project_grade_category.get_feature_names():
    bow_features.append(f5)

for f6 in vectorizer_project_subject_category.get_feature_names():
    bow_features.append(f6)

for f7 in vectorizer_project_subject_subcategories.get_feature_names():
    bow_features.append(f7)

bow_features.append("price")

bow_features.append("title_word_count")
bow_features.append("essay_word_count")
bow_features.append("teacher_number_of_previously_posted_projects")
```

In [87]:
```
len(bow_features)
```

Out[87]: 8901

In [93]:
```
#https://stackoverflow.com/questions/50526898/how-to-get-feature-importance-in-naive-bayes
#top20 positive feature and negative fature

print('Top 20 features from positive class:')
neg_class_prob_sorted = naive_bayes_bow.feature_log_prob_[0, :].argsort()   #class 0
pos_class_prob_sorted = naive_bayes_bow.feature_log_prob_[1, :].argsort()   #c
print(np.take(bow_features, neg_class_prob_sorted[-20:]))
print('-'*50)
print(np.take(bow_features, pos_class_prob_sorted[-20:]))
```

```
Top 20 features from positive class:
['use' 'skills' 'materials' 'able' 'reading' 'day' 'love'
 'teacher_number_of_previously_posted_projects' 'come' 'work' 'need'
 'many' 'nannan' 'help' 'learn' 'not' 'classroom' 'learning' 'school'
 'students']
--------------------------------------------------
['would' 'class' 'come' 'able' 'day' 'love'
 'teacher_number_of_previously_posted_projects' 'use' 'reading' 'need'
 'work' 'nannan' 'many' 'help' 'learn' 'not' 'classroom' 'learning'
 'school' 'students']
```

calculate tfidf for feature project_title and essay

In [94]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfVectorizer.html
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)


vectorizer_essay_tfidf = TfidfVectorizer()
vectorizer_essay_tfidf.fit(X_train['preprocessed_essays'].values) # fit has to happen only on train data

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

print("After vectorizations")
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)

print("="*100)
```

```
(49041, 13) (49041,)
(24155, 13) (24155,)
(36052, 13) (36052,)
====================================================================================================
After vectorizations
(49041, 41126) (49041,)
(24155, 41126) (24155,)
(36052, 41126) (36052,)
====================================================================================================
```

In [95]:
```
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extraction.text.TfidfVectorizer.html
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("="*100)

vectorizer_project_title_tfidf = TfidfVectorizer()
vectorizer_project_title_tfidf.fit(X_train['preprocessed_titles'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_project_title_tfidf = vectorizer_project_title_tfidf.transform(X_train['preprocessed_titles'].values)
X_cv_project_title_tfidf = vectorizer_project_title_tfidf.transform(X_cv['preprocessed_titles'].values)
X_test_project_title_tfidf =vectorizer_project_title_tfidf.transform(X_test['preprocessed_titles'].values)

print("After vectorizations")
print(X_train_project_title_tfidf.shape, y_train.shape)
print(X_cv_project_title_tfidf.shape, y_cv.shape)
print(X_test_project_title_tfidf.shape, y_test.shape)

print("="*100)
```

```
(49041, 13) (49041,)
(24155, 13) (24155,)
(36052, 13) (36052,)
====================================================================================================
After vectorizations
(49041, 11537) (49041,)
(24155, 11537) (24155,)
(36052, 11537) (36052,)
====================================================================================================
```

Concatinating all the features

In [96]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/408403
9
from scipy.sparse import hstack
X_tr_2 = hstack((X_train_essay_tfidf,X_train_project_title_tfidf,X_train
_state_ohe,X_train_teacher_ohe,X_train_grade_ohe,X_train_subject_ohe,X_t
rain_sub_subject_ohe,X_train_price_norm,X_train_title_word_count_norm,X_
train_essay_word_count_norm,X_train_project_submit_count_norm)).tocsr()
X_cr_2 = hstack((X_cv_essay_tfidf,X_cv_project_title_tfidf,X_cv_state_oh
e,X_cv_teacher_ohe,X_cv_grade_ohe,X_cv_subject_ohe,X_cv_sub_subject_ohe,
X_cv_price_norm,X_cv_title_word_count_norm,X_cv_essay_word_count_norm,X_
cv_project_submit_count_norm)).tocsr()
X_te_2 = hstack((X_test_essay_tfidf,X_test_project_title_tfidf,X_test_st
ate_ohe,X_test_teacher_ohe,X_test_grade_ohe,X_test_subject_ohe,X_test_su
b_subject_ohe,X_test_price_norm,X_test_title_word_count_norm,X_test_essa
y_word_count_norm,X_test_project_submit_count_norm)).tocsr()

print("Final Data matrix")
print(X_tr_2.shape, y_train.shape)
print(X_cr_2.shape, y_cv.shape)
print(X_te_2.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(49041, 53154) (49041,)
(24155, 53154) (24155,)
(36052, 53154) (36052,)
====================================================================
==============================
```

In [97]:
```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probabi
lity estimates of the positive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your tr_loop will be 49041
 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

In [98]:
```
import matplotlib.pyplot as plt
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import roc_auc_score
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive clas
s, confidence values, or non-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with
greater label.

"""

train_auc = []
cv_auc = []
log_alpha=[]
#alpha value taken from course case study
alpha = [0.00001,0.0005, 0.0001,0.005,0.001,0.05,0.01,0.1,0.5,1,5,10,50,
100]
for i in tqdm(alpha):
    print("for alpha =", i)
    naive_bayes_tfidf = MultinomialNB(alpha=i,class_prior = [0.5, 0.5])
    naive_bayes_tfidf.fit(X_tr_2, y_train)

    y_train_pred = batch_predict( naive_bayes_tfidf, X_tr_2)
    y_cv_pred = batch_predict( naive_bayes_tfidf, X_cr_2)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probabi
lity estimates of the positive class
    # 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))

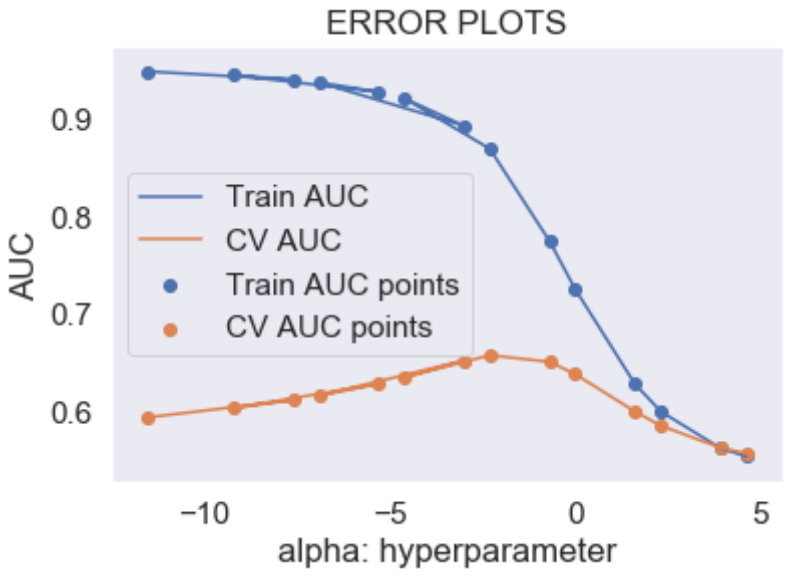
for j in tqdm(alpha):
    k=math.log(j)
    log_alpha.append(k)

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

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

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

```
  0%|          | 0/14 [00:00<?, ?it/s]
for alpha = 1e-05
  7%|▋         | 1/14 [00:00<00:05,  2.28it/s]
for alpha = 0.0005
 14%|█▍        | 2/14 [00:00<00:04,  2.40it/s]
for alpha = 0.0001
 21%|██        | 3/14 [00:01<00:04,  2.34it/s]
for alpha = 0.005
 29%|██▊       | 4/14 [00:01<00:04,  2.50it/s]
for alpha = 0.001
 36%|███▌      | 5/14 [00:01<00:03,  2.60it/s]
for alpha = 0.05
 43%|████▎     | 6/14 [00:02<00:02,  2.72it/s]
for alpha = 0.01
 50%|█████     | 7/14 [00:02<00:02,  2.82it/s]
for alpha = 0.1
 57%|█████▋    | 8/14 [00:02<00:02,  2.76it/s]
for alpha = 0.5
 64%|██████▍   | 9/14 [00:03<00:01,  2.85it/s]
for alpha = 1
 71%|███████▏  | 10/14 [00:03<00:01,  2.92it/s]
for alpha = 5
 79%|███████▊  | 11/14 [00:03<00:01,  2.93it/s]
for alpha = 10
 86%|████████▌ | 12/14 [00:04<00:00,  2.87it/s]
for alpha = 50
 93%|█████████▎| 13/14 [00:04<00:00,  2.91it/s]
for alpha = 100
100%|██████████| 14/14 [00:04<00:00,  2.81it/s]
100%|██████████| 14/14 [00:00<00:00, 13270.11it/s]
```



Gridsearch for tfidf vector

In [99]:
```
#https://scikit-learn.org/stable/modules/grid_search.html
#Gridsearchcv
from sklearn.model_selection import GridSearchCV
naive_bayes = MultinomialNB(class_prior=[0.5,0.5])
#alpha value taken from course case study problem
parameters = {'alpha':[0.00001,0.0005, 0.0001,0.005,0.001,0.05,0.01,0.1,
0.5,1,5,10,50,100]}

clf = GridSearchCV(naive_bayes, parameters, cv= 10, scoring='roc_auc',re
turn_train_score=True,verbose=2)

clf.fit(X_tr_2, 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']
alpha = [0.00001,0.0005, 0.0001,0.005,0.001,0.05,0.01,0.1,0.5,1,5,10,50,
100]


plt.figure(figsize=(20,10))

plt.plot(alpha, train_auc, label='Train AUC')

# this code is copied from here: https://stackoverflow.com/a/48803361/40
84039
# plt.gca().fill_between(K, train_auc - train_auc_std,train_auc + train_
auc_std,alpha=0.2,color='darkblue')



plt.plot(alpha, cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/40
84039
#plt.gca().fill_between(alpha,cv_auc - cv_auc_std,cv_auc + cv_auc_std,al
pha=0.3,color='darkorange')

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


plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("alpha: hyperparameter v/s AUC")
plt.grid(color='black', linestyle='-', linewidth=0.5)
plt.show()
```

```
Fitting 10 folds for each of 14 candidates, totalling 140 fits
[CV] alpha=1e-05 .....................................................

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent
workers.

[CV] ..................................... alpha=1e-05, total=   0.1s
[CV] alpha=1e-05 .....................................................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.3s remaining:
0.0s
```

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[CV] ................................... alpha=1e-05, total=   0.1s
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[CV] ........................................ alpha=10, total=   0.1s
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[CV] ....................................... alpha=100, total=   0.1s
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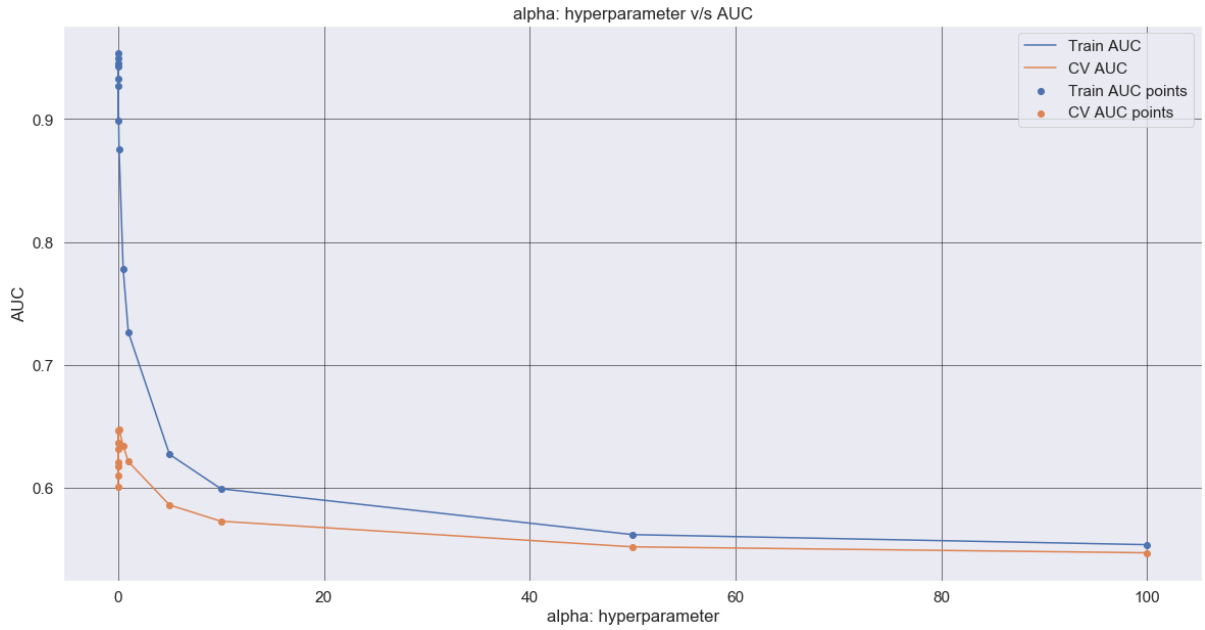
[CV] ....................................... alpha=100, total=   0.1s
[CV] alpha=100 .......................................................
[CV] ....................................... alpha=100, total=   0.1s
[CV] alpha=100 .......................................................
[CV] ....................................... alpha=100, total=   0.1s
[CV] alpha=100 .......................................................
[CV] ....................................... alpha=100, total=   0.1s

[Parallel(n_jobs=1)]: Done 140 out of 140 | elapsed:   19.4s finished
```



In [100]:
```
#Output of GridSearchCV
print('Best score: ',clf.best_score_)
print('Best alpha value : ',clf.best_params_)
```

```
Best score:  0.6474980865573342
Best alpha value :  {'alpha': 0.1}
```

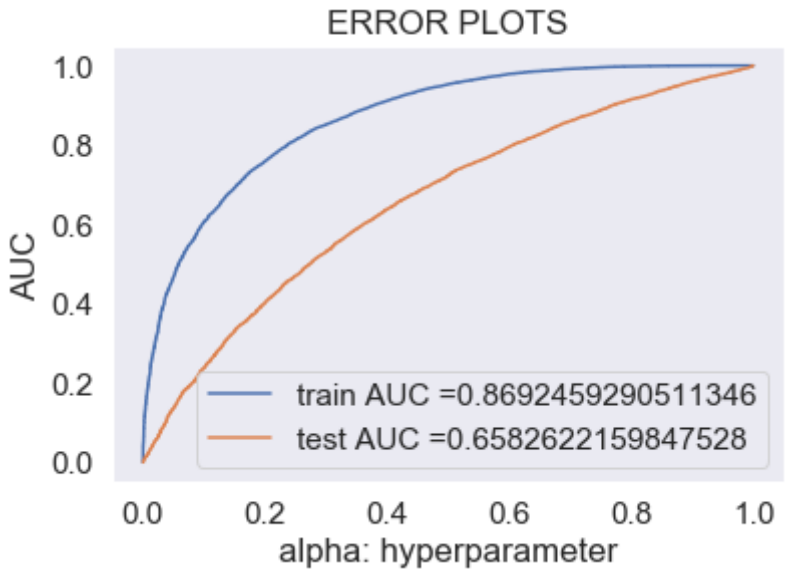
In [101]:
```
best_alpha=0.1
from sklearn.metrics import roc_curve, auc


naive_bayes_tfidf = MultinomialNB(alpha=0.1,class_prior = [0.5, 0.5] )
naive_bayes_tfidf.fit(X_tr_2, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability
estimates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(naive_bayes_tfidf, X_tr_2)
y_test_pred = batch_predict(naive_bayes_tfidf, X_te_2)

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, tr
ain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_t
pr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [102]:
```
# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is v
ery high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for thr
eshold", np.round(t,3))
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t
)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t
)))
```

```
====================================================================
============================
the maximum value of tpr*(1-fpr) 0.6114695068639759 for threshold 0.525
Train confusion matrix
[[ 5650  1776]
 [ 8170 33445]]
Test confusion matrix
[[ 2517  2942]
 [ 7578 23015]]
```

calculate confusion matrix on set2 train data

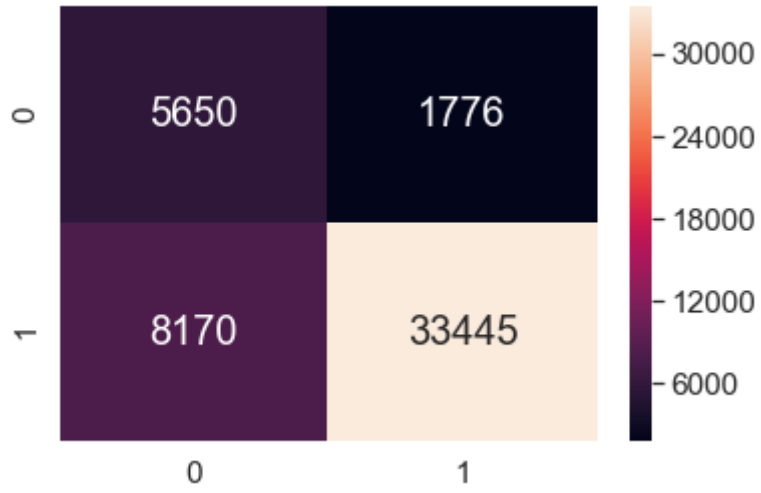
In [104]:
```
#https://stackoverflow.com/questions/61748441/how-to-fix-the-values-displayed-in-a-confusion-matrix-in-exponential-form-to-nor
#https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix/35572520#35572520
from sklearn.metrics import confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt

print("Train data confusion matrix")

confusion_matrix_train_data_set2 = pd.DataFrame(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_train_data_set2, annot=True,annot_kws={"size": 20}, fmt='g')
```

```
Train data confusion matrix
```

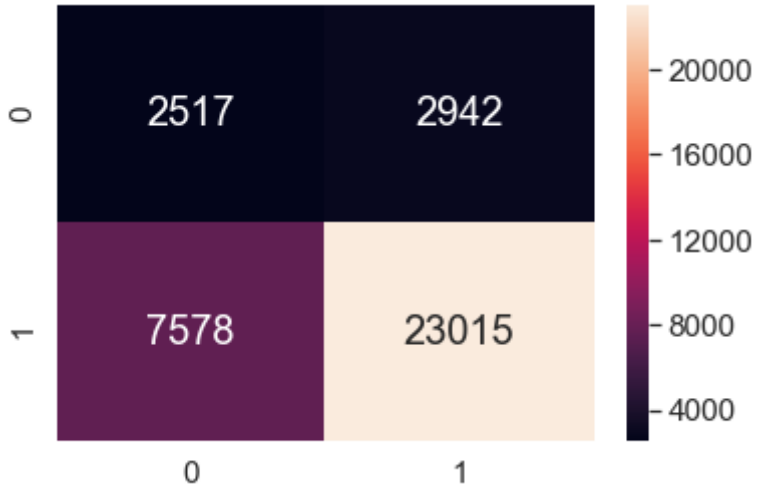
Out[104]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x169ebe518>
```



calculate confusion matrix on set2 test data

In [105]:
```
confusion_matrix_test_data_set2 = pd.DataFrame(confusion_matrix(y_test,
predict_with_best_t(y_test_pred, best_t)), range(2),range(2))
sns.set(font_scale=1.4)#for label size
sns.heatmap(confusion_matrix_test_data_set2, annot=True,annot_kws={"siz
e": 20}, fmt='g')
```

Out[105]: <matplotlib.axes._subplots.AxesSubplot at 0x14b5960f0>



In [107]:
```
#https://www.geeksforgeeks.org/python-ways-to-concatenate-two-lists/
#https://scikit-learn.org/stable/modules/generated/sklearn.feature_extra
ction.text.TfidfVectorizer.html
tfidf_features=[]
for f1 in vectorizer_essay_tfidf.get_feature_names():
    tfidf_features.append(f1)

for f2 in vectorizer_project_title_tfidf.get_feature_names():
    tfidf_features.append(f2)

for f3 in vectorizer_school_state.get_feature_names():
    tfidf_features.append(f3)

for f4 in vectorizer_teacher_prefix.get_feature_names():
    tfidf_features.append(f4)

for f5 in  vectorizer_project_grade_category.get_feature_names():
    tfidf_features.append(f5)

for f6 in vectorizer_project_subject_category.get_feature_names():
    tfidf_features.append(f6)

for f7 in vectorizer_project_subject_subcategories.get_feature_names():
    tfidf_features.append(f7)

tfidf_features.append("price")
tfidf_features.append("quantity")
tfidf_features.append("title_word_count")
tfidf_features.append("essay_word_count")
tfidf_features.append("teacher_number_of_previously_posted_projects")
```

In [108]:
```
len(tfidf_features)
```

Out[108]:
```
53155
```

In [110]:
```
#find top20 feature using tfidf
#https://stackoverflow.com/questions/50526898/how-to-get-feature-importance-in-naive-bayes

neg_class_prob_sorted = naive_bayes_tfidf.feature_log_prob_[0, :].argsort()   #class 0
pos_class_prob_sorted = naive_bayes_tfidf.feature_log_prob_[1, :].argsort()   #class1
print("Top 20 Negative features from set2")
print(np.take(tfidf_features, neg_class_prob_sorted[:20]))
print('-'*100)
print("Top 20 Positive features from set2")
print(np.take(tfidf_features, pos_class_prob_sorted[:20]))
```

```
Top 20 Negative features from set2
['litany' 'overdoses' 'overdeck' 'overcommitted' 'islanders' 'vigorous'
 'overcast' 'overbearing' 'viii' 'overaged' 'overactivity' 'overactive'
 'overachieving' 'overachievers' 'overachiever' 'overabundance' 'ovens'
 'islands' 'ovary' 'oval']
----------------------------------------------------------------------------
----------------------------
Top 20 Positive features from set2
['therapeutically' 'eyedroppers' 'eyesore' 'pics' 'blackfeet' 'wasco'
 'picoult' 'jordanian' 'linus' 'jope' 'miguelito' 'faceing' 'facelift'
 'wast' 'wasteland' 'snacs' 'eyebrow' 'snips' 'wasatch' 'extruder']
```

In [111]:
```
# Please compare all your models using Prettytable library
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

#If you get a ModuleNotFoundError error , install prettytable using: pip
3 install prettytable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Alpha:Hyper Parameter", "Test-A
UC"]

x.add_row(["BagOfWords", "MultinomialNaive Bayes", 0.5, 0.69])
x.add_row(["TFIDF", "MultinomialNaive Bayes", 0.1, 0.64])

print(x)
```

```
+------------+-----------------------+----------------------+--------
--+
| Vectorizer |         Model         | Alpha:Hyper Parameter | Test-AU
C |
+------------+-----------------------+----------------------+--------
--+
| BagOfWords | MultinomialNaive Bayes |          0.5          |   0.69
|
|   TFIDF    | MultinomialNaive Bayes |          0.1          |   0.64
|
+------------+-----------------------+----------------------+--------
--+
```

Summary : After Unvariate amalyisis teachener number of project previously submitted ,we find that it will affect on project approved or not.so we include that feature in model.I used Gridsearch and compute best alpha paramter for both Bag of words and tfidf and got test accuracy score 0.68 and 0.64.Also find set 1 and set 2 top 20 features.

In [ ]: