Chandanachandu124@gmail.com_assignment-7

July 4, 2019

```
In [3]: %matplotlib inline
        import warnings
        warnings.filterwarnings("ignore")

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

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

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

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

        from tqdm import tqdm
        import os

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

1 1.1 Reading Data

```
In [4]: project_data = pd.read_csv('train_data.csv')
        resource_data = pd.read_csv('resources.csv')
```

```
In [5]: print("Number of data points in train data", project_data.shape)
        print('-'*50)
        print("The attributes of data :", project_data.columns.values)
```

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

```
In [6]: # 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.col


        #sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084
        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[6]:        Unnamed: 0       id                        teacher_id teacher_prefix  \
        55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           Mrs.
        76127       37728  p043609  3f60494c61921b3b43ab61bdde2904df            Ms.

              school_state                Date project_grade_category  \
        55660           CA 2016-04-27 00:27:36          Grades PreK-2
        76127           UT 2016-04-27 00:31:25             Grades 3-5

              project_subject_categories            project_subject_subcategories  \
        55660             Math & Science  Applied Sciences, Health & Life Science
```

```
76127                   Special Needs                           Special Needs

                                      project_title  \
55660  Engineering STEAM into the Primary Classroom
76127                       Sensory Tools for Focus

                                         project_essay_1  \
55660  I have been fortunate enough to use the Fairy ...
76127  Imagine being 8-9 years old. You're in your th...

                                         project_essay_2  \
55660  My students come from a variety of backgrounds...
76127  Most of my students have autism, anxiety, anot...

                                         project_essay_3  \
55660  Each month I try to do several science or STEM...
76127  It is tough to do more than one thing at a tim...

                                         project_essay_4  \
55660  It is challenging to develop high quality scie...
76127  When my students are able to calm themselves d...

                                project_resource_summary  \
55660  My students need STEM kits to learn critical s...
76127  My students need Boogie Boards for quiet senso...

       teacher_number_of_previously_posted_projects  project_is_approved
55660                                            53                    1
76127                                             4                    1
```

```
In [7]: project_data["teacher_prefix"].fillna(" ", inplace = True)
```

```
In [8]: teacher_prefix = []

        for i in range(len(project_data)):
            a = project_data["teacher_prefix"][i].replace('.',' ')
            teacher_prefix.append(a)
```

```
In [9]: project_data.drop(['teacher_prefix'], axis=1, inplace=True)
```

```
In [10]: project_data["teacher_prefix"] =teacher_prefix
```

```
In [11]: project_data.head(5)
```

```
Out[11]:        Unnamed: 0       id                        teacher_id school_state  \
         55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           CA
         76127       37728  p043609  3f60494c61921b3b43ab61bdde2904df           UT
         51140       74477  p189804  4a97f3a390bfe21b99cf5e2b81981c73           CA
         473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           GA
```

```
41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           WA

                     Date project_grade_category project_subject_categories  \
55660 2016-04-27 00:27:36          Grades PreK-2             Math & Science
76127 2016-04-27 00:31:25             Grades 3-5              Special Needs
51140 2016-04-27 00:46:53          Grades PreK-2        Literacy & Language
473   2016-04-27 00:53:00          Grades PreK-2           Applied Learning
41558 2016-04-27 01:05:25             Grades 3-5        Literacy & Language

                 project_subject_subcategories  \
55660  Applied Sciences, Health & Life Science
76127                            Special Needs
51140                                 Literacy
473                          Early Development
41558                                 Literacy

                                        project_title  \
55660    Engineering STEAM into the Primary Classroom
76127                         Sensory Tools for Focus
51140  Mobile Learning with a Mobile Listening Center
473            Flexible Seating for Flexible Learning
41558          Going Deep: The Art of Inner Thinking!

                                          project_essay_1  \
55660  I have been fortunate enough to use the Fairy ...
76127  Imagine being 8-9 years old. You're in your th...
51140  Having a class of 24 students comes with diver...
473    I recently read an article about giving studen...
41558  My students crave challenge, they eat obstacle...

                                          project_essay_2  \
55660  My students come from a variety of backgrounds...
76127  Most of my students have autism, anxiety, anot...
51140  I have a class of twenty-four kindergarten stu...
473    I teach at a low-income (Title 1) school. Ever...
41558  We are an urban, public k-5 elementary school...

                                          project_essay_3  \
55660  Each month I try to do several science or STEM...
76127  It is tough to do more than one thing at a tim...
51140  By having a mobile listening and storage cente...
473    We need a classroom rug that we can use as a c...
41558  With the new common core standards that have b...

                                          project_essay_4  \
55660  It is challenging to develop high quality scie...
76127  When my students are able to calm themselves d...
51140  A mobile listening center will help keep equip...
```

```
         473    Benjamin Franklin once said, \"Tell me and I f...
         41558  These remarkable gifts will provide students w...

                                         project_resource_summary  \
         55660  My students need STEM kits to learn critical s...
         76127  My students need Boogie Boards for quiet senso...
         51140  My students need a mobile listening center to ...
         473    My students need flexible seating in the class...
         41558  My students need copies of the New York Times ...

                teacher_number_of_previously_posted_projects  project_is_approved  \
         55660                                             53                    1
         76127                                              4                    1
         51140                                             10                    1
         473                                                2                    1
         41558                                              2                    1

               teacher_prefix
         55660            Mrs
         76127             Mr
         51140             Ms
         473              Mrs
         41558            Mrs
```

```
In [12]: project_grade_category = []

         for i in range(len(project_data)):
             a = project_data["project_grade_category"][i].replace(" ", "_").replace("-","_")
             project_grade_category.append(a)
```

```
In [13]: project_data.drop(['project_grade_category'], axis=1, inplace=True)
```

```
In [14]: project_data["project_grade_category"] = project_grade_category
```

```
In [15]: project_data.head(5)
```

```
Out[15]:        Unnamed: 0       id                        teacher_id school_state  \
         55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           CA
         76127       37728  p043609  3f60494c61921b3b43ab61bdde2904df           UT
         51140       74477  p189804  4a97f3a390bfe21b99cf5e2b81981c73           CA
         473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           GA
         41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           WA

                                Date project_subject_categories  \
         55660 2016-04-27 00:27:36             Math & Science
         76127 2016-04-27 00:31:25              Special Needs
         51140 2016-04-27 00:46:53        Literacy & Language
         473   2016-04-27 00:53:00           Applied Learning
         41558 2016-04-27 01:05:25        Literacy & Language
```

```
                 project_subject_subcategories  \
55660  Applied Sciences, Health & Life Science
76127                            Special Needs
51140                                 Literacy
473                          Early Development
41558                                 Literacy

                                        project_title  \
55660    Engineering STEAM into the Primary Classroom
76127                         Sensory Tools for Focus
51140  Mobile Learning with a Mobile Listening Center
473            Flexible Seating for Flexible Learning
41558          Going Deep: The Art of Inner Thinking!

                                         project_essay_1  \
55660  I have been fortunate enough to use the Fairy ...
76127  Imagine being 8-9 years old. You're in your th...
51140  Having a class of 24 students comes with diver...
473    I recently read an article about giving studen...
41558  My students crave challenge, they eat obstacle...

                                         project_essay_2  \
55660  My students come from a variety of backgrounds...
76127  Most of my students have autism, anxiety, anot...
51140  I have a class of twenty-four kindergarten stu...
473    I teach at a low-income (Title 1) school. Ever...
41558  We are an urban, public k-5 elementary school...

                                         project_essay_3  \
55660  Each month I try to do several science or STEM...
76127  It is tough to do more than one thing at a tim...
51140  By having a mobile listening and storage cente...
473    We need a classroom rug that we can use as a c...
41558  With the new common core standards that have b...

                                         project_essay_4  \
55660  It is challenging to develop high quality scie...
76127  When my students are able to calm themselves d...
51140  A mobile listening center will help keep equip...
473    Benjamin Franklin once said, \"Tell me and I f...
41558  These remarkable gifts will provide students w...

                                project_resource_summary  \
55660  My students need STEM kits to learn critical s...
76127  My students need Boogie Boards for quiet senso...
51140  My students need a mobile listening center to ...
473    My students need flexible seating in the class...
```

```
41558  My students need copies of the New York Times ...

       teacher_number_of_previously_posted_projects  project_is_approved  \
55660                                            53                    1
76127                                             4                    1
51140                                            10                    1
473                                               2                    1
41558                                             2                    1

      teacher_prefix project_grade_category
55660           Mrs          Grades_PreK_2
76127            Mr             Grades_6_8
51140            Ms             Grades_6_8
473             Mrs          Grades_PreK_2
41558           Mrs          Grades_PreK_2
```

2 1.2 Preprocessing of project_subject_categoriesű

In [16]:
```
catogories = list(project_data['project_subject_categories'].values)
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", "Warm
        if 'The' in j.split(): # this will split each of the catogory based on space
            j=j.replace('The','') # if we have the words "The" we are going to replac
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing s
        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]))
```

3 1.3 Preprocessing of project_subject_subcategories

In [17]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/
```

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

        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", "Warm
                if 'The' in j.split(): # this will split each of the catogory based on space
                    j=j.replace('The','') # if we have the words "The" we are going to replac
                j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:
                temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing s
                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/22898595/40840
        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]))
```

4 1.4 Clean Titles (Text preprocessing)

```
In [18]: # 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'
                     "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him'
                     'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself',
                     'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "
                     'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', '
                     'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'a
                     'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'throug
                     'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', '
                     'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'a
                     'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'to
                     's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", '
                     've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't
                     "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mi
                     "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't",
                     'won', "won't", 'wouldn', "wouldn't"]
```

```
In [19]: # 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 [20]: clean_titles = []

         for titles in tqdm(project_data["project_title"]):
             title = decontracted(titles)
             title = title.replace('\\r', ' ')
             title = title.replace('\\"', ' ')
             title = title.replace('\\n', ' ')
             title = re.sub('[^A-Za-z0-9]+', ' ', title)
             title = ' '.join(f for f in title.split() if f not in stopwords)
             clean_titles.append(title.lower().strip())
```

```
100%|| 109248/109248 [00:03<00:00, 30841.29it/s]
```

```
In [21]: project_data["clean_titles"] = clean_titles
```

```
In [22]: project_data.drop(['project_title'], axis=1, inplace=True)
```

Number of Words in Title

```
In [23]: title_word_count = []
```

```
In [24]: for a in project_data["clean_titles"] :
             b = len(a.split())
             title_word_count.append(b)
```

```
In [25]: project_data["title_word_count"] = title_word_count
```

```
In [26]: project_data.head(5)
```

```
Out[26]:        Unnamed: 0       id                        teacher_id school_state  \
         55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           CA
         76127       37728  p043609  3f60494c61921b3b43ab61bdde2904df           UT
         51140       74477  p189804  4a97f3a390bfe21b99cf5e2b81981c73           CA
         473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           GA
         41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           WA

                             Date                                   project_essay_1  \
         55660 2016-04-27 00:27:36  I have been fortunate enough to use the Fairy ...
         76127 2016-04-27 00:31:25  Imagine being 8-9 years old. You're in your th...
         51140 2016-04-27 00:46:53  Having a class of 24 students comes with diver...
         473   2016-04-27 00:53:00  I recently read an article about giving studen...
         41558 2016-04-27 01:05:25  My students crave challenge, they eat obstacle...

                                                  project_essay_2  \
         55660  My students come from a variety of backgrounds...
         76127  Most of my students have autism, anxiety, anot...
         51140  I have a class of twenty-four kindergarten stu...
         473    I teach at a low-income (Title 1) school. Ever...
         41558  We are an urban, public k-5 elementary school...

                                                  project_essay_3  \
         55660  Each month I try to do several science or STEM...
         76127  It is tough to do more than one thing at a tim...
         51140  By having a mobile listening and storage cente...
         473    We need a classroom rug that we can use as a c...
         41558  With the new common core standards that have b...

                                                  project_essay_4  \
         55660  It is challenging to develop high quality scie...
         76127  When my students are able to calm themselves d...
         51140  A mobile listening center will help keep equip...
         473    Benjamin Franklin once said, \"Tell me and I f...
         41558  These remarkable gifts will provide students w...

                                         project_resource_summary  \
         55660  My students need STEM kits to learn critical s...
         76127  My students need Boogie Boards for quiet senso...
         51140  My students need a mobile listening center to ...
         473    My students need flexible seating in the class...
         41558  My students need copies of the New York Times ...

                teacher_number_of_previously_posted_projects  project_is_approved  \
         55660                                            53                    1
         76127                                             4                    1
         51140                                            10                    1
         473                                               2                    1
         41558                                             2                    1
```

```
      teacher_prefix project_grade_category   clean_categories  \
55660           Mrs           Grades_PreK_2       Math_Science
76127            Mr              Grades_6_8       SpecialNeeds
51140            Ms              Grades_6_8  Literacy_Language
473             Mrs           Grades_PreK_2    AppliedLearning
41558           Mrs           Grades_PreK_2  Literacy_Language

                      clean_subcategories  \
55660  AppliedSciences Health_LifeScience
76127                        SpecialNeeds
51140                            Literacy
473                      EarlyDevelopment
41558                            Literacy

                                  clean_titles  title_word_count
55660      engineering steam primary classroom                 4
76127                      sensory tools focus                 3
51140  mobile learning mobile listening center                 5
473         flexible seating flexible learning                 4
41558        going deep the art inner thinking                 6
```

5 1.6 Combine 4 Project essays into 1 Essay

```
In [27]: # 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)
```

6 1.7 Clean Essays (Text preprocessing)

```
In [28]: clean_essay = []

         for ess in tqdm(project_data["essay"]):
             ess = decontracted(ess)
             ess = ess.replace('\\r', ' ')
             ess = ess.replace('\\"', ' ')
             ess = ess.replace('\\n', ' ')
             ess = re.sub('[^A-Za-z0-9]+', ' ', ess)
             ess = ' '.join(f for f in ess.split() if f not in stopwords)
             clean_essay.append(ess.lower().strip())
```

```
100%|| 109248/109248 [01:13<00:00, 1496.29it/s]
```

```
In [29]: project_data["clean_essays"] = clean_essay
In [30]: project_data.drop(['essay'], axis=1, inplace=True)
```

Number of Words in Essay

```
In [31]: essay_word_count = []
```

```
In [32]: for ess in project_data["clean_essays"] :
             c = len(ess.split())
             essay_word_count.append(c)
```

```
In [33]: project_data["essay_word_count"] = essay_word_count
```

```
In [34]: project_data.head(5)
```

```
Out[34]:        Unnamed: 0       id                        teacher_id school_state  \
         55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           CA
         76127       37728  p043609  3f60494c61921b3b43ab61bdde2904df           UT
         51140       74477  p189804  4a97f3a390bfe21b99cf5e2b81981c73           CA
         473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           GA
         41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           WA

                              Date                                    project_essay_1  \
         55660 2016-04-27 00:27:36  I have been fortunate enough to use the Fairy ...
         76127 2016-04-27 00:31:25  Imagine being 8-9 years old. You're in your th...
         51140 2016-04-27 00:46:53  Having a class of 24 students comes with diver...
         473   2016-04-27 00:53:00  I recently read an article about giving studen...
         41558 2016-04-27 01:05:25  My students crave challenge, they eat obstacle...

                                                  project_essay_2  \
         55660  My students come from a variety of backgrounds...
         76127  Most of my students have autism, anxiety, anot...
         51140  I have a class of twenty-four kindergarten stu...
         473    I teach at a low-income (Title 1) school. Ever...
         41558  We are an urban, public k-5 elementary school...

                                                  project_essay_3  \
         55660  Each month I try to do several science or STEM...
         76127  It is tough to do more than one thing at a tim...
         51140  By having a mobile listening and storage cente...
         473    We need a classroom rug that we can use as a c...
         41558  With the new common core standards that have b...

                                                  project_essay_4  \
         55660  It is challenging to develop high quality scie...
         76127  When my students are able to calm themselves d...
         51140  A mobile listening center will help keep equip...
         473    Benjamin Franklin once said, \"Tell me and I f...
         41558  These remarkable gifts will provide students w...
```

```
                                project_resource_summary  \
55660  My students need STEM kits to learn critical s...   
76127  My students need Boogie Boards for quiet senso...   
51140  My students need a mobile listening center to ...   
473    My students need flexible seating in the class...   
41558  My students need copies of the New York Times ...   

       teacher_number_of_previously_posted_projects  project_is_approved  \
55660                                            53                    1   
76127                                             4                    1   
51140                                            10                    1   
473                                               2                    1   
41558                                             2                    1   

      teacher_prefix project_grade_category   clean_categories  \
55660            Mrs          Grades_PreK_2       Math_Science   
76127             Mr             Grades_6_8       SpecialNeeds   
51140             Ms             Grades_6_8  Literacy_Language   
473              Mrs          Grades_PreK_2    AppliedLearning   
41558            Mrs          Grades_PreK_2  Literacy_Language   

                     clean_subcategories  \
55660  AppliedSciences Health_LifeScience   
76127                       SpecialNeeds   
51140                           Literacy   
473                     EarlyDevelopment   
41558                           Literacy   

                                  clean_titles  title_word_count  \
55660      engineering steam primary classroom                 4   
76127                      sensory tools focus                 3   
51140  mobile learning mobile listening center                 5   
473         flexible seating flexible learning                 4   
41558        going deep the art inner thinking                 6   

                                            clean_essays  essay_word_count  
55660  i fortunate enough use fairy tale stem kits cl...               175  
76127  imagine 8 9 years old you third grade classroo...               179  
51140  having class 24 students comes diverse learner...               116  
473    i recently read article giving students choice...               127  
41558  my students crave challenge eat obstacles brea...               114  
```

7 1.9 Calculate Sentiment Scores for the essays

```
In [35]: import nltk
         from nltk.sentiment.vader import SentimentIntensityAnalyzer
```

```
In [36]: analyser = SentimentIntensityAnalyzer()
In [37]: neg = []
         pos = []
         neu = []
         compound = []

         for a in tqdm(project_data["clean_essays"]) :
             b = analyser.polarity_scores(a)['neg']
             c = analyser.polarity_scores(a)['pos']
             d = analyser.polarity_scores(a)['neu']
             e = analyser.polarity_scores(a)['compound']
             neg.append(b)
             pos.append(c)
             neu.append(d)
             compound.append(e)
```

```
100%|| 109248/109248 [16:50<00:00, 108.15it/s]
```

```
In [38]: project_data["pos"] = pos

In [39]: project_data["neg"] = neg

In [40]: project_data["neu"] = neu

In [41]: project_data["compound"] = compound

In [42]: project_data.head(5)
```

```
Out[42]:        Unnamed: 0       id                        teacher_id school_state  \
         55660        8393  p205479  2bf07ba08945e5d8b2a3f269b2b3cfe5           CA
         76127       37728  p043609  3f60494c61921b3b43ab61bdde2904df           UT
         51140       74477  p189804  4a97f3a390bfe21b99cf5e2b81981c73           CA
         473        100660  p234804  cbc0e38f522143b86d372f8b43d4cff3           GA
         41558       33679  p137682  06f6e62e17de34fcf81020c77549e1d5           WA

                               Date                                     project_essay_1  \
         55660 2016-04-27 00:27:36  I have been fortunate enough to use the Fairy ...
         76127 2016-04-27 00:31:25  Imagine being 8-9 years old. You're in your th...
         51140 2016-04-27 00:46:53  Having a class of 24 students comes with diver...
         473   2016-04-27 00:53:00  I recently read an article about giving studen...
         41558 2016-04-27 01:05:25  My students crave challenge, they eat obstacle...

                                                 project_essay_2  \
         55660  My students come from a variety of backgrounds...
         76127  Most of my students have autism, anxiety, anot...
         51140  I have a class of twenty-four kindergarten stu...
         473    I teach at a low-income (Title 1) school. Ever...
         41558  We are an urban, public k-5 elementary school...
```

```
                                         project_essay_3  \
55660  Each month I try to do several science or STEM...
76127  It is tough to do more than one thing at a tim...
51140  By having a mobile listening and storage cente...
473    We need a classroom rug that we can use as a c...
41558  With the new common core standards that have b...

                                         project_essay_4  \
55660  It is challenging to develop high quality scie...
76127  When my students are able to calm themselves d...
51140  A mobile listening center will help keep equip...
473    Benjamin Franklin once said, \"Tell me and I f...
41558  These remarkable gifts will provide students w...

                                project_resource_summary    ...     \
55660  My students need STEM kits to learn critical s...    ...
76127  My students need Boogie Boards for quiet senso...    ...
51140  My students need a mobile listening center to ...    ...
473    My students need flexible seating in the class...    ...
41558  My students need copies of the New York Times ...    ...

        clean_categories                 clean_subcategories  \
55660       Math_Science  AppliedSciences Health_LifeScience
76127       SpecialNeeds                        SpecialNeeds
51140  Literacy_Language                            Literacy
473      AppliedLearning                    EarlyDevelopment
41558  Literacy_Language                            Literacy

                                  clean_titles title_word_count  \
55660      engineering steam primary classroom                4
76127                      sensory tools focus                3
51140  mobile learning mobile listening center                5
473         flexible seating flexible learning                4
41558        going deep the art inner thinking                6

                                            clean_essays essay_word_count  \
55660  i fortunate enough use fairy tale stem kits cl...              175
76127  imagine 8 9 years old you third grade classroo...              179
51140  having class 24 students comes diverse learner...              116
473    i recently read article giving students choice...              127
41558  my students crave challenge eat obstacles brea...              114

         pos    neg    neu  compound
55660  0.205  0.013  0.783    0.9867
76127  0.248  0.072  0.680    0.9897
51140  0.262  0.017  0.721    0.9860
473    0.187  0.030  0.783    0.9524
41558  0.288  0.029  0.683    0.9873
```

```
[5 rows x 24 columns]
```

8 1.10 Test - Train Split

```
In [43]: # train test split

         from sklearn.model_selection import train_test_split

         X_train, X_test, y_train, y_test = train_test_split(project_data, project_data['proje
```

```
In [44]: X_train.drop(['project_is_approved'], axis=1, inplace=True)
         X_test.drop(['project_is_approved'], axis=1, inplace=True)
```

9 Preparing data for models

```
In [45]: project_data.columns
```

```
Out[45]: Index(['Unnamed: 0', 'id', 'teacher_id', 'school_state', 'Date',
                'project_essay_1', 'project_essay_2', 'project_essay_3',
                'project_essay_4', 'project_resource_summary',
                'teacher_number_of_previously_posted_projects', 'project_is_approved',
                'teacher_prefix', 'project_grade_category', 'clean_categories',
                'clean_subcategories', 'clean_titles', 'title_word_count',
                'clean_essays', 'essay_word_count', 'pos', 'neg', 'neu', 'compound'],
               dtype='object')
```

we are going to consider

- school_state : categorical data
- clean_categories : categorical data
- clean_subcategories : categorical data
- project_grade_category : categorical data
- teacher_prefix : categorical data
- project_title : text data
- text : text data
- project_resource_summary: text data (optional)
- quantity : numerical (optional)
- teacher_number_of_previously_posted_projects : numerical
- price : numerical

- title_word_count : numerical
- essay_word_count : numerical
- essay sentiment [positive] : numerical
- essay sentiment [negative] : numerical
- essay sentiment [neutral] : numerical
- essay sentiment [compound] : numerical

10 2.1 Vectorizing Categorical data

11 One Hot Encode - Clean Categories of Projects

```
In [46]: # we use count vectorizer to convert the values into one

         from sklearn.feature_extraction.text import CountVectorizer

         vectorizer_proj = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=
         vectorizer_proj.fit(X_train['clean_categories'].values)

         categories_one_hot_train = vectorizer_proj.transform(X_train['clean_categories'].valu
         categories_one_hot_test = vectorizer_proj.transform(X_test['clean_categories'].values

         print(vectorizer_proj.get_feature_names())

         print("Shape of matrix of Train data after one hot encoding ",categories_one_hot_trai
         print("Shape of matrix of Test data after one hot encoding ",categories_one_hot_test.
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds', '
Shape of matrix of Train data after one hot encoding  (73196, 9)
Shape of matrix of Test data after one hot encoding  (36052, 9)
```

12 One Hot Encode - Clean Sub-Categories of Projectsű

```
In [47]: # we use count vectorizer to convert the values into one

         vectorizer_sub_proj = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lo
         vectorizer_sub_proj.fit(X_train['clean_subcategories'].values)

         sub_categories_one_hot_train = vectorizer_sub_proj.transform(X_train['clean_subcatego
         sub_categories_one_hot_test = vectorizer_sub_proj.transform(X_test['clean_subcategori


         print(vectorizer_sub_proj.get_feature_names())
         print("Shape of matrix of Train data after one hot encoding ",sub_categories_one_hot_t
         print("Shape of matrix of Test data after one hot encoding ",sub_categories_one_hot_te
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
Shape of matrix of Train data after one hot encoding  (73196, 30)
Shape of matrix of Test data after one hot encoding  (36052, 30)
```

13 One Hot Encode - School States

```
In [48]: my_counter = Counter()
         for state in project_data['school_state'].values:
             my_counter.update(state.split())

In [49]: school_state_cat_dict = dict(my_counter)
         sorted_school_state_cat_dict = dict(sorted(school_state_cat_dict.items(), key=lambda k

In [50]: ## we use count vectorizer to convert the values into one hot encoded features

         vectorizer_states = CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys
         vectorizer_states.fit(X_train['school_state'].values)

         school_state_categories_one_hot_train = vectorizer_states.transform(X_train['school_s
         school_state_categories_one_hot_test = vectorizer_states.transform(X_test['school_sta

         print(vectorizer_states.get_feature_names())

         print("Shape of matrix of Train data after one hot encoding ",school_state_categories_
         print("Shape of matrix of Test data after one hot encoding ",school_state_categories_o
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'SD', 'NE', 'DE', 'AK', 'NH', 'WV', 'ME', 'HI', 'DC', 'NM', 'KS
Shape of matrix of Train data after one hot encoding  (73196, 51)
Shape of matrix of Test data after one hot encoding  (36052, 51)
```

14 One Hot Encode - Project Grade Category

```
In [51]: my_counter = Counter()
         for project_grade in project_data['project_grade_category'].values:
             my_counter.update(project_grade.split())

In [52]: project_grade_cat_dict = dict(my_counter)
         sorted_project_grade_cat_dict = dict(sorted(project_grade_cat_dict.items(), key=lambda

In [53]: ## we use count vectorizer to convert the values into one hot encoded features

         vectorizer_grade = CountVectorizer(vocabulary=list(sorted_project_grade_cat_dict.keys
         vectorizer_grade.fit(X_train['project_grade_category'].values)

         project_grade_categories_one_hot_train = vectorizer_grade.transform(X_train['project_g
         project_grade_categories_one_hot_test = vectorizer_grade.transform(X_test['project_gra

         print(vectorizer_grade.get_feature_names())

         print("Shape of matrix of Train data after one hot encoding ",project_grade_categories
         print("Shape of matrix of Test data after one hot encoding ",project_grade_categories_
```

```
['Grades_9_12', 'Grades_6_8', 'Grades_3_5', 'Grades_PreK_2']
Shape of matrix of Train data after one hot encoding  (73196, 4)
Shape of matrix of Test data after one hot encoding  (36052, 4)
```

15 One Hot Encode - Teacher Prefix

```
In [54]: my_counter = Counter()
         for teacher_prefix in project_data['teacher_prefix'].values:
             teacher_prefix = str(teacher_prefix)
             my_counter.update(teacher_prefix.split())
```

```
In [55]: teacher_prefix_cat_dict = dict(my_counter)
         sorted_teacher_prefix_cat_dict = dict(sorted(teacher_prefix_cat_dict.items(), key=lamb
```

```
In [56]: vectorizer_teacher = CountVectorizer(vocabulary=list(sorted_teacher_prefix_cat_dict.ke
         vectorizer_teacher.fit(X_train['teacher_prefix'].values.astype("U"))

         teacher_prefix_categories_one_hot_train = vectorizer_teacher.transform(X_train['teache
         teacher_prefix_categories_one_hot_test = vectorizer_teacher.transform(X_test['teacher_

         print(vectorizer_teacher.get_feature_names())

         print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_trai
         print("Shape of matrix after one hot encoding ",teacher_prefix_categories_one_hot_test
```

```
['Dr', 'Teacher', 'Mr', 'Ms', 'Mrs']
Shape of matrix after one hot encoding  (73196, 5)
Shape of matrix after one hot encoding  (36052, 5)
```

16 2.2 Vectorizing Text data

17 A) Bag of Words (BOW) with bi-grams with min_df=10

18 Bag of words - Train Data - Essaysű

```
In [57]: vectorizer_bow_essay = CountVectorizer(ngram_range=(2,2), min_df=10)

         vectorizer_bow_essay.fit(X_train["clean_essays"])

         text_bow_train = vectorizer_bow_essay.transform(X_train["clean_essays"])

         print("Shape of matrix after one hot encoding ",text_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (73196, 132675)
```

19 Bag of words - Test Data - Essays

```
In [58]: text_bow_test = vectorizer_bow_essay.transform(X_test["clean_essays"])
         print("Shape of matrix after one hot encoding ",text_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 132675)
```

20 Bag of words - Train Data - Titles

```
In [59]: vectorizer_bow_title = CountVectorizer(ngram_range=(2,2), min_df=10)

         vectorizer_bow_title.fit(X_train["clean_titles"])

         title_bow_train = vectorizer_bow_title.transform(X_train["clean_titles"])
         print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (73196, 2667)
```

21 Bag of words - Test Data - Titles

```
In [60]: title_bow_test = vectorizer_bow_title.transform(X_test["clean_titles"])
         print("Shape of matrix after one hot encoding ",title_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 2667)
```

22 B) TFIDF vectorizer with bi-grams with min_df=10

TFIDF - Train Data - Essays

```
In [61]: from sklearn.feature_extraction.text import TfidfVectorizer

         vectorizer_tfidf_essay = TfidfVectorizer(ngram_range=(2,2), min_df=10)
         vectorizer_tfidf_essay.fit(X_train["clean_essays"])

         text_tfidf_train = vectorizer_tfidf_essay.transform(X_train["clean_essays"])
         print("Shape of matrix after one hot encoding ",text_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (73196, 132675)
```

23 TFIDF - Test Data - Essays

```
In [62]: text_tfidf_test = vectorizer_tfidf_essay.transform(X_test["clean_essays"])
         print("Shape of matrix after one hot encoding ",text_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 132675)
```

24 TFIDF - Train Data - Titles

```
In [63]: vectorizer_tfidf_titles = TfidfVectorizer(ngram_range=(2,2), min_df=10)

         vectorizer_tfidf_titles.fit(X_train["clean_titles"])
         title_tfidf_train = vectorizer_tfidf_titles.transform(X_train["clean_titles"])
         print("Shape of matrix after one hot encoding ",title_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (73196, 2667)
```

25 TFIDF - Test Data - Titles

```
In [64]: title_tfidf_test = vectorizer_tfidf_titles.transform(X_test["clean_titles"])
         print("Shape of matrix after one hot encoding ",title_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (36052, 2667)
```

26 C) Using Pretrained Models : AVG W2V

```
In [65]: with open('glove_vectors', 'rb') as f:
             model = pickle.load(f)
             glove_words =  set(model.keys())
```

```
In [66]: words_train_essays = []

         for i in X_train["clean_essays"] :
             words_train_essays.extend(i.split(' '))
```

```
In [67]: ## Find the total number of words in the Train data of Essays.

         print("all the words in the corpus", len(words_train_essays))
```

```
all the words in the corpus 11086932
```

```
In [68]: ## Find the unique words in this set of words

         words_train_essay = set(words_train_essays)
         print("the unique words in the corpus", len(words_train_essay))
```

```
the unique words in the corpus 48346
```

```
In [69]: # Find the words present in both Glove Vectors as well as our corpus.

         inter_words = set(model.keys()).intersection(words_train_essay)

         print("The number of words that are present in both glove vectors and our corpus are
         is nearly {}% ".format(len(inter_words), np.round((float(len(inter_words))/len(words_
```

```
The number of words that are present in both glove vectors and our corpus are 43499 which is n
```

```
In [70]: words_corpus_train_essay = {}

         words_glove = set(model.keys())

         for i in words_train_essay:
             if i in words_glove:
                 words_corpus_train_essay[i] = model[i]

         print("word 2 vec length", len(words_corpus_train_essay))
```

```
word 2 vec length 43499
```

27 Train - Essays

```
In [71]: # average Word2Vec
         # compute average word2vec for each review.

         avg_w2v_vectors_train = [];
```

```
        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 glove_words:
                    vector += model[word]
                    cnt_words += 1
            if cnt_words != 0:
                vector /= cnt_words
            avg_w2v_vectors_train.append(vector)

        print(len(avg_w2v_vectors_train))
        print(len(avg_w2v_vectors_train[0]))
```

```
100%|| 73196/73196 [00:28<00:00, 2587.88it/s]


73196
300
```

28 Test - Essays

```
In [72]: # average Word2Vec
         # compute average word2vec for each review.

         avg_w2v_vectors_test = [];

         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 glove_words:
                     vector += model[word]
                     cnt_words += 1
             if cnt_words != 0:
                 vector /= cnt_words
             avg_w2v_vectors_test.append(vector)

         print(len(avg_w2v_vectors_test))
         print(len(avg_w2v_vectors_test[0]))
```

```
100%|| 36052/36052 [00:13<00:00, 2598.44it/s]


36052
300
```

29 Train - Titles

```
In [73]: # Similarly you can vectorize for title also

         avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored i
         for sentence in tqdm(X_train["clean_titles"]): # for each title
             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
             avg_w2v_vectors_titles_train.append(vector)

         print(len(avg_w2v_vectors_titles_train))
         print(len(avg_w2v_vectors_titles_train[0]))
```

```
100%|| 73196/73196 [00:01<00:00, 52419.45it/s]


73196
300
```

30 Test - Titles

```
In [74]: # Similarly you can vectorize for title also

         avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in
         for sentence in tqdm(X_test["clean_titles"]): # for each title
             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
             avg_w2v_vectors_titles_test.append(vector)

         print(len(avg_w2v_vectors_titles_test))
         print(len(avg_w2v_vectors_titles_test[0]))
```

```
100%|| 36052/36052 [00:00<00:00, 47920.27it/s]
```

```
36052
300
```

31 D) Using Pretrained Models: TFIDF weighted W2V

Train - Essays

```
In [75]: 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 [76]: # average Word2Vec
         # compute average word2vec for each review.
         tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in thi
         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((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) #
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_train.append(vector)

         print(len(tfidf_w2v_vectors_train))
         print(len(tfidf_w2v_vectors_train[0]))
```

```
100%|| 73196/73196 [03:11<00:00, 381.86it/s]
```

```
73196
300
```

32 Test - Essays

```
In [77]: # compute average word2vec for each review.

         tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this
         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((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # 
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_test.append(vector)

         print(len(tfidf_w2v_vectors_test))
         print(len(tfidf_w2v_vectors_test[0]))
```

```
100%|| 36052/36052 [01:47<00:00, 264.43it/s]


36052
300
```

33 Train - Titles

```
In [78]: tfidf_model = TfidfVectorizer()
         tfidf_model.fit(X_train["clean_titles"])
         # 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 [79]: # compute average word2vec for each review.

         tfidf_w2v_vectors_titles_train = [];

         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((s
                     tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # 
                     vector += (vec * tf_idf) # calculating tfidf weighted w2v
                     tf_idf_weight += tf_idf
             if tf_idf_weight != 0:
                 vector /= tf_idf_weight
             tfidf_w2v_vectors_titles_train.append(vector)
```

```
        print(len(tfidf_w2v_vectors_titles_train))
        print(len(tfidf_w2v_vectors_titles_train[0]))
```

```
100%|| 73196/73196 [00:03<00:00, 20079.85it/s]


73196
300
```

34 Test - Titles

```
In [80]: # compute average word2vec for each review.

        tfidf_w2v_vectors_titles_test = [];

        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((s
                    tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # 
                    vector += (vec * tf_idf) # calculating tfidf weighted w2v
                    tf_idf_weight += tf_idf
            if tf_idf_weight != 0:
                vector /= tf_idf_weight
            tfidf_w2v_vectors_titles_test.append(vector)

        print(len(tfidf_w2v_vectors_titles_test))
        print(len(tfidf_w2v_vectors_titles_test[0]))
```

```
100%|| 36052/36052 [00:02<00:00, 17842.29it/s]


36052
300
```

35 2.3 Vectorizing Numerical features

```
In [81]: # https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-
        price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_
        price_data.head(2)
```

```
Out[81]:         id   price  quantity
        0  p000001  459.56         7
        1  p000002  515.89        21
```

```
In [82]: # join two dataframes in python:
         X_train = pd.merge(X_train, price_data, on='id', how='left')
         X_test = pd.merge(X_test, price_data, on='id', how='left')
```

36 A) Price

```
In [83]: from sklearn.preprocessing import Normalizer

         normalizer = Normalizer()

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

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

         price_train = normalizer.transform(X_train['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_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

37 B) Quantity

```
In [84]: normalizer = Normalizer()

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

         quantity_train = normalizer.transform(X_train['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_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

38 C) Number of Projects previously proposed by Teacher

```
In [85]: normalizer = Normalizer()

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

         normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape

         prev_projects_train = normalizer.transform(X_train['teacher_number_of_previously_poste
         prev_projects_test = normalizer.transform(X_test['teacher_number_of_previously_posted_

         print("After vectorizations")
         print(prev_projects_train.shape, y_train.shape)
         print(prev_projects_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

39 D) Title word Count

```
In [86]: normalizer = Normalizer()
```

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

         title_word_count_train = normalizer.transform(X_train['title_word_count'].values.resha
         title_word_count_test = normalizer.transform(X_test['title_word_count'].values.reshape

         print("After vectorizations")
         print(title_word_count_train.shape, y_train.shape)
         print(title_word_count_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

40 E) Essay word Count

```
In [87]: normalizer = Normalizer()

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

         essay_word_count_train = normalizer.transform(X_train['essay_word_count'].values.resha
         essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.reshape

         print("After vectorizations")
         print(essay_word_count_train.shape, y_train.shape)
         print(essay_word_count_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

41 F) Essay Sentiments - pos

```
In [88]: normalizer = Normalizer()

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

         essay_sent_pos_train = normalizer.transform(X_train['pos'].values.reshape(-1,1))
         essay_sent_pos_test = normalizer.transform(X_test['pos'].values.reshape(-1,1))

         print("After vectorizations")
         print(essay_sent_pos_train.shape, y_train.shape)
         print(essay_sent_pos_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

42 G) Essay Sentiments - neg

```
In [89]: normalizer = Normalizer()

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

         essay_sent_neg_train = normalizer.transform(X_train['neg'].values.reshape(-1,1))
         essay_sent_neg_test = normalizer.transform(X_test['neg'].values.reshape(-1,1))

         print("After vectorizations")
         print(essay_sent_neg_train.shape, y_train.shape)
         print(essay_sent_neg_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

43 H) Essay Sentiments - neu

```
In [90]: normalizer = Normalizer()

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

         essay_sent_neu_train = normalizer.transform(X_train['neu'].values.reshape(-1,1))
         essay_sent_neu_test = normalizer.transform(X_test['neu'].values.reshape(-1,1))

         print("After vectorizations")
         print(essay_sent_neu_train.shape, y_train.shape)
         print(essay_sent_neu_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

44 I) Essay Sentiments - compound

```
In [91]: normalizer = Normalizer()

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

         essay_sent_comp_train = normalizer.transform(X_train['compound'].values.reshape(-1,1))
         essay_sent_comp_test = normalizer.transform(X_test['compound'].values.reshape(-1,1))

         print("After vectorizations")
         print(essay_sent_comp_train.shape, y_train.shape)
         print(essay_sent_comp_test.shape, y_test.shape)
         print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
===============================================================================================
```

45 Assignment 7: SVM

1. **[Task-1] Apply Support Vector Machines(SGDClassifier with hinge loss: Linear SVM) on these feature**

   categorical, numerical features + project_title(BOW) + preprocessed_eassay (BOW)
   categorical, numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
   categorical, numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
   categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2.The hyper paramter tuning (best alpha in range [10^-4 to 10^4], and the best penalty among '11', '12') Find the best hyper parameter which will give the maximum AUC value Find the best hyper paramter using k-fold cross validation or simple cross validation data Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

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

4.[Task-2] Apply the Support Vector Machines on these features by finding the best hyper paramter as suggested in step 2 and step 3 Consider these set of features school_state : categorical data clean_categories : categorical data clean_subcategories : categorical data project_grade_category :categorical data teacher_prefix : categorical data quantity : numerical data teacher_number_of_previously_posted_projects : numerical data price : numerical data sentiment score's of each of the essay : numerical data number of words in the title : numerical data number of words in the combine essays : numerical data Apply TruncatedSVD on TfidfVectorizer of essay text, choose the number of components (`n_components`) using elbow method : numerical data

Conclusion:

```
 You need to summarize the results at the end of the notebook, summarize it in the table fo

* There will be an issue of data-leakage if you vectorize the entire data and then split it int
* To avoid the issue of data-leakage, make sure to split your data first and then vectorize it
* While vectorizing your data, apply the method fit_transform() on you train data, and apply t
* For more details please go through this link.
```

46 Support Vector Machines

47 Set 1: Categorical, Numerical features + Project_title(BOW) + Preprocessed_essay (BOW with min_df=10)

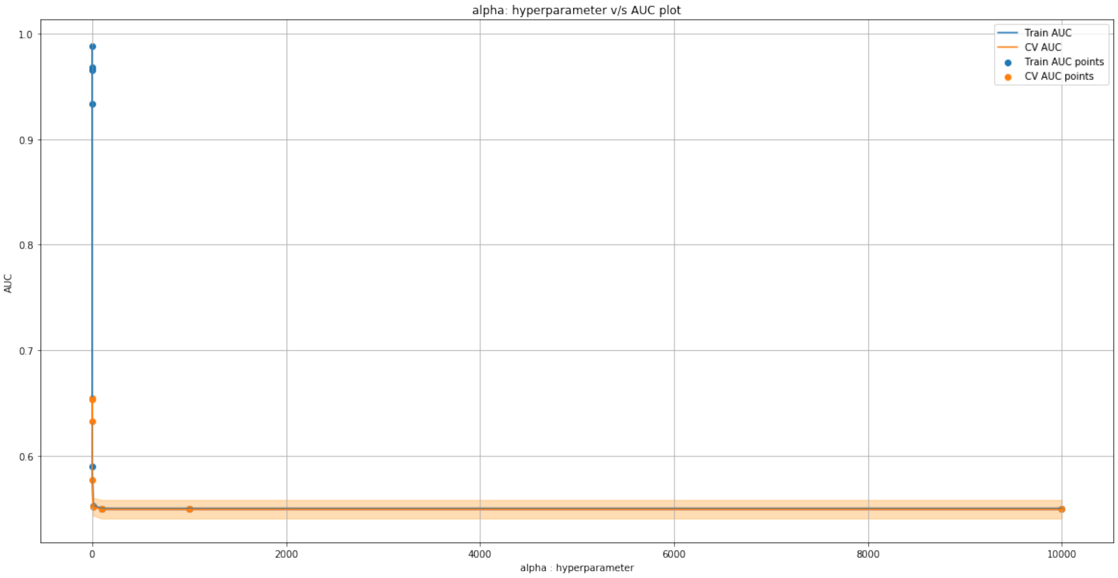
```
In [92]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
         from scipy.sparse import hstack

         X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_ca
         X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_cate

In [93]: print("Final Data matrix")
         print(X_tr.shape, y_train.shape)
         print(X_te.shape, y_test.shape)
         print("="*100)
```

```
Final Data matrix
(73196, 135450) (73196,)
(36052, 135450) (36052,)
===============================================================================================
```

48 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l2)

```
In [94]: from sklearn.model_selection import GridSearchCV
         from sklearn.linear_model import SGDClassifier

In [95]: sv = SGDClassifier(loss='hinge', penalty='l2')

         parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10*

         clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

         clf.fit(X_tr, y_train)
```

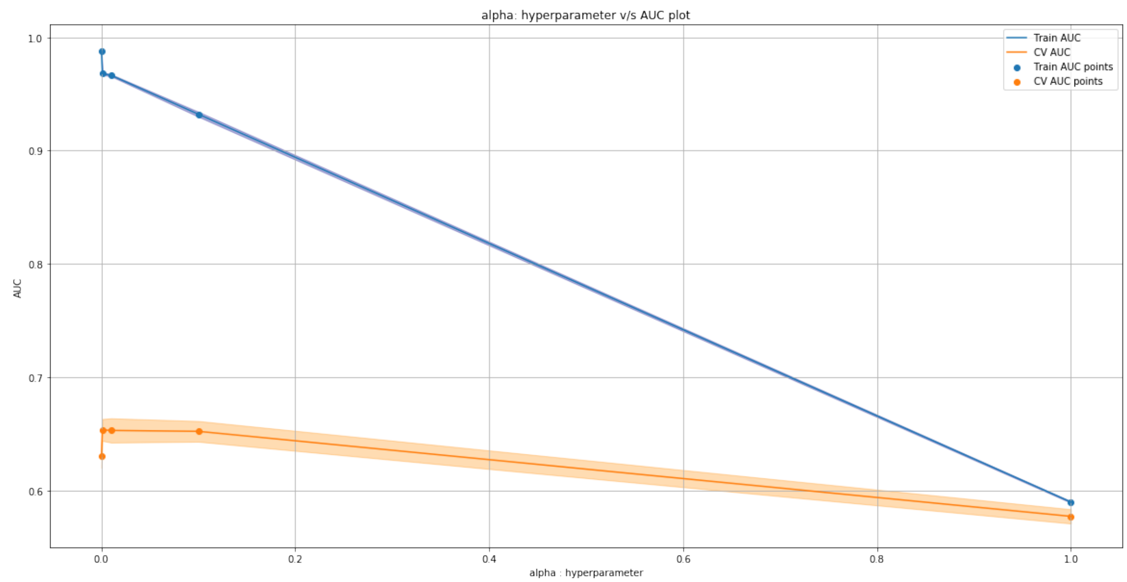
```
          train_auc= clf.cv_results_['mean_train_score']
          train_auc_std= clf.cv_results_['std_train_score']
          cv_auc = clf.cv_results_['mean_test_score']
          cv_auc_std= clf.cv_results_['std_test_score']

In [96]: plt.figure(figsize=(20,10))

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

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

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


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



Inference: we are not able to deteremine the appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values.

```
In [97]: sv = SGDClassifier(loss='hinge', penalty='l2')

         parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0]}

         clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

         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']
```

```
In [98]: plt.figure(figsize=(20,10))

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

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

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


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

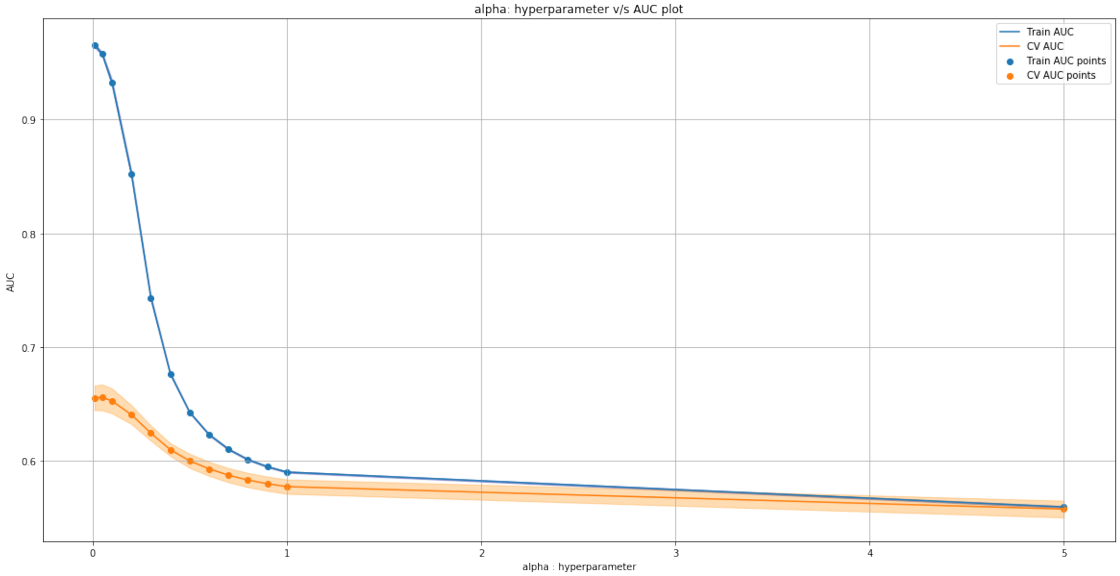


Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might lead to expected result.

```
In [99]: sv = SGDClassifier(loss='hinge', penalty='l2')

         parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 5

         clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

         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']
```

```
In [100]: plt.figure(figsize=(20,10))

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

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

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

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

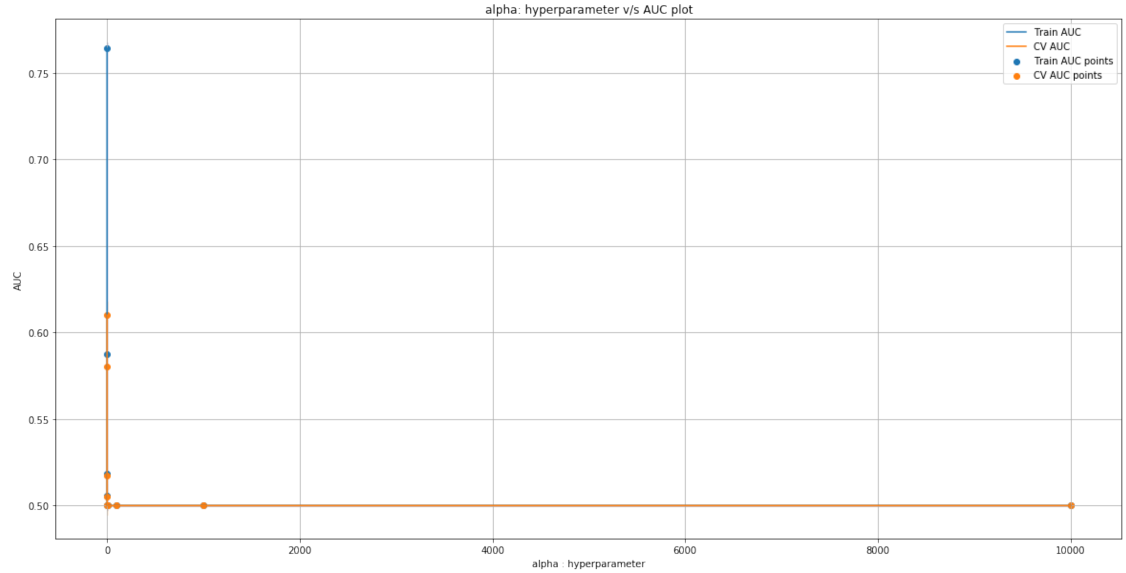


Inference 1) 0.3 is chosen as the best hyperparameter value. 2) The AUC values for the parameters/points after 0.1 are lower. While for 0.1 there is a major difference between the Train and the Test model. So, 0.3 is considered.

49 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l1)

```
In [101]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

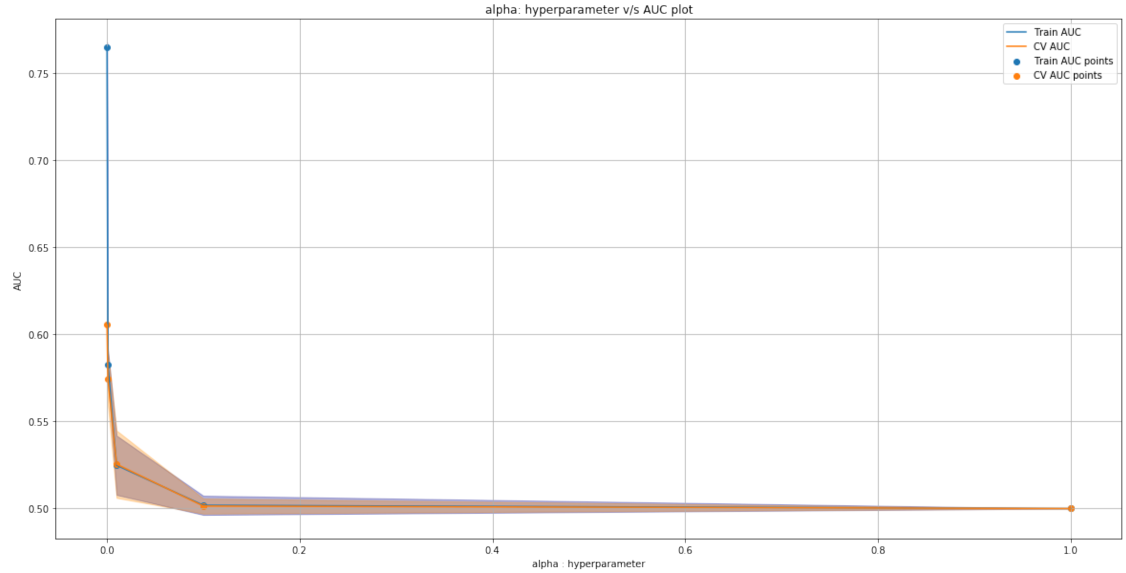
```
In [102]: plt.figure(figsize=(20,10))

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

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

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


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



Inference: re-running on a smaller set of parameter values

```
In [103]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
          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']
```

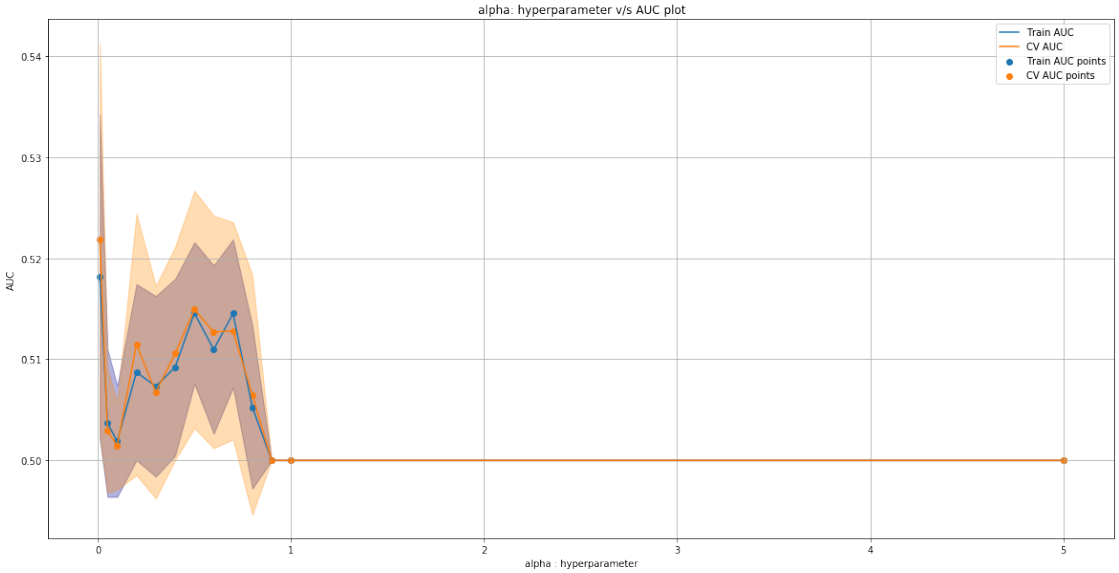
```
In [104]: plt.figure(figsize=(20,10))

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

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

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


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



```
In [105]: sv = SGDClassifier(loss='hinge', penalty='l1')
```

```
            parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0,

            clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

            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']
```

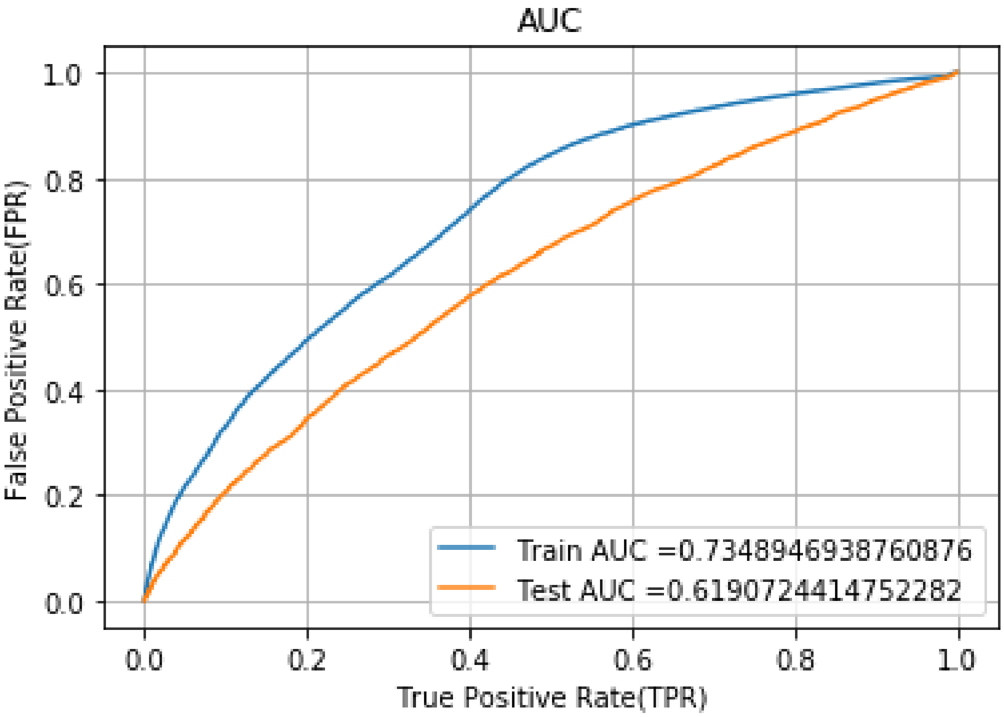
```
In [106]: plt.figure(figsize=(20,10))

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

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

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


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



Inference 1. I was not able to deteremine the appropriate value for my parameter. 2. L1 regularization yields a comparitively lower AUC score and the range seems to be more thicker, making it difficult to choose an appropriate value.

50 Train the model using the best hyper parameter value

```
In [107]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
          from sklearn.metrics import roc_curve, auc


          model = SGDClassifier(loss='hinge', penalty='l2', alpha=0.3)

          model.fit(X_tr, y_train)

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

          y_train_pred = model.decision_function(X_tr)
          y_test_pred = model.decision_function(X_te)

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

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



51 Confusion Matrix

```
In [108]: def predict(proba, threshould, fpr, tpr):

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

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

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

52 Train Data

```
In [109]: print("="*100)
          from sklearn.metrics import confusion_matrix
```

```
        print("Train confusion matrix")
        print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

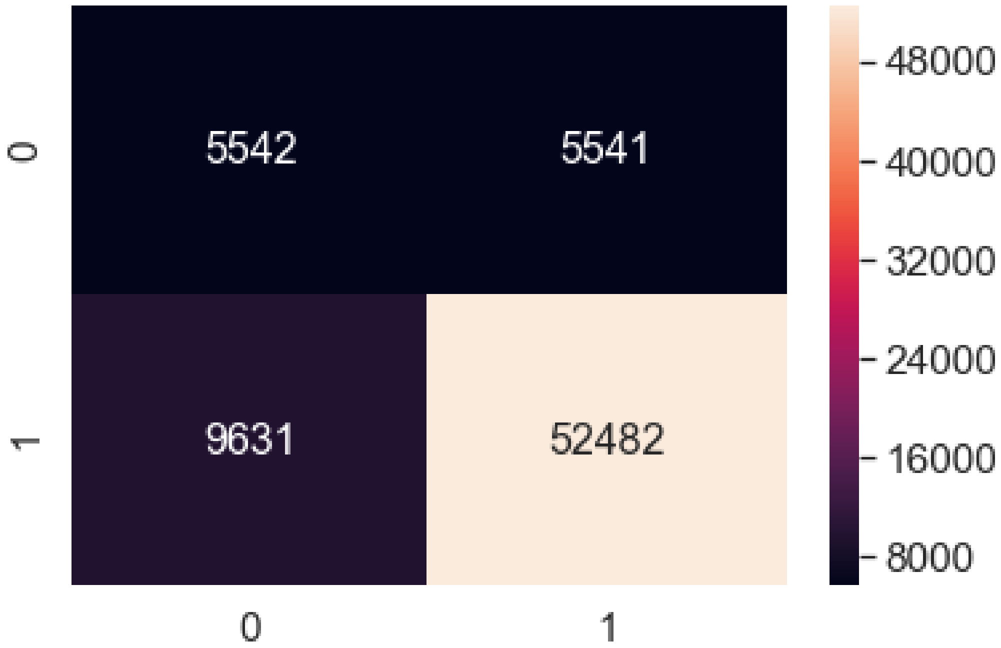
```
==========================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 1.0
[[ 5542  5541]
 [ 9631 52482]]
```

```
In [110]: conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, 
```

```
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 1.0
```

```
In [111]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[111]: <matplotlib.axes._subplots.AxesSubplot at 0x1e14c09a748>
```

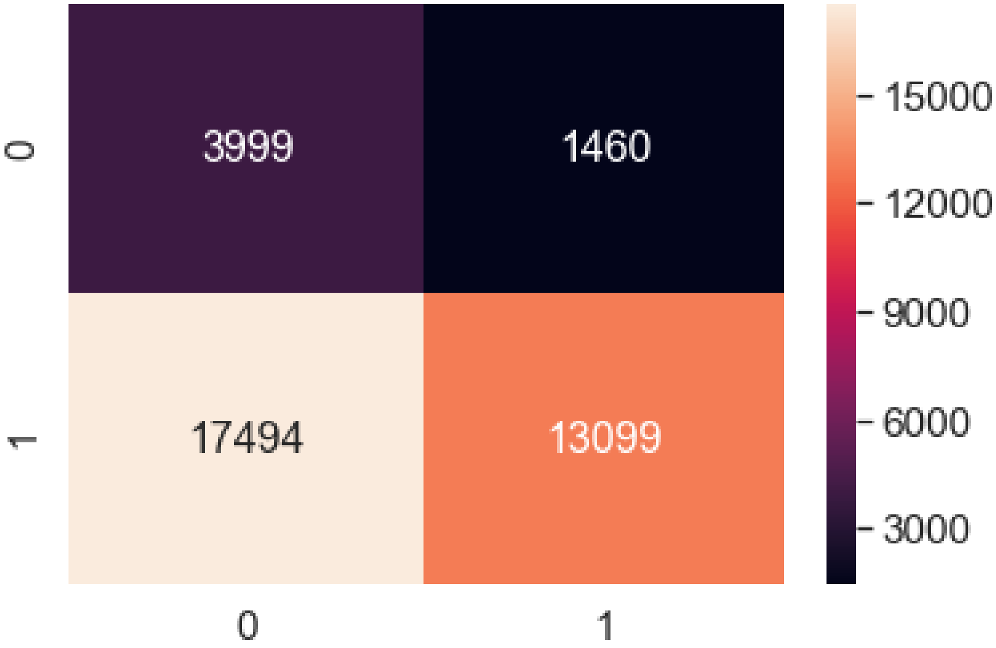


53 Test Data

```
In [112]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
==========================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 1.009
[[ 3999  1460]
 [17494 13099]]
```

```
In [113]: conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_

the maximum value of tpr*(1-fpr) 0.24999999161092995 for threshold 1.009
```

```
In [114]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_1, annot=True,annot_kws={"size": 16}, fmt='g')

Out[114]: <matplotlib.axes._subplots.AxesSubplot at 0x1e10019c160>
```



54 Set 2 : Categorical, Numerical features + Project_title(TFIDF) + Preprocessed_essay (TFIDF min_df=10)

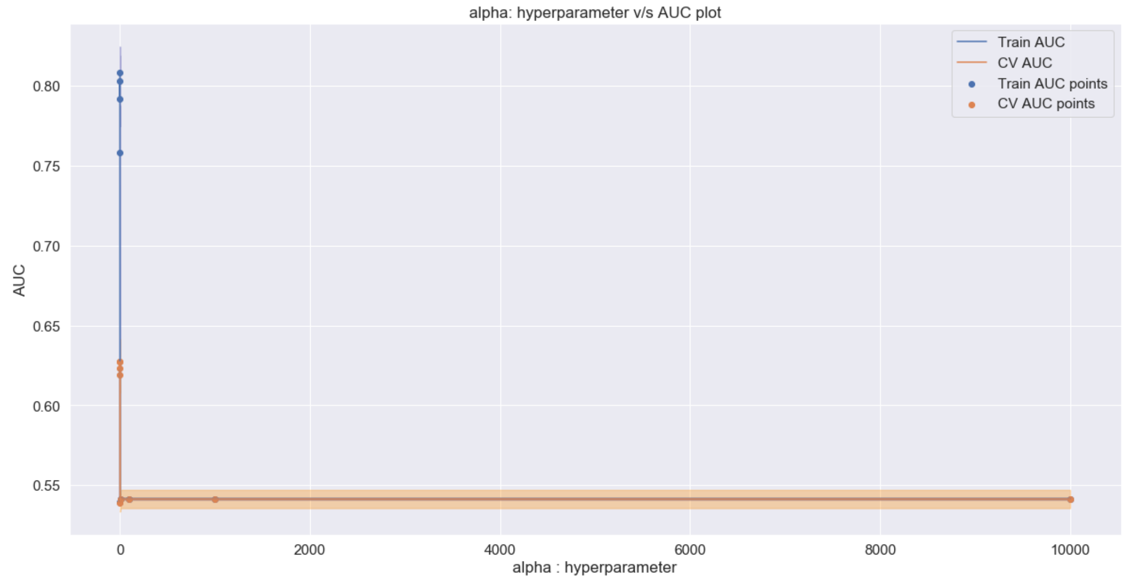
```
In [115]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
          from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_cat
In [116]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)
```

```
Final Data matrix
(73196, 135450) (73196,)
(36052, 135450) (36052,)
===============================================================================================
```

55 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l2)

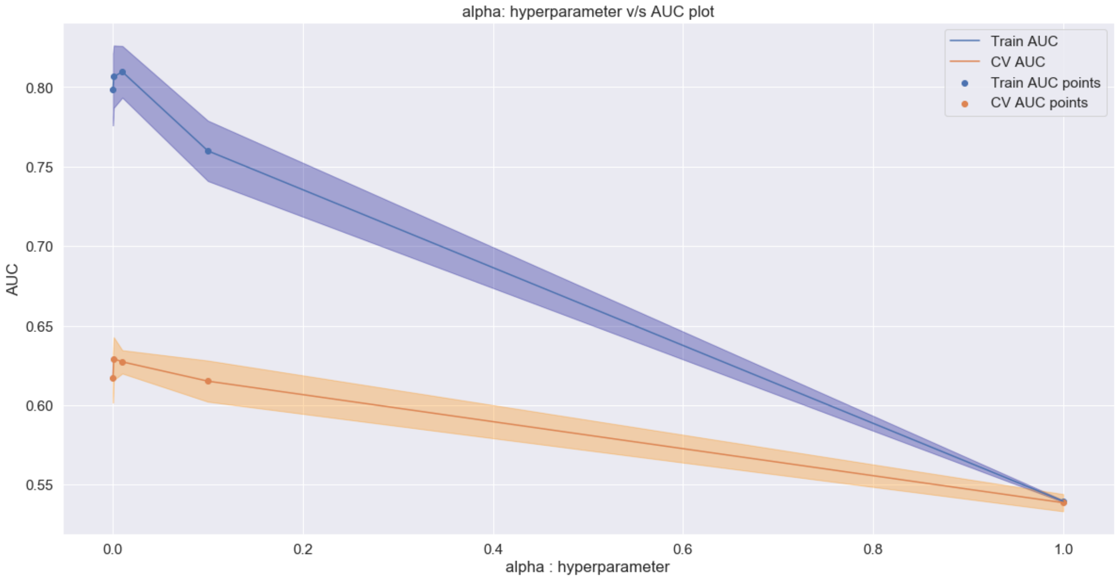
```
In [117]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [118]: plt.figure(figsize=(20,10))

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

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

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


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



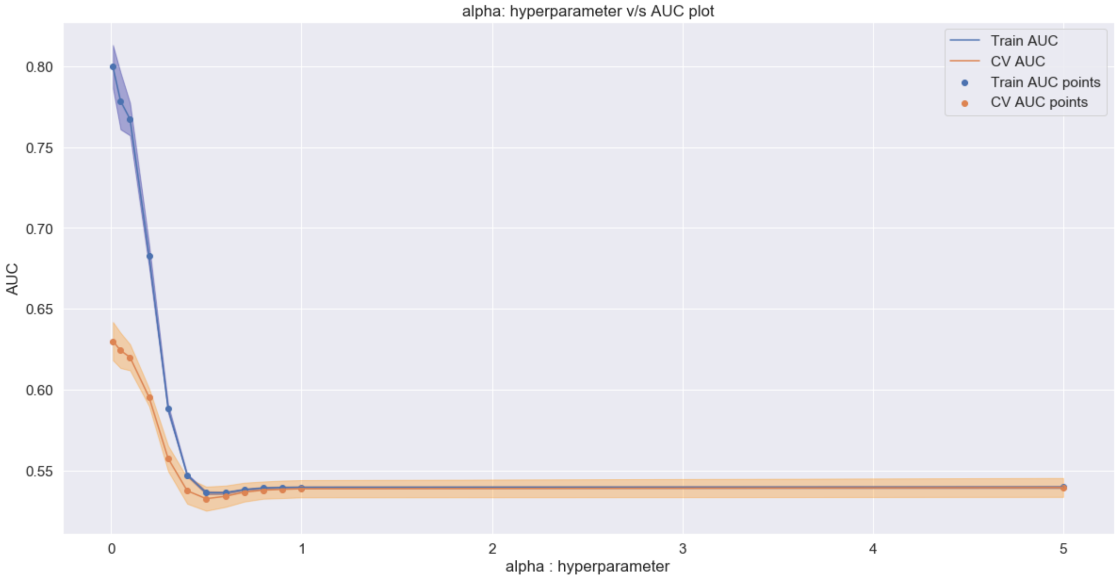
Inference: appropriate value for parameter is not able to determine so we run on smaller set of parameter values.

```
In [119]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']

In [120]: plt.figure(figsize=(20,10))

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

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

          plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
          plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
          plt.legend()
          plt.xlabel("alpha : hyperparameter")
          plt.ylabel("AUC")
          plt.title("alpha: hyperparameter v/s AUC plot")
          plt.show()
```



```
In [121]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0,

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']

In [122]: plt.figure(figsize=(20,10))

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

          plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
```

```
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,al

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


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



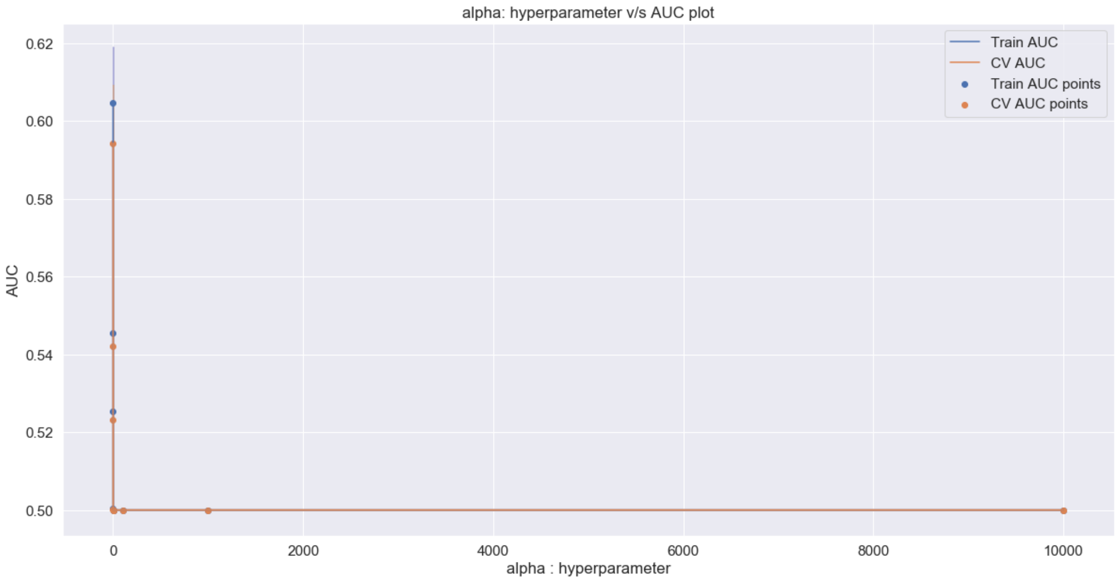
Inference 1) The AUC values for the parameters after 0.1 are to be lower. While for 0.1 there to be a major difference between the Train and the Test model. 2) Points below 0.2 had a lower AUC score, almost closer to 0.55

56 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l1)

```
In [123]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

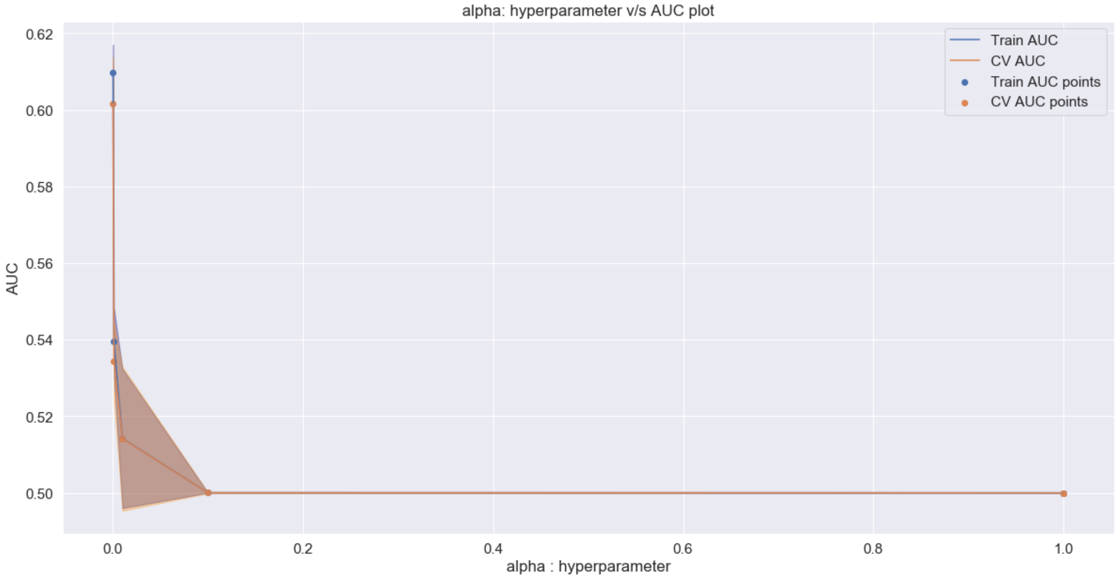
```
In [124]: plt.figure(figsize=(20,10))

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

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

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


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



Inference: Appropriate value is not determined so, i re-run with some small sets of paramters

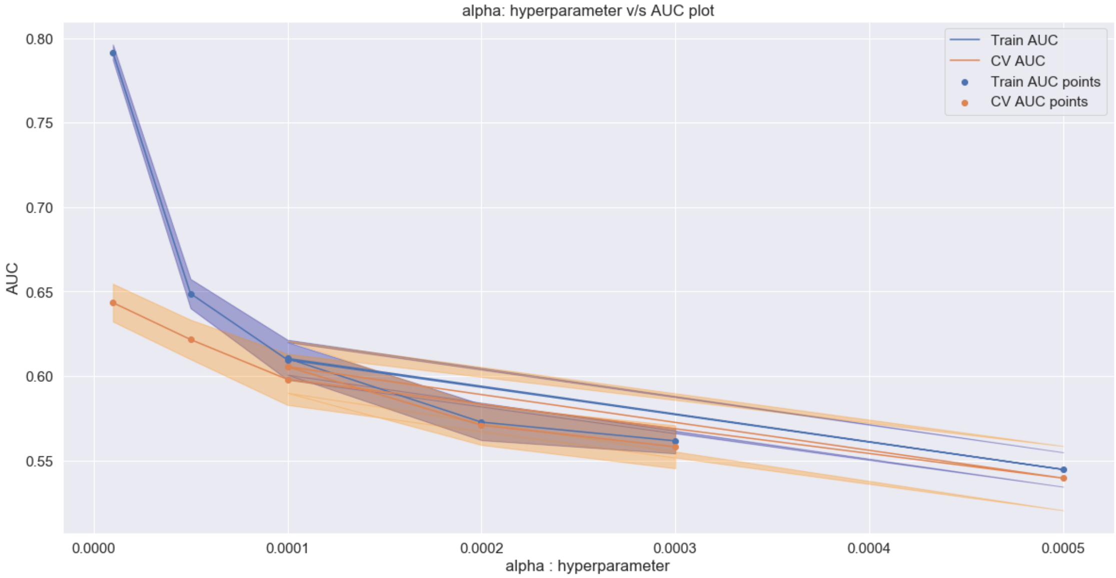
```
In [125]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0]}
          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [126]: plt.figure(figsize=(20,10))

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

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

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


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



```
In [127]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[0.00001,0.00005,0.0001, 0.0005, 0.0001, 0.0002, 0.0003]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [128]: plt.figure(figsize=(20,10))

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

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

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


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

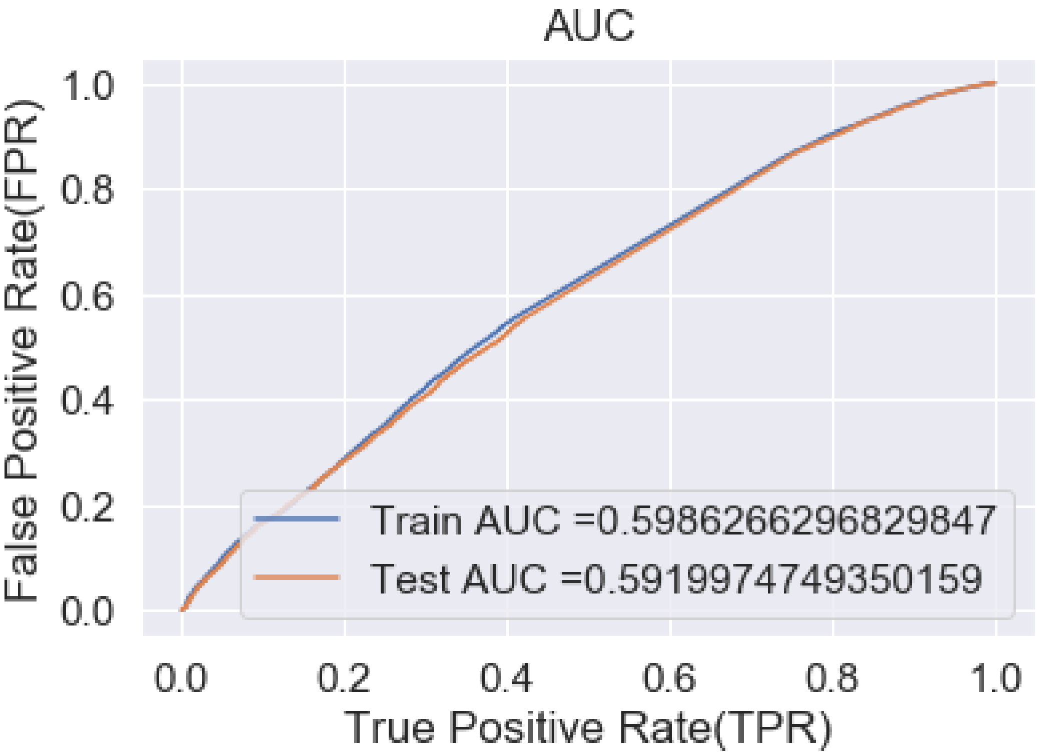


Inference 1) 0.0001 was chosen as an appropriate value for my parameter. 2) L1 Regularization seems to yield better parameter value when compared to L2 Regularization. 3) AUC scores are low for the points after 0.0001. 4) The difference between the train and test model is high for the values less than 0.0001

57 Train the model using the best hyper parameter value

In [129]:
```
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
from sklearn.metrics import roc_curve, auc


model = SGDClassifier(loss='hinge', penalty='l1', alpha=0.0001)

model.fit(X_tr, y_train)

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

y_train_pred = model.decision_function(X_tr)
y_test_pred = model.decision_function(X_te)

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

plt.plot(train_fpr, train_tpr, label="Train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="Test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("True Positive Rate(TPR)")
```

```
        plt.ylabel("False Positive Rate(FPR)")
        plt.title("AUC")
        plt.show()
```



58 Confusion Matrix

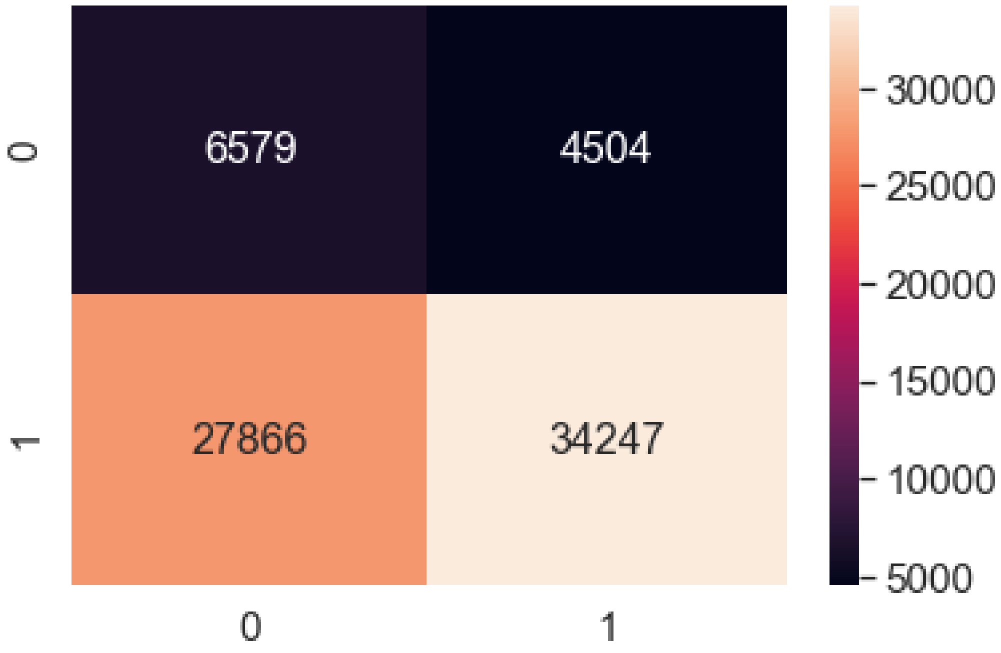
```
In [130]: print("="*100)
          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

```
========================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2412368237956204 for threshold 1.073
[[ 6579  4504]
 [27866 34247]]
```

```
In [131]: conf_matr_df_train_2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, t
```

```
the maximum value of tpr*(1-fpr) 0.2412368237956204 for threshold 1.073
```

```
In [132]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_2, annot=True,annot_kws={"size": 16}, fmt='g')

Out[132]: <matplotlib.axes._subplots.AxesSubplot at 0x1e15b685278>
```

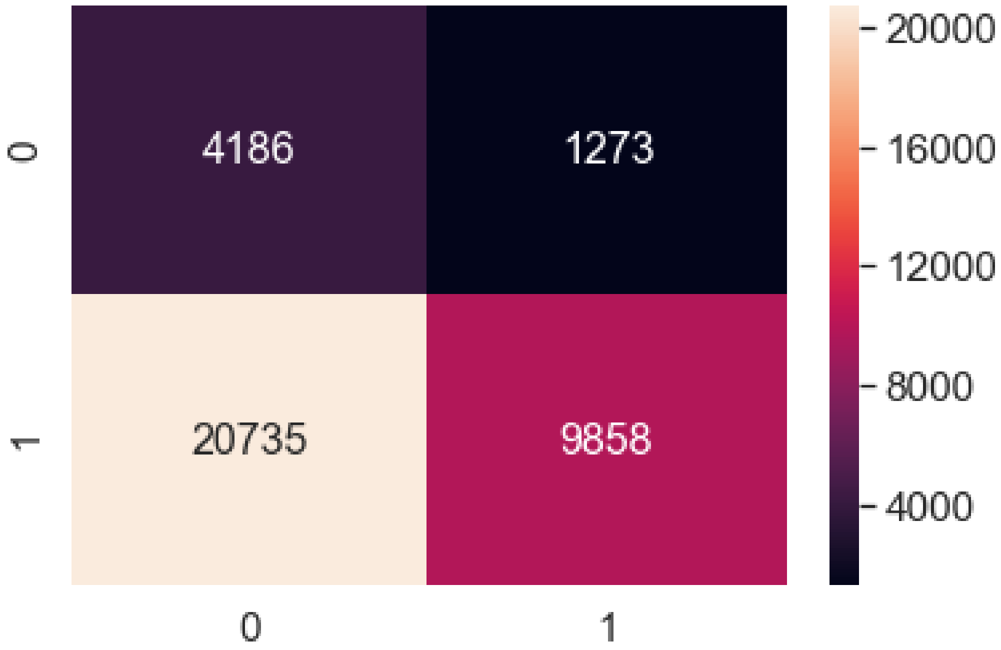


Test Data

```
In [133]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp

==============================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24378100621257612 for threshold 1.11
[[ 4186  1273]
 [20735  9858]]
```

```
In [134]: conf_matr_df_test_2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_

the maximum value of tpr*(1-fpr) 0.24378100621257612 for threshold 1.11
```

```
In [135]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_2, annot=True,annot_kws={"size": 16}, fmt='g')

Out[135]: <matplotlib.axes._subplots.AxesSubplot at 0x1e10011ecf8>
```



59 Set 3 : Categorical, Numerical features + Project_title(AVG W2V) + Preprocessed_essay (AVG W2V)

```
In [136]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
          from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_cat
```

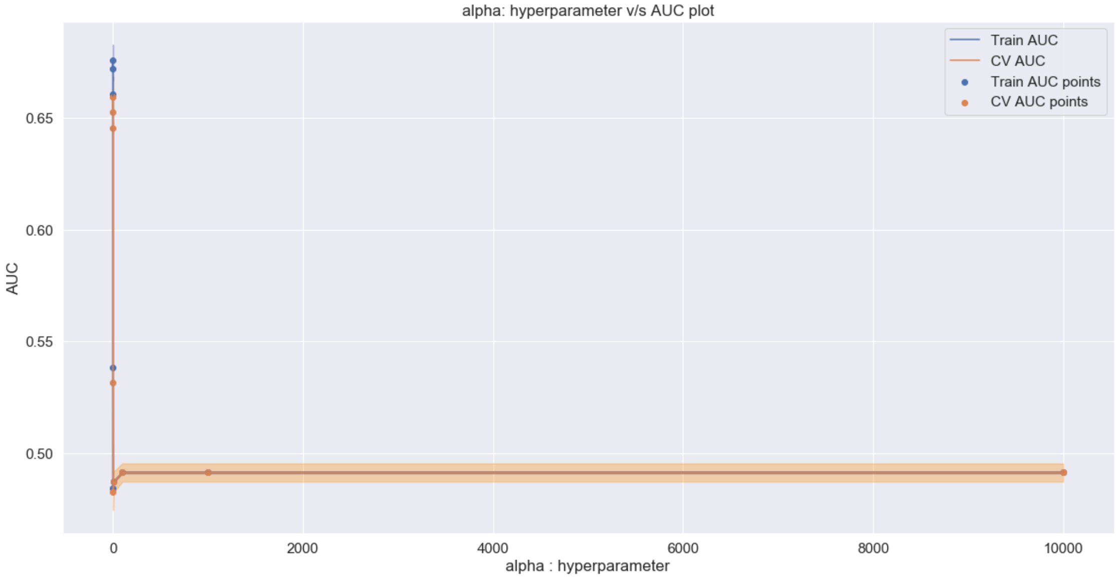
```
In [137]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)
```

```
Final Data matrix
(73196, 708) (73196,)
(36052, 708) (36052,)
===============================================================================================
```

60 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l2)

```
In [138]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 10

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [139]: plt.figure(figsize=(20,10))

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

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

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


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

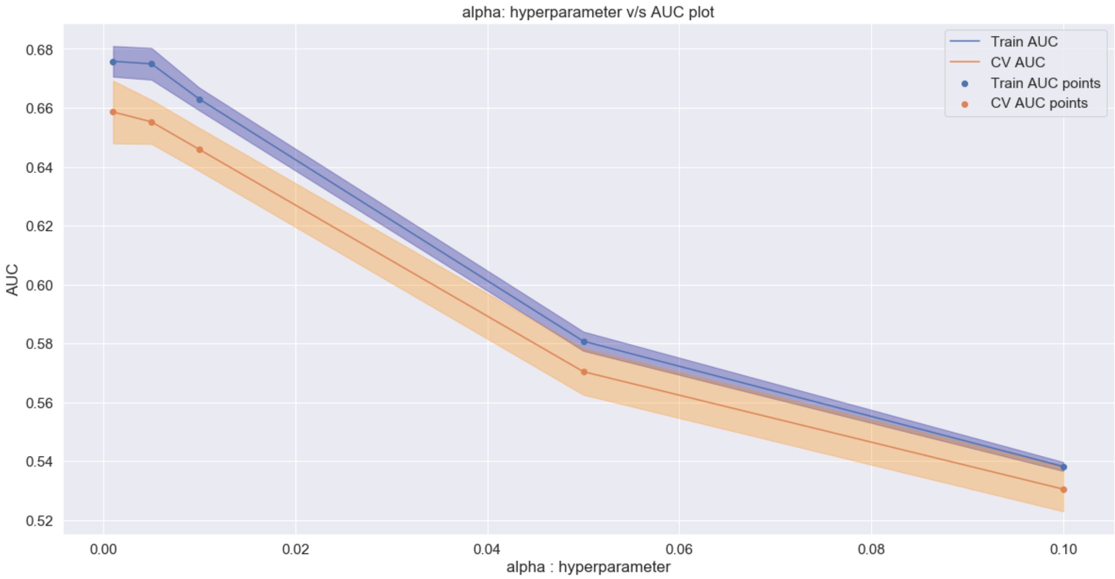


Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might yield the expected result. 3. Values in the range of 10^-4, 10^-3 & 10^-2 had considerable amount of difference in the AUC scores of Train and Cross Validation data. 4. Values in the range of 10^-2 to 10^-1 have a better chance of being the appropriate hyperparameter value. While the values more than 10^-1 has a pretty low AUC score. 5. So, I shall consider values in the range of 10^-3 to 10^-1

```
In [140]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[0.001, 0.005, 0.01, 0.05, 0.1]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [141]: plt.figure(figsize=(20,10))

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

          plt.plot(parameters['alpha'], cv_auc, label='CV AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
```

```
plt.gca().fill_between(parameters['alpha'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,al

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


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

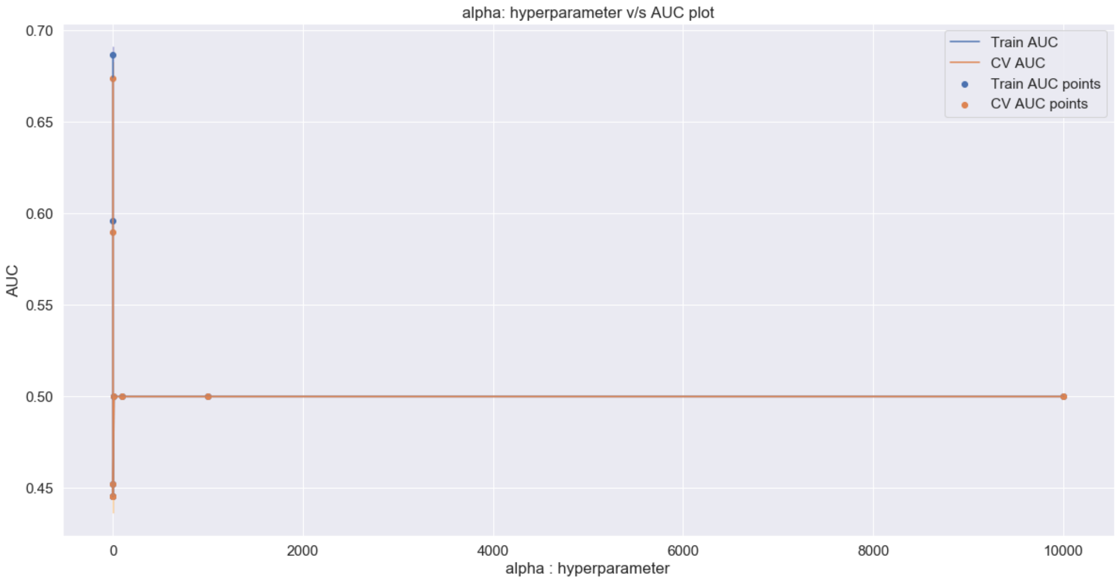


Inference 1) 0.005 is considered as the best value, because the points after and before have a lesser AUC score. 2) Also the difference between the Train and Cross Validation data is similar, the model tends to perform better and similar.

61 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l1)

```
In [142]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          clf.fit(X_tr, y_train)

          train_auc= clf.cv_results_['mean_train_score']
```

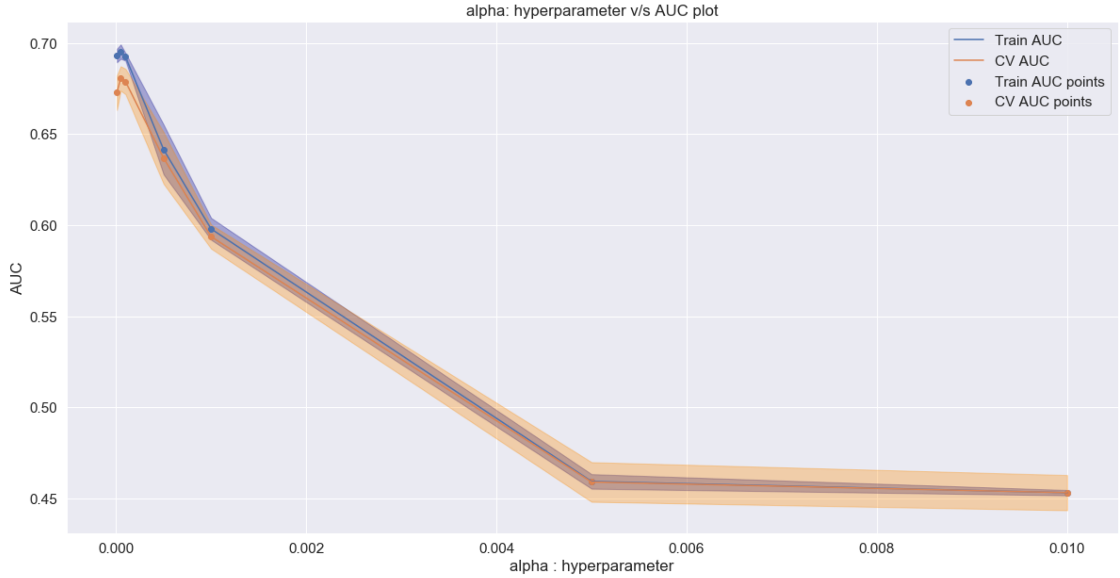
```
         train_auc_std= clf.cv_results_['std_train_score']
         cv_auc = clf.cv_results_['mean_test_score']
         cv_auc_std= clf.cv_results_['std_test_score']

In [143]: plt.figure(figsize=(20,10))

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

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

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


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



Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might yield the expected result. 3. Values in the range of 10^-4 to 10^-3 as alpha value have a better AUC score as well as lesser difference in AUC values.

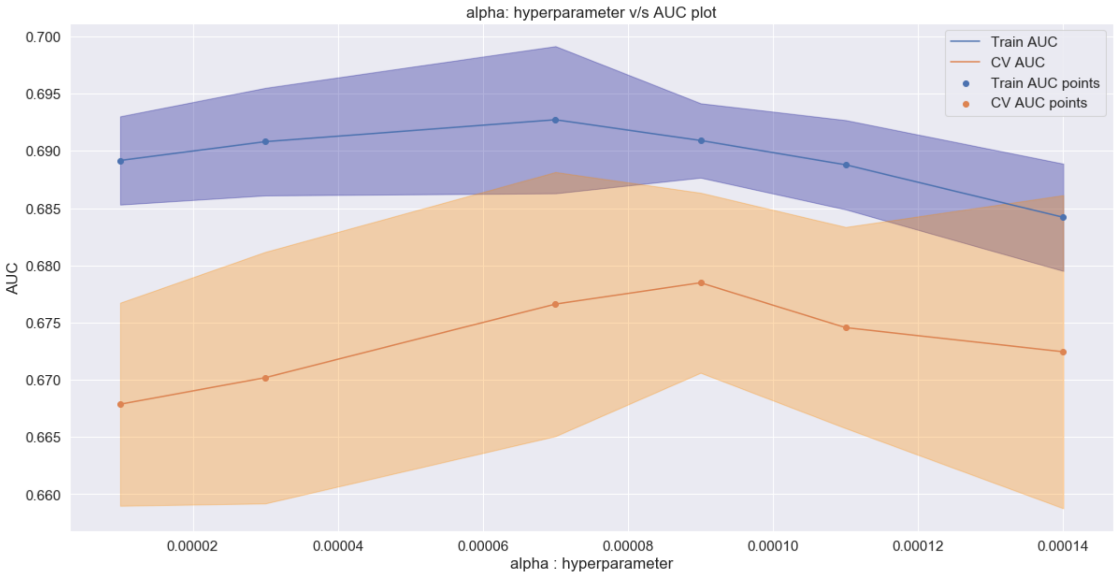
```
In [144]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[0.00001, 0.00005, 0.0001, 0.0005, 0.001, 0.005, 0.01]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [145]: plt.figure(figsize=(20,10))

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

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

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


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



Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might yield the expected result.

```
In [146]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[0.00001, 0.00003, 0.00007, 0.00009, 0.00011, 0.00014]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']

In [147]: plt.figure(figsize=(20,10))

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

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

          plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
          plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
          plt.legend()
          plt.xlabel("alpha : hyperparameter")
          plt.ylabel("AUC")
          plt.title("alpha: hyperparameter v/s AUC plot")
          plt.show()
```

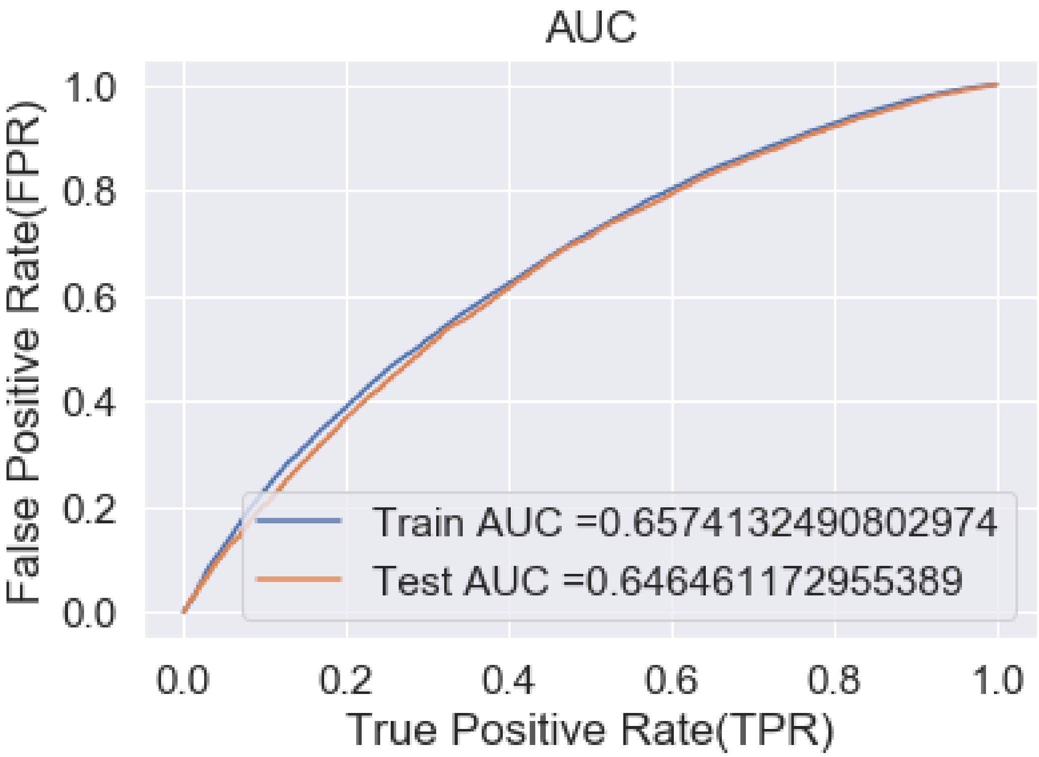


Inference 1. Values around 0.00005 to 0.00011 had almost similar AUC scores and similar Difference in Test and Cross Validation AUC scores. 2. 0.00005 was chosen by me. 3. BOTH L1 & L2 PERFORM EQUALLY GOOD ON THIS SET OF DATA

62 Train the model using the best hyper parameter value (L2)

```
In [148]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
          from sklearn.metrics import roc_curve, auc


          model = SGDClassifier(loss='hinge', penalty='l2', alpha=0.005)

          model.fit(X_tr, y_train)

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

          y_train_pred = model.decision_function(X_tr)
          y_test_pred = model.decision_function(X_te)
```

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

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



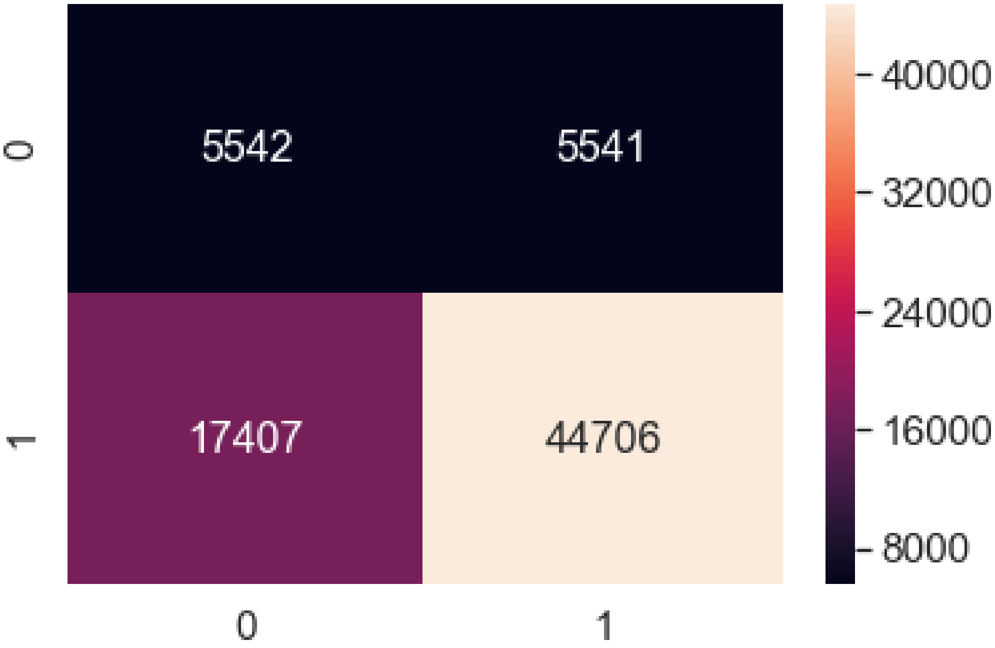
Confusion Matrix (L2)
Train Data

```
In [149]: print("="*100)
          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

```
===============================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 0.998
[[ 5542  5541]
 [17407 44706]]
```

```
In [150]: conf_matr_df_train_3_l2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_prec

the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 0.998
```

```
In [151]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_3_l2, annot=True,annot_kws={"size": 16}, fmt='g')

Out[151]: <matplotlib.axes._subplots.AxesSubplot at 0x1e14c18f780>
```



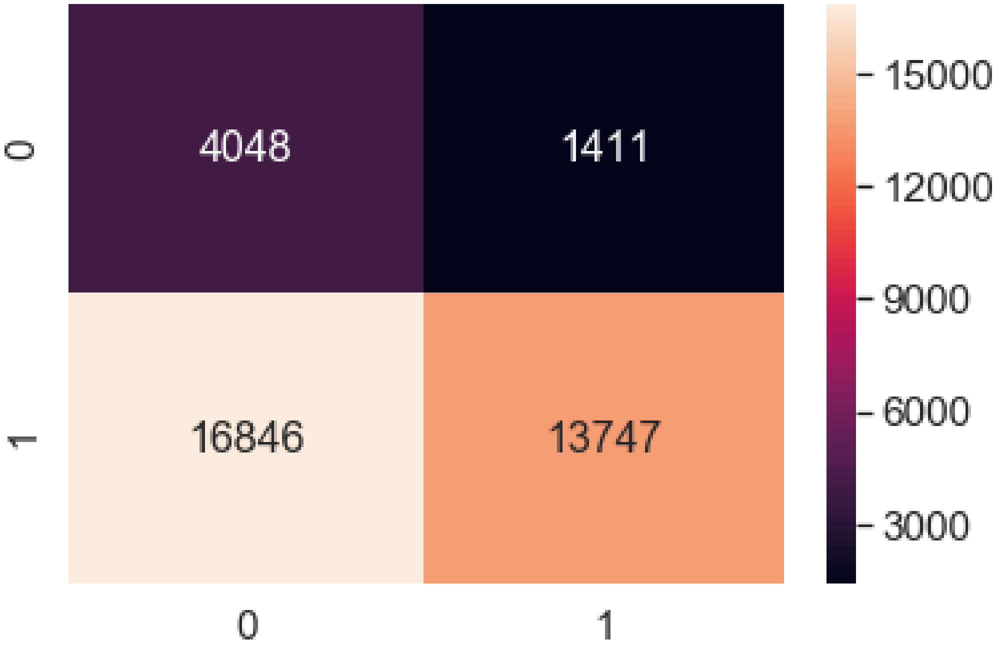
Test Data

```
In [152]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp

==================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 1.014
[[ 4048  1411]
 [16846 13747]]
```

```
In [153]: conf_matr_df_test_3_l2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, 

the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 1.014
```

```
In [154]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_3_l2, annot=True,annot_kws={"size": 16}, fmt='g')
```

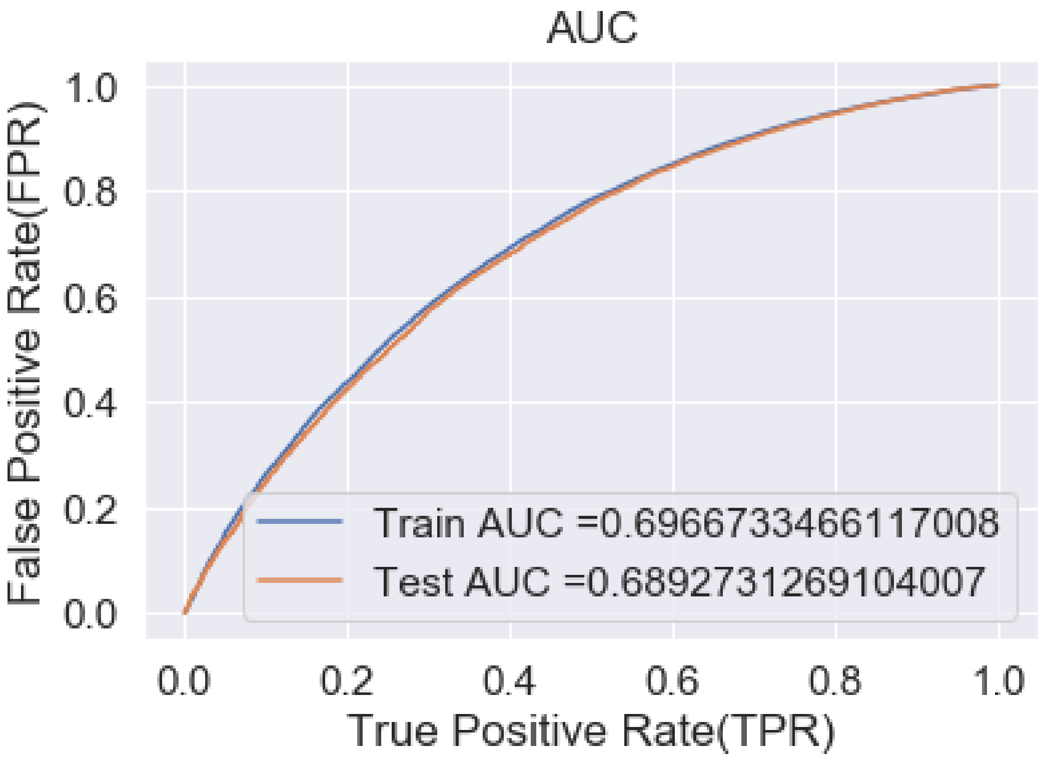
```
Out[154]: <matplotlib.axes._subplots.AxesSubplot at 0x1e131ed4f28>
```



63 Train the model using the best hyper parameter value (L1)

```
In [155]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
          from sklearn.metrics import roc_curve, auc


          model = SGDClassifier(loss='hinge', penalty='l1', alpha=0.00005)

          model.fit(X_tr, y_train)

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

          y_train_pred = model.decision_function(X_tr)
          y_test_pred = model.decision_function(X_te)

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

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



64 Confusion Matrix (L1)

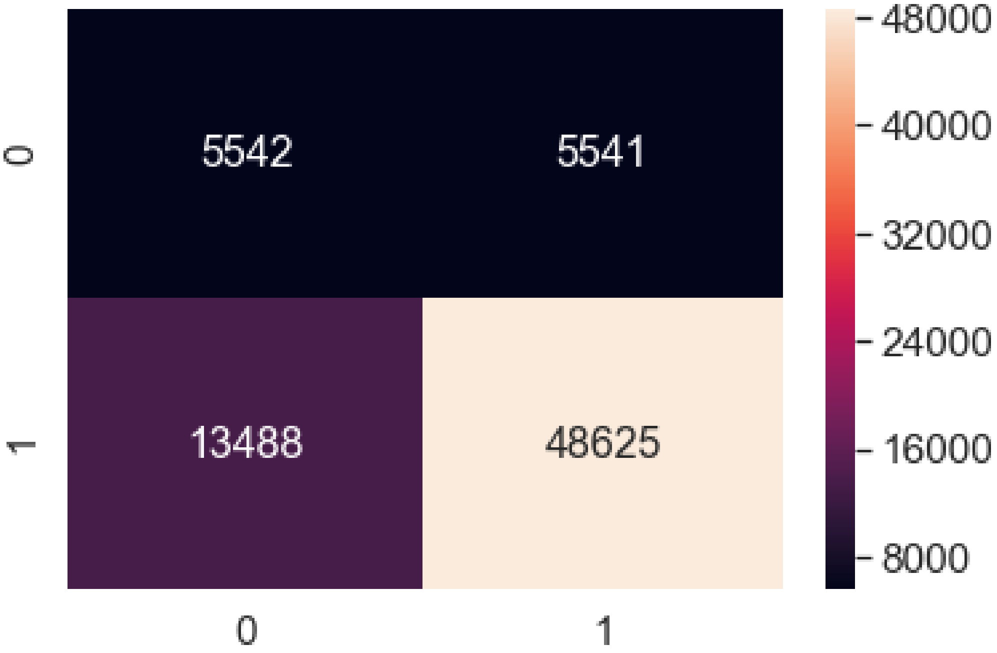
Train Data

```
In [156]: print("="*100)
          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

```
===============================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 2.178
[[ 5542  5541]
 [13488 48625]]
```

```
In [157]: conf_matr_df_train_3_l1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_prec

the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 2.178
```

```
In [158]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_3_l1, annot=True,annot_kws={"size": 16}, fmt='g')

Out[158]: <matplotlib.axes._subplots.AxesSubplot at 0x1e14d0791d0>
```

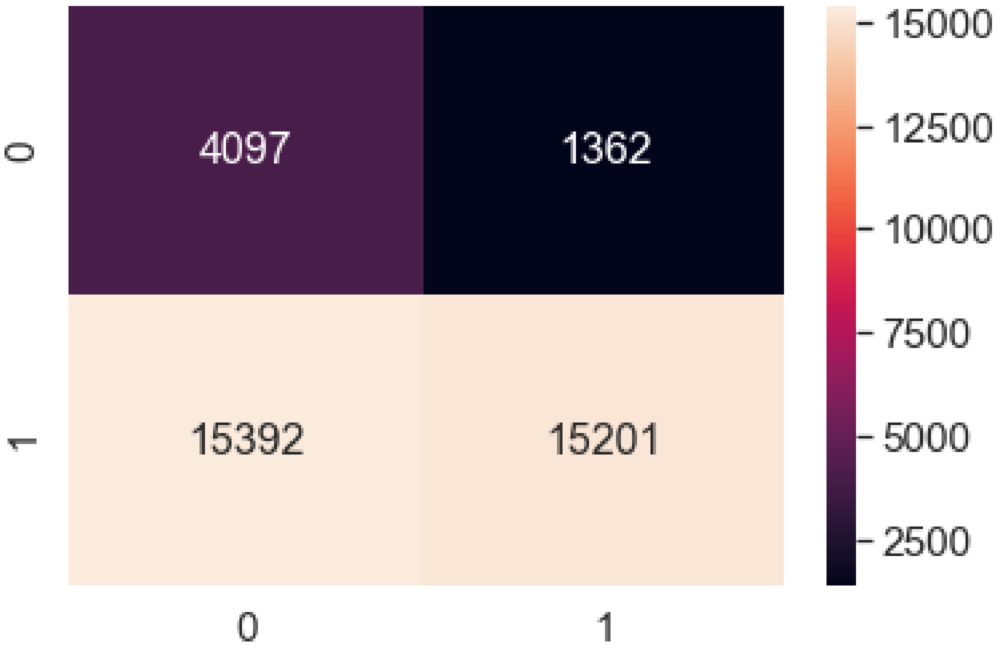


Test Data

```
In [159]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp

==================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 3.078
[[ 4097  1362]
 [15392 15201]]
```

```
In [160]: conf_matr_df_test_3_l1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, t

the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 3.078
```

```
In [161]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_3_l1, annot=True,annot_kws={"size": 16}, fmt='g')

Out[161]: <matplotlib.axes._subplots.AxesSubplot at 0x1e100095208>
```



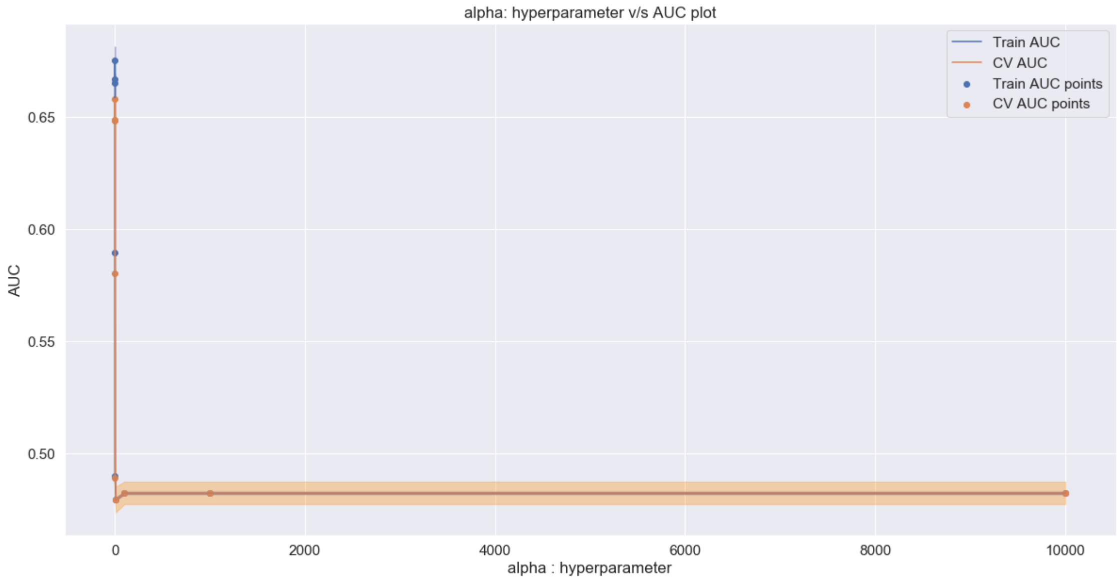
65 Set 4 : Categorical, Numerical features + Project_title(TFIDF W2V) + Preprocessed_essay (TFIDF W2V)

```
In [162]: # merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
          from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_ca

In [163]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)

Final Data matrix
(73196, 708) (73196,)
(36052, 708) (36052,)
==============================================================================================
```

66 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l2)

```
In [164]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

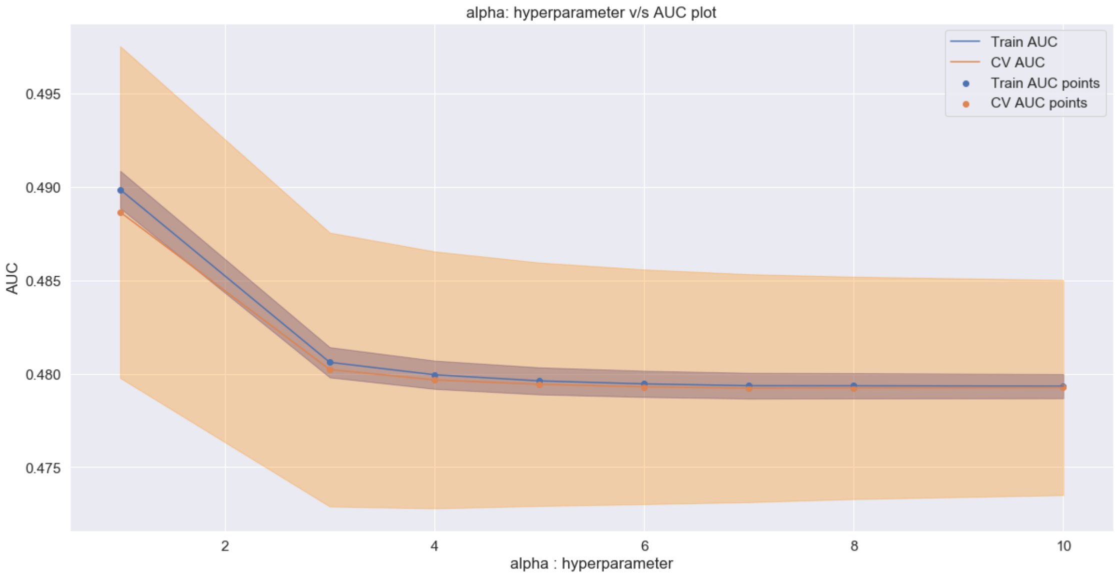
```
In [165]: plt.figure(figsize=(20,10))

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

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

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


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



Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might yield the expected result.

```
In [166]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[1, 3, 4, 5, 6, 7, 8, 10]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [167]: plt.figure(figsize=(20,10))

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

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

          plt.scatter(parameters['alpha'], train_auc, label='Train AUC points')
          plt.scatter(parameters['alpha'], cv_auc, label='CV AUC points')
          plt.legend()
          plt.xlabel("alpha : hyperparameter")
          plt.ylabel("AUC")
          plt.title("alpha: hyperparameter v/s AUC plot")
          plt.show()
```

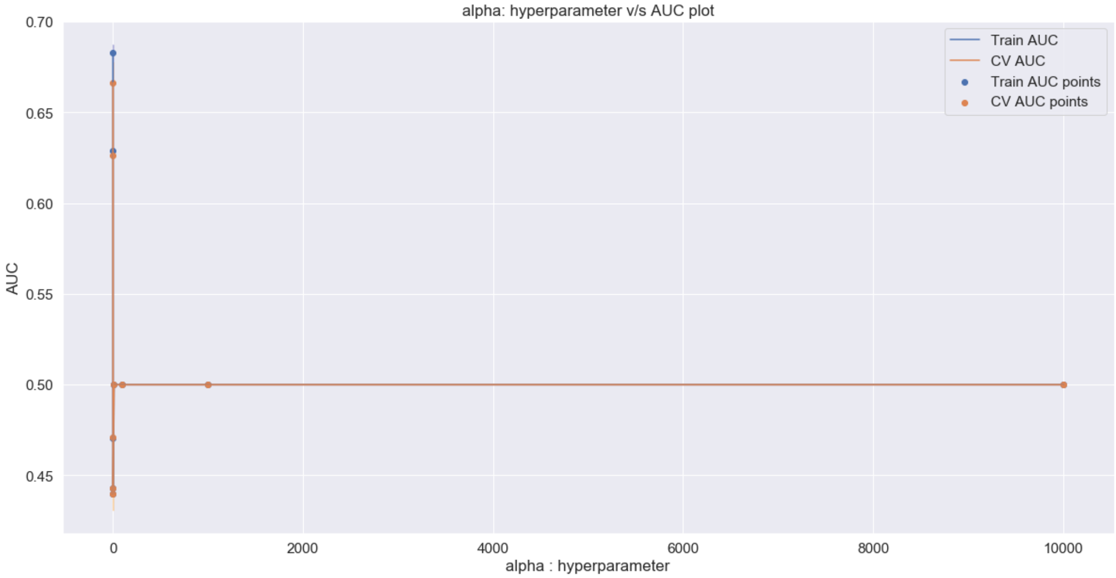


Inference 1) Alpha value 6 seems to be a better hyperparameter value when compared to the other hyperparameters. 2) It has a better AUC score and points before and after do not have similar AUC scores.

67 GridSearchCV (K fold Cross Validation) using Penalty(regularization = l1)

```
In [168]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [169]: plt.figure(figsize=(20,10))

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

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

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


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

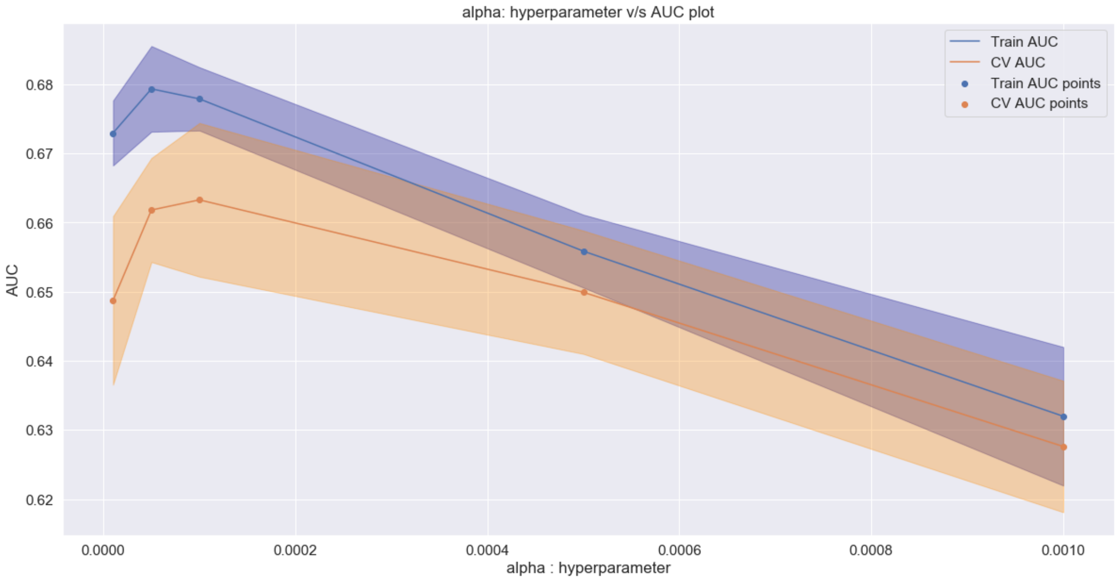


Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might yield the expected result.

```
In [170]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[0.00001, 0.00005, 0.0001, 0.0005, 0.001]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')
```

```
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']
```

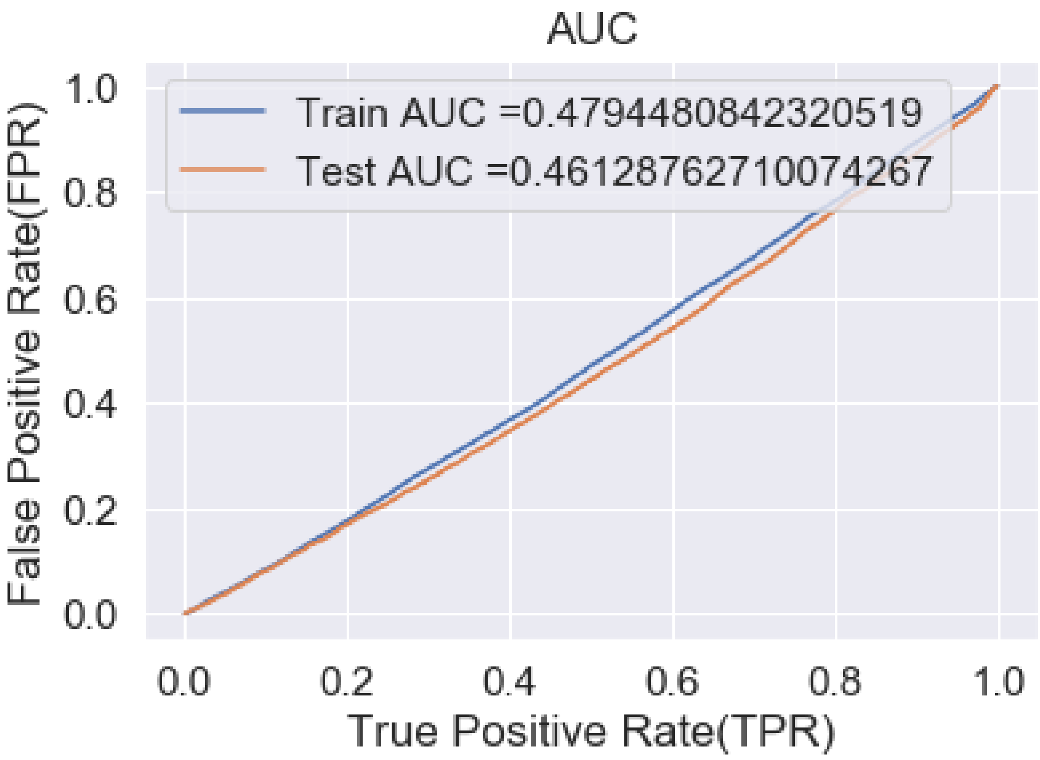
```
In [171]: plt.figure(figsize=(20,10))

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

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

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


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



Inference 0.0005 is considered as the Alpha value

68 Train the model using the best hyper parameter value (L2)

```
In [172]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
          from sklearn.metrics import roc_curve, auc


          model = SGDClassifier(loss='hinge', penalty='l2', alpha= 6.0)

          model.fit(X_tr, y_train)

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

          y_train_pred = model.decision_function(X_tr)
          y_test_pred = model.decision_function(X_te)

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

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



69 Confusion Matrix (L2)

Train Data

```
In [173]: print("="*100)
          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

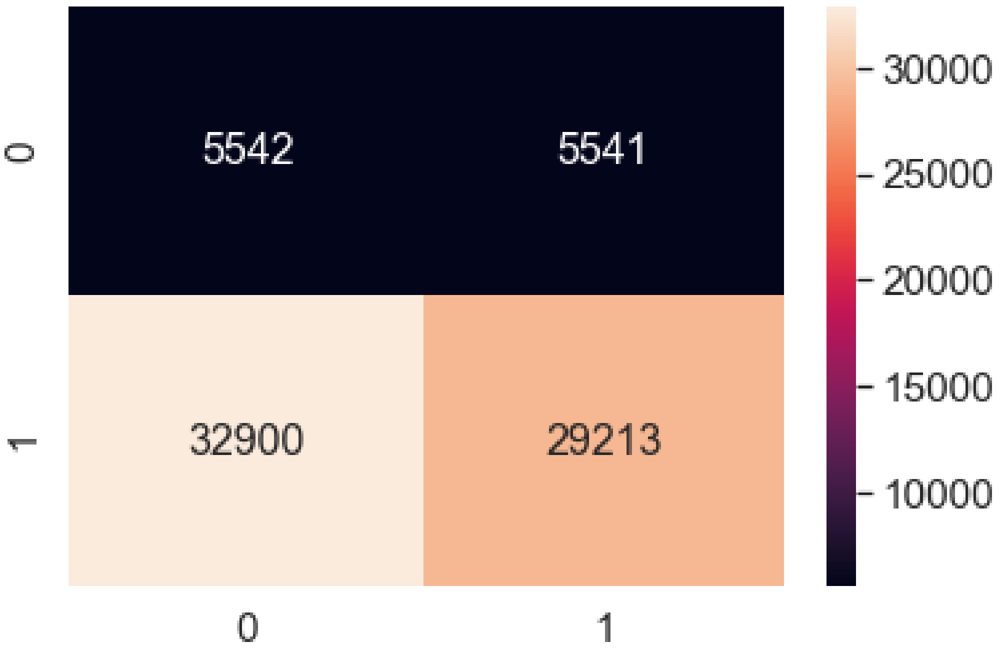
```
===============================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 1.028
[[ 5542  5541]
 [32900 29213]]
```

```
In [174]: conf_matr_df_train_4_l2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pre
```

```
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 1.028
```

```
In [175]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_4_l2, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[175]: <matplotlib.axes._subplots.AxesSubplot at 0x1e12bf02b00>
```

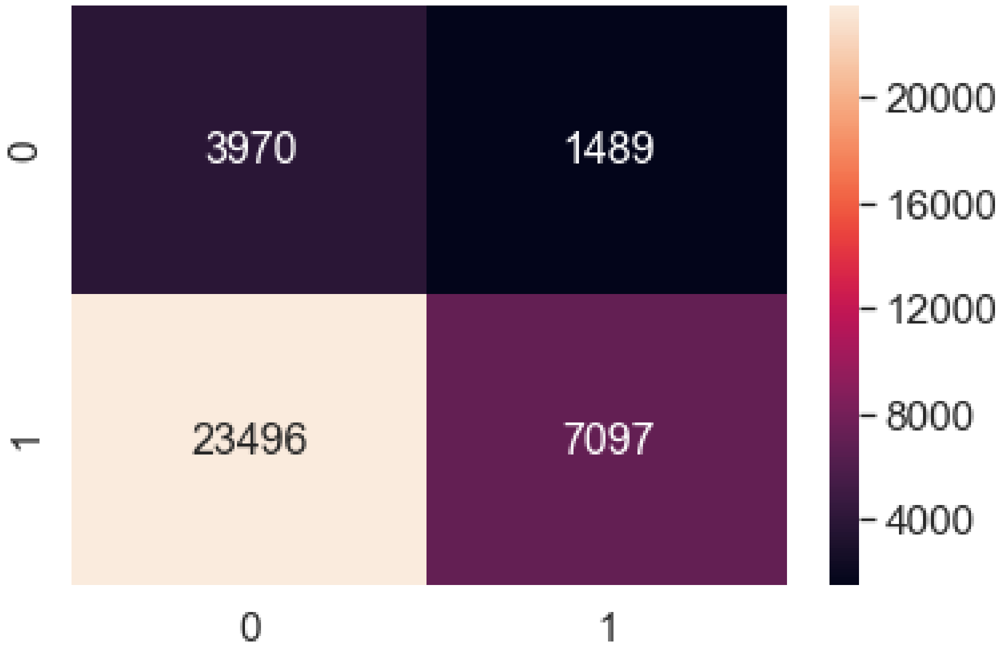


Test Data

```
In [176]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp

====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 1.073
[[ 3970  1489]
 [23496  7097]]
```

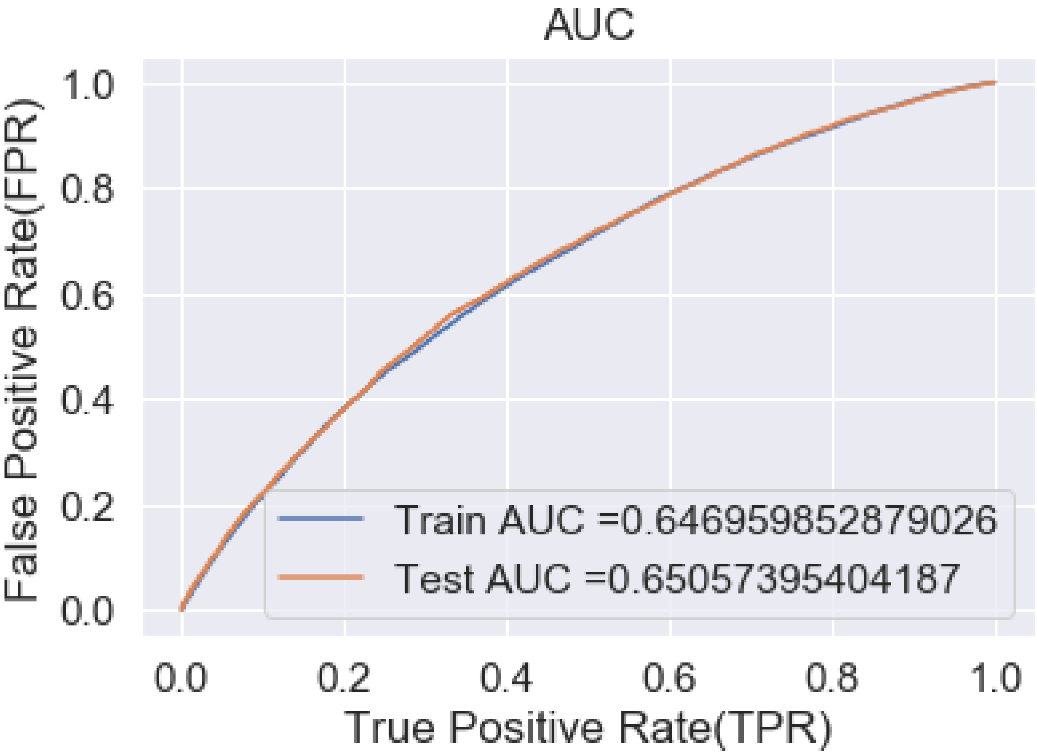
```
In [177]: conf_matr_df_test_4_l2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, t

the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 1.073
```

```
In [178]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_4_l2, annot=True,annot_kws={"size": 16}, fmt='g')

Out[178]: <matplotlib.axes._subplots.AxesSubplot at 0x1e131e45f28>
```



70 Train the model using the best hyper parameter value (L1)

```
In [179]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
          from sklearn.metrics import roc_curve, auc


          model = SGDClassifier(loss='hinge', penalty='l1', alpha=0.0005)

          model.fit(X_tr, y_train)

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

          y_train_pred = model.decision_function(X_tr)
          y_test_pred = model.decision_function(X_te)

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

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



71 Confusion Matrix (L1)

Train Data

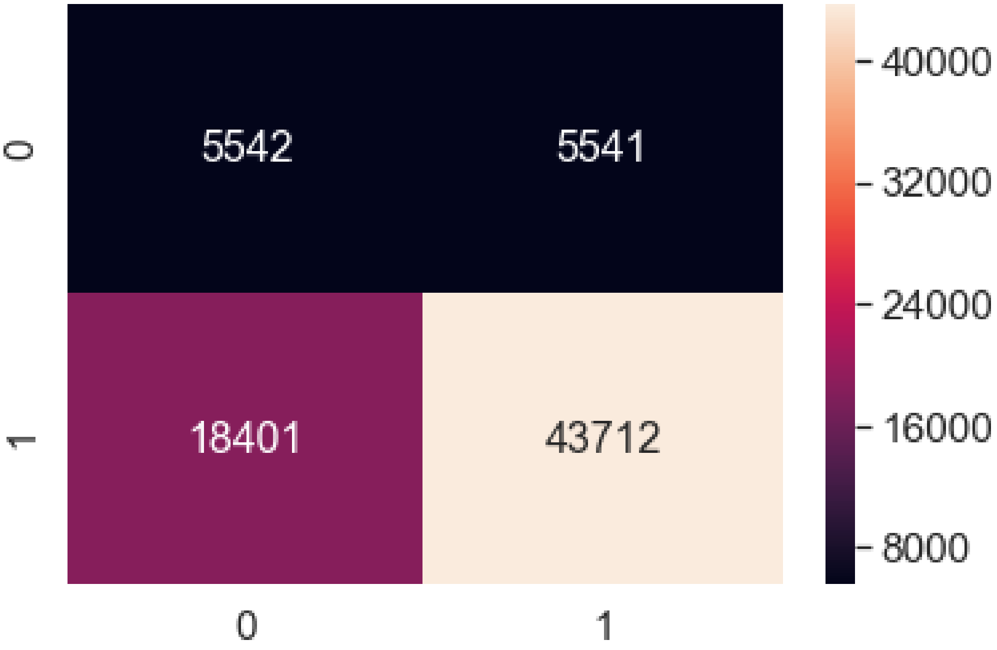
```
In [180]: print("="*100)
          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

```
========================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 0.99
[[ 5542  5541]
 [18401 43712]]
```

```
In [181]: conf_matr_df_train_4_l1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred
```

```
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 0.99
```

```
In [182]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_4_l1, annot=True,annot_kws={"size": 16}, fmt='g')

Out[182]: <matplotlib.axes._subplots.AxesSubplot at 0x1e131edbc88>
```

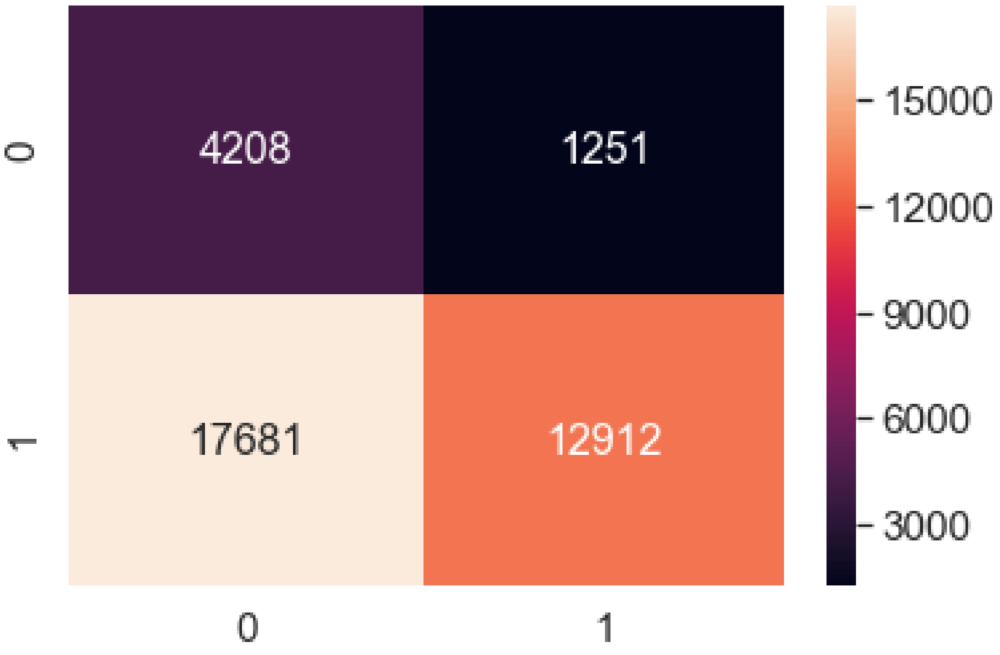


Test Data

```
In [183]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp

====================================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999244983697 for threshold 1.009
[[ 4208  1251]
 [17681 12912]]
```

```
In [184]: conf_matr_df_test_4_l1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, 

the maximum value of tpr*(1-fpr) 0.2499999244983697 for threshold 1.009
```

```
In [185]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_4_l1, annot=True,annot_kws={"size": 16}, fmt='g')

Out[185]: <matplotlib.axes._subplots.AxesSubplot at 0x1e160ab6630>
```



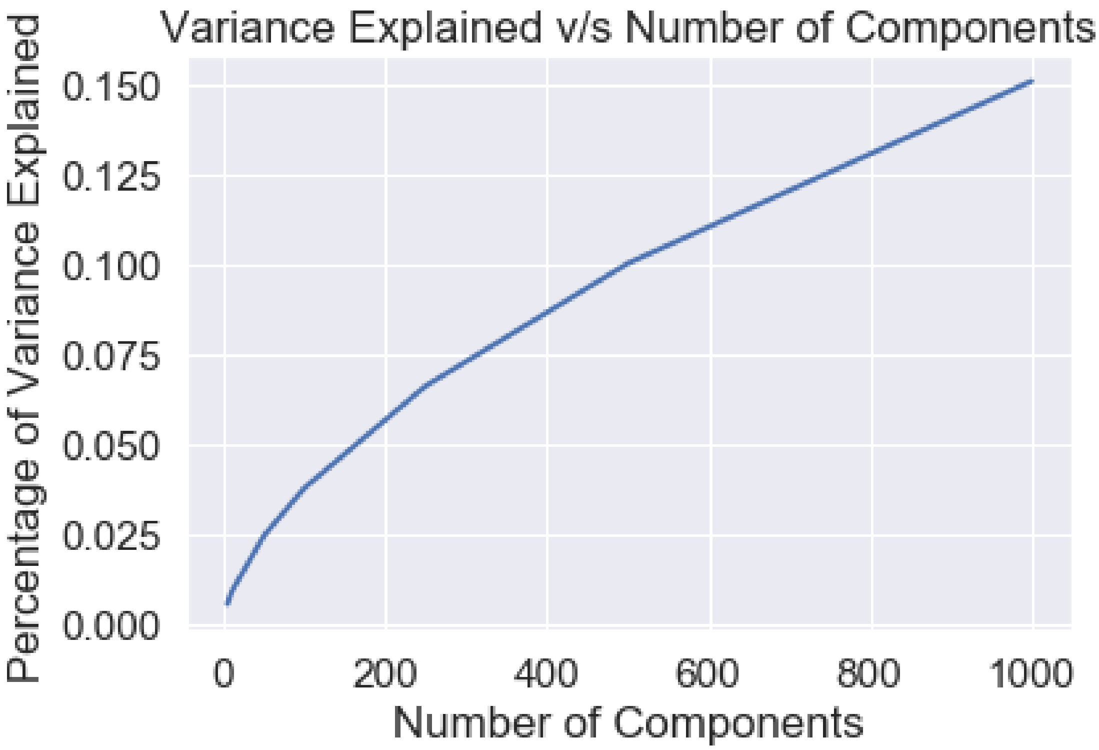
72 Set 5 : Categorical features, Numerical features by TruncatedSVD on TfidfVectorizer

73 A) Using Elbow method to narrow down the best number of Components

```
In [186]: text_tfidf_train.shape

Out[186]: (73196, 132675)

In [187]: from sklearn.decomposition import TruncatedSVD

          index = [5,10,50,100,250,500,1000]
          variance_sum = []

          for i in tqdm(index):
              svd = TruncatedSVD(n_components= i, n_iter=7, random_state=42)
              svd.fit(text_tfidf_train)
              variance_sum.append(svd.explained_variance_ratio_.sum())

100%|| 7/7 [08:12<00:00, 115.99s/it]


In [188]: index = [5,10,50,100,250,500,1000]
In [189]: variance_sum
```

```
Out[189]: [0.005486146944981743,
           0.008790190661189273,
           0.024400663285875042,
           0.03765583906163524,
           0.0660503496714561,
           0.10016647306512982,
           0.15094518050270472]
```

```
In [190]: plt.xlabel("Number of Components")
          plt.ylabel("Percentage of Variance Explained")
          plt.title("Variance Explained v/s Number of Components")
          plt.plot(index,variance_sum,lw=2)
          plt.show()
```



74 Train Data

```
In [193]: svd = TruncatedSVD(n_components= 1000, n_iter=7, random_state=42)
          svd.fit(text_tfidf_train)
          svd_train = svd.transform(text_tfidf_train)
```

```
In [194]: print("Shape of matrix after Decomposition ",svd_train.shape)
```

```
Shape of matrix after Decomposition  (73196, 1000)
```

75 Test Data

```
In [195]: svd_test = svd.transform(text_tfidf_test)
          print("Shape of matrix after Decomposition ",svd_test.shape)
```

```
Shape of matrix after Decomposition  (36052, 1000)
```

```
In [197]: from scipy.sparse import hstack

          X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train, school_state_c
          X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test, school_state_ca
```

```
In [198]: print("Final Data matrix")
          print(X_tr.shape, y_train.shape)
          print(X_te.shape, y_test.shape)
          print("="*100)
```

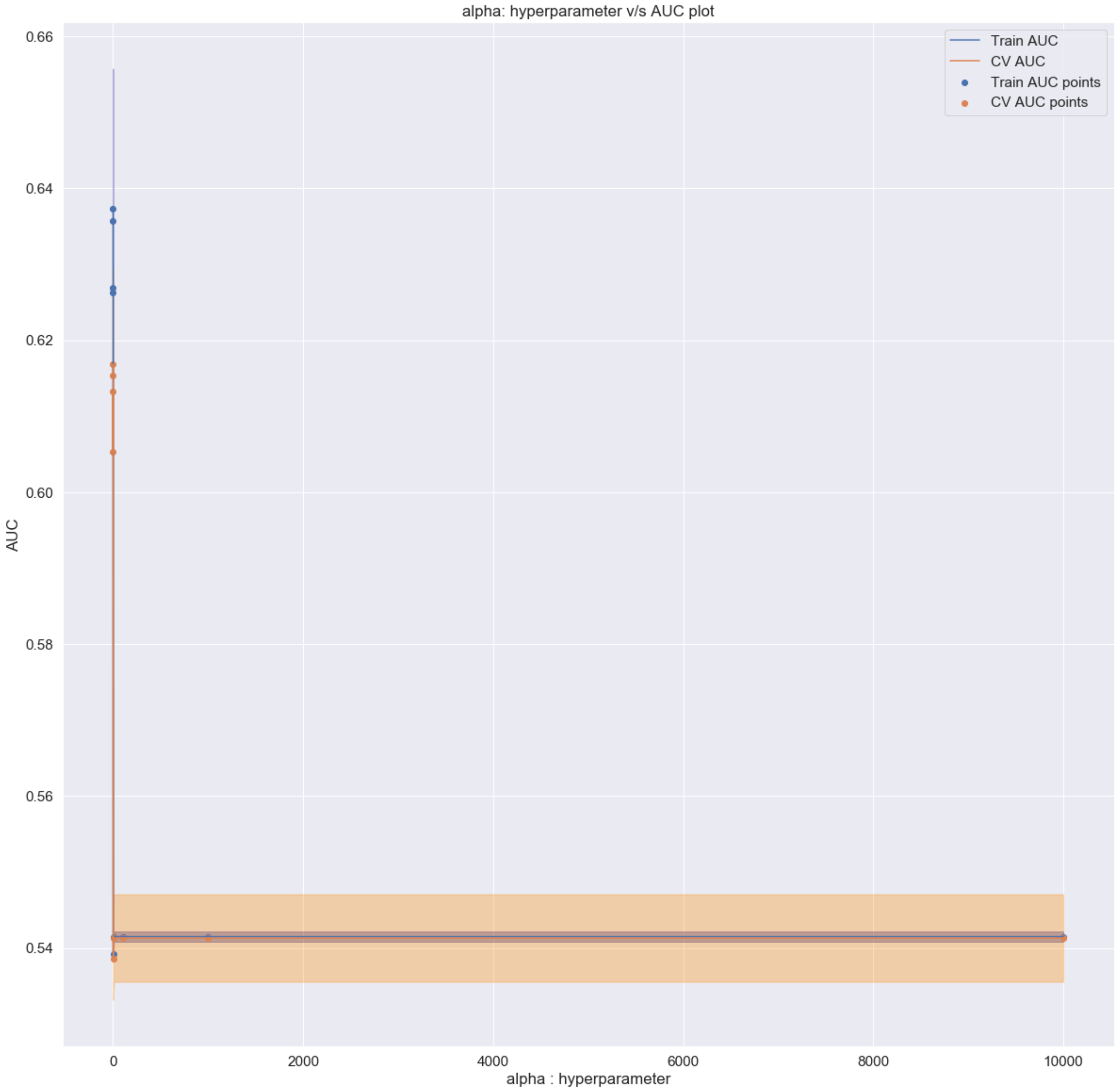
```
Final Data matrix
(73196, 1108) (73196,)
(36052, 1108) (36052,)
===============================================================================================
```

76 A) GridSearchCV (K fold Cross Validation) using Penalty(regularization = l2)

```
In [204]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

```
In [205]: plt.figure(figsize=(20,20))

          plt.plot(parameters['alpha'], train_auc, label='Train AUC')
          # this code is copied from here: https://stackoverflow.com/a/48803361/4084039
```

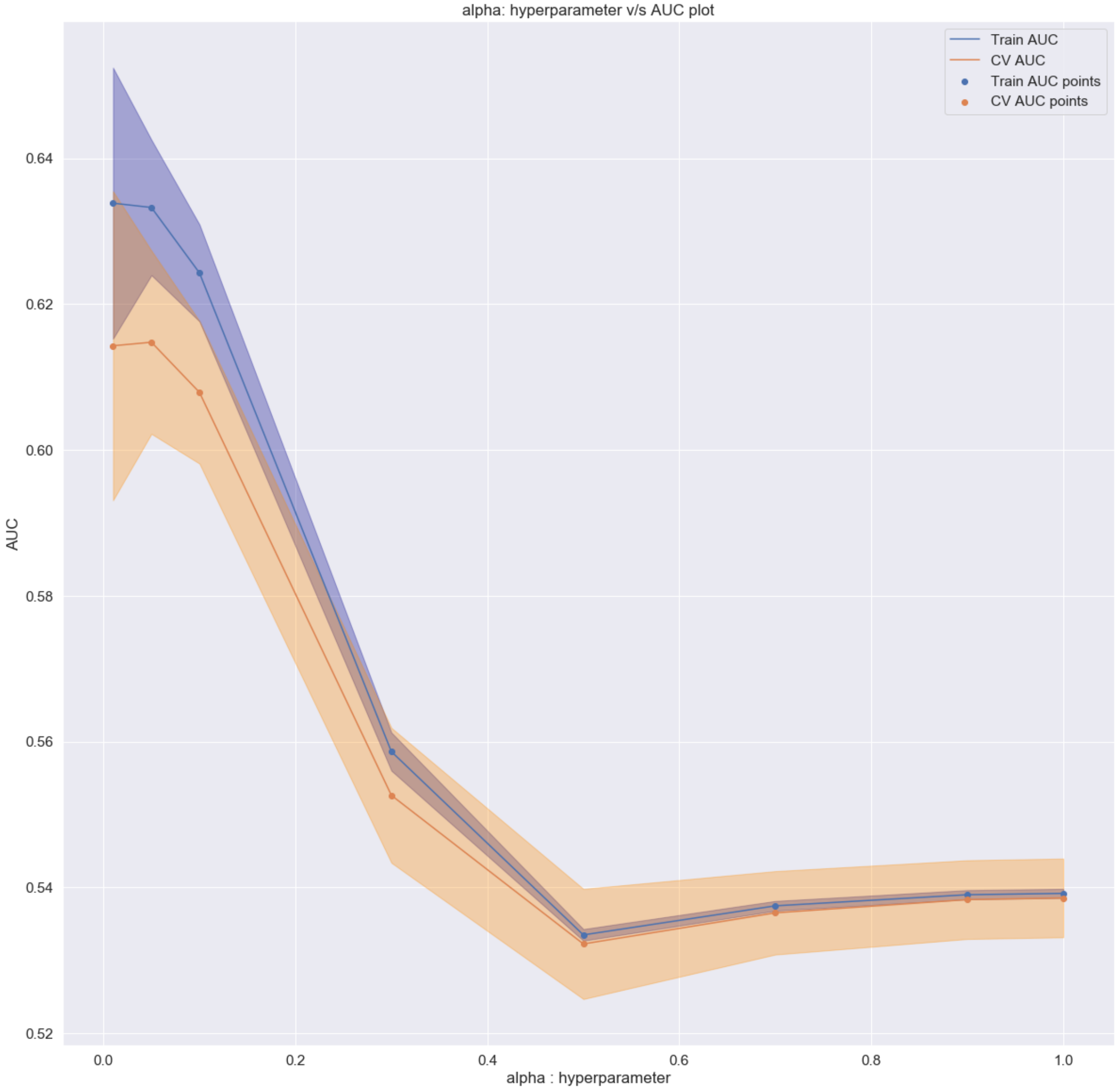
```
plt.gca().fill_between(parameters['alpha'],train_auc - train_auc_std,train_auc + tra

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

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


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



Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might yield the expected result. 3. Alpha values in the range of 0.1 to 1 seems to be a suitable range

```
In [206]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[0.01, 0.05, 0.1, 0.3, 0.5, 0.7, 0.9, 1.0]}

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']
```

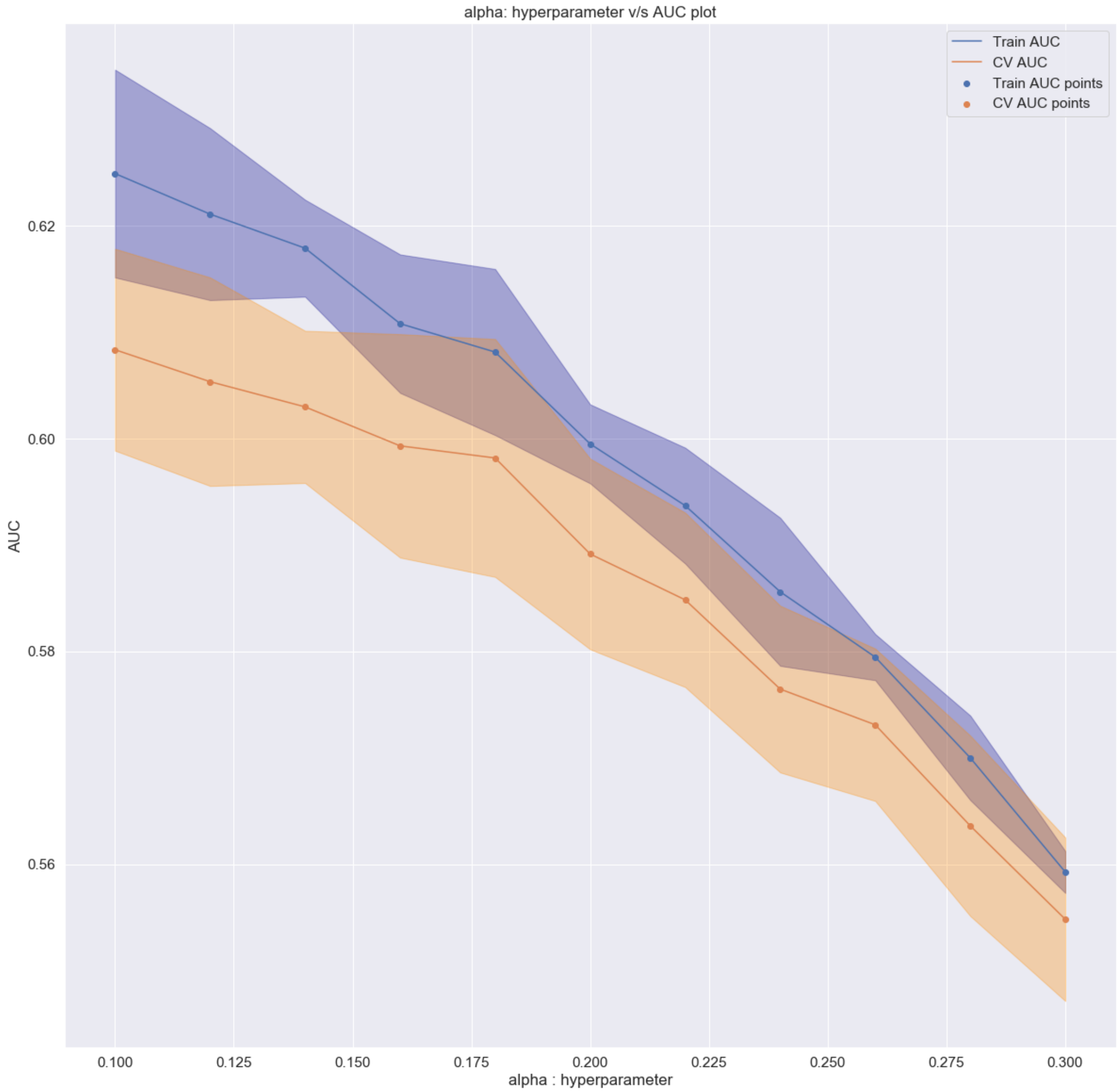
```
In [207]: plt.figure(figsize=(20,20))

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

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

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


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



Inference 1. I was not able to deteremine an appropriate value for my parameter. So, I have re-run the GridSearchCV on a smaller set of parameter values. 2. I was able to narrow down to a range of alpha values that might yield the expected result. 3. Alpha values in the range of 0.1 to 0.3 seems to be a suitable ran

```
In [208]: sv = SGDClassifier(loss='hinge', penalty='l2')

          parameters = {'alpha':[0.10, 0.12, 0.14, 0.16, 0.18, 0.2, 0.22, 0.24, 0.26, 0.28, 0.

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']

In [209]: plt.figure(figsize=(20,20))

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

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

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


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

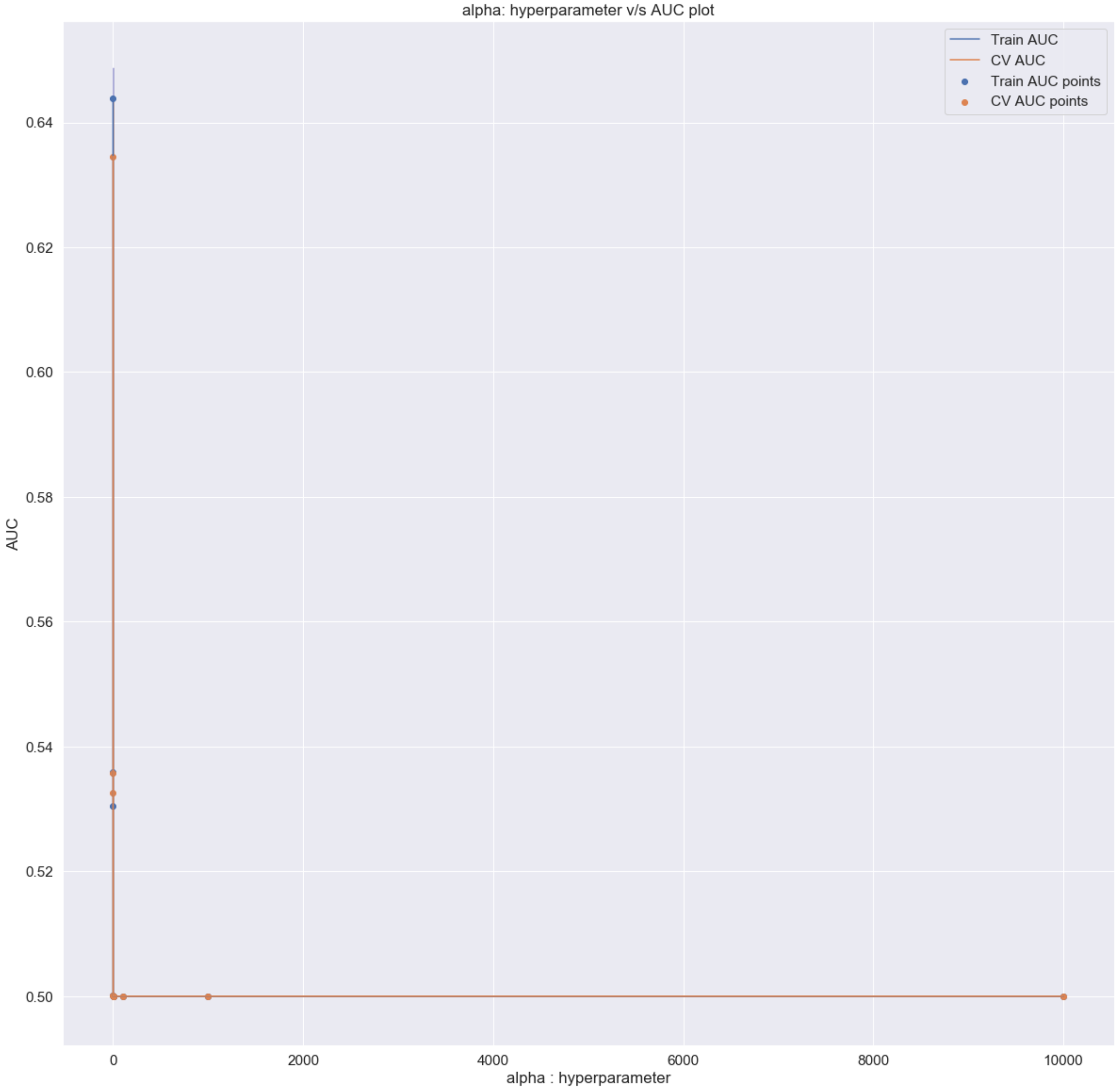


77 Inference

0.18 can be considered as the alpha value. B) GridSearchCV (K fold Cross Validation) using Penalty(regularization = l1)

```
In [210]: sv = SGDClassifier(loss='hinge', penalty='l1')

          parameters = {'alpha':[10**-4, 10**-3, 10**-2, 10**-1, 10**0, 10**1, 10**2, 10**3, 1

          clf = GridSearchCV(sv, parameters, cv= 10, scoring='roc_auc')

          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']

In [211]: plt.figure(figsize=(20,20))

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

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

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


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

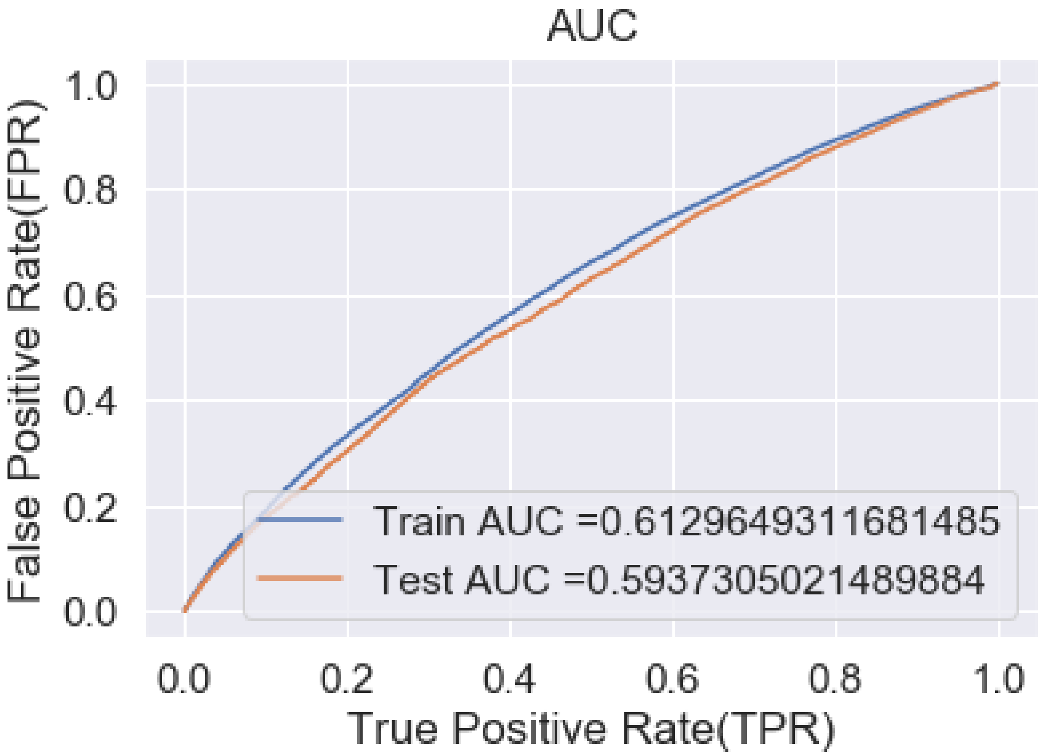


Inference 0.0001 can be considered as the alpha value.

78 Train the model using the best hyper parameter value (L2)

```
In [212]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
          from sklearn.metrics import roc_curve, auc


          model = SGDClassifier(loss='hinge', penalty='l2', alpha= 0.18)

          model.fit(X_tr, y_train)

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

```
y_train_pred = model.decision_function(X_tr)
y_test_pred = model.decision_function(X_te)

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

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



79 Confusion Matrix (L2)

Train Data

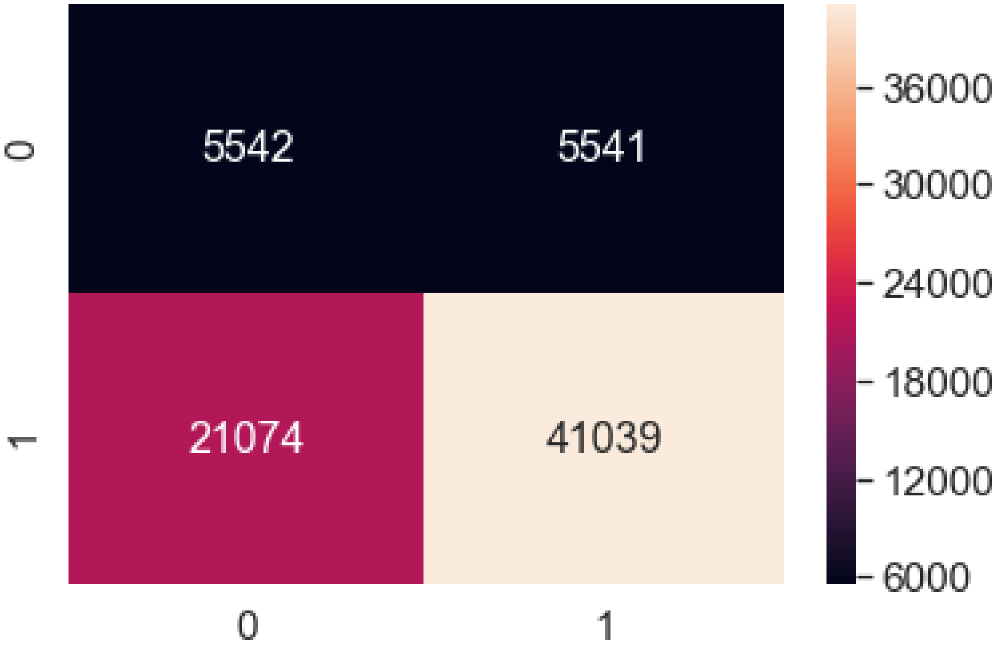
```
In [213]: print("="*100)
          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
==============================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 1.0
[[ 5542  5541]
 [21074 41039]]
```

```
In [214]: conf_matr_df_train_5_12 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pre
```

```
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 1.0
```

```
In [215]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_5_12, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[215]: <matplotlib.axes._subplots.AxesSubplot at 0x1e14be7db38>
```



80 Test data

```
In [216]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
```

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

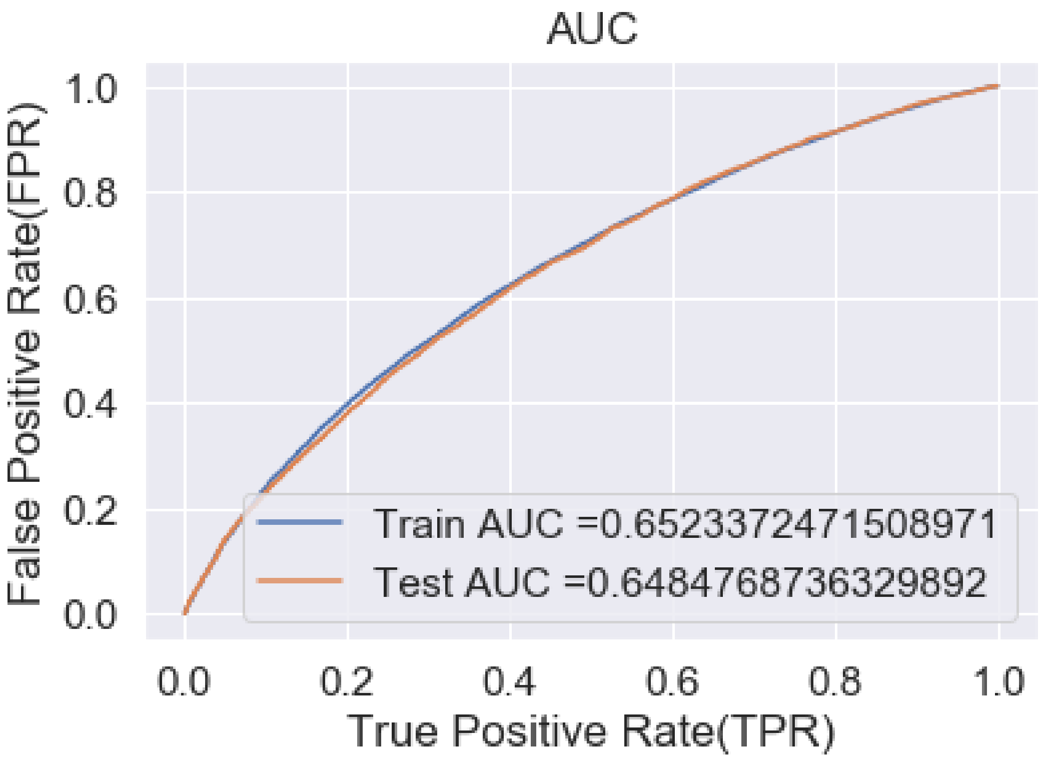
```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 1.001
[[ 4060  1399]
 [19009 11584]]
```

```
In [217]: conf_matr_df_test_5_l2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, t
```

```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 1.001
```

81 Train the model using the best hyper parameter value (L1)

```
In [218]: # https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#s
          from sklearn.metrics import roc_curve, auc


          model = SGDClassifier(loss='hinge', penalty='l1', alpha= 0.0001)

          model.fit(X_tr, y_train)

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

          y_train_pred = model.decision_function(X_tr)
          y_test_pred = model.decision_function(X_te)

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

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



82 Confusion Matrix (L1)

83 Train Data

```
In [219]: print("="*100)
          from sklearn.metrics import confusion_matrix
          print("Train confusion matrix")
          print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, trai
```

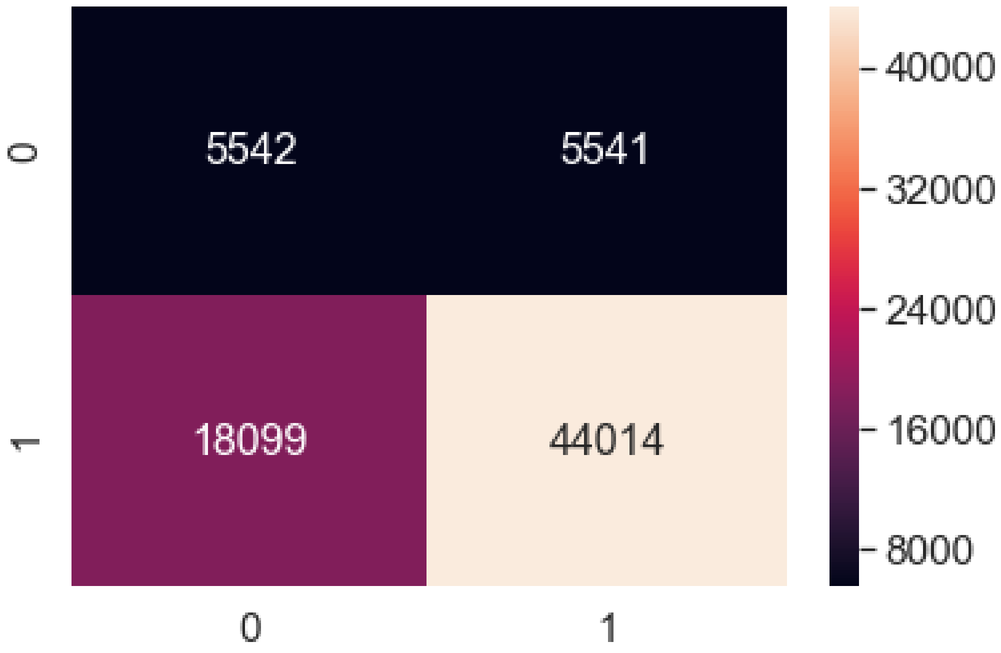
```
====================================================================================================
Train confusion matrix
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 0.886
[[ 5542  5541]
 [18099 44014]]
```

```
In [220]: conf_matr_df_train_5_l1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pre
```

```
the maximum value of tpr*(1-fpr) 0.2499999979647145 for threshold 0.886
```

```
In [221]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_train_5_l1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[221]: <matplotlib.axes._subplots.AxesSubplot at 0x1e14cf418d0>
```



84 Test Data

```
In [222]: print("="*100)
          print("Test confusion matrix")
          print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fp
```

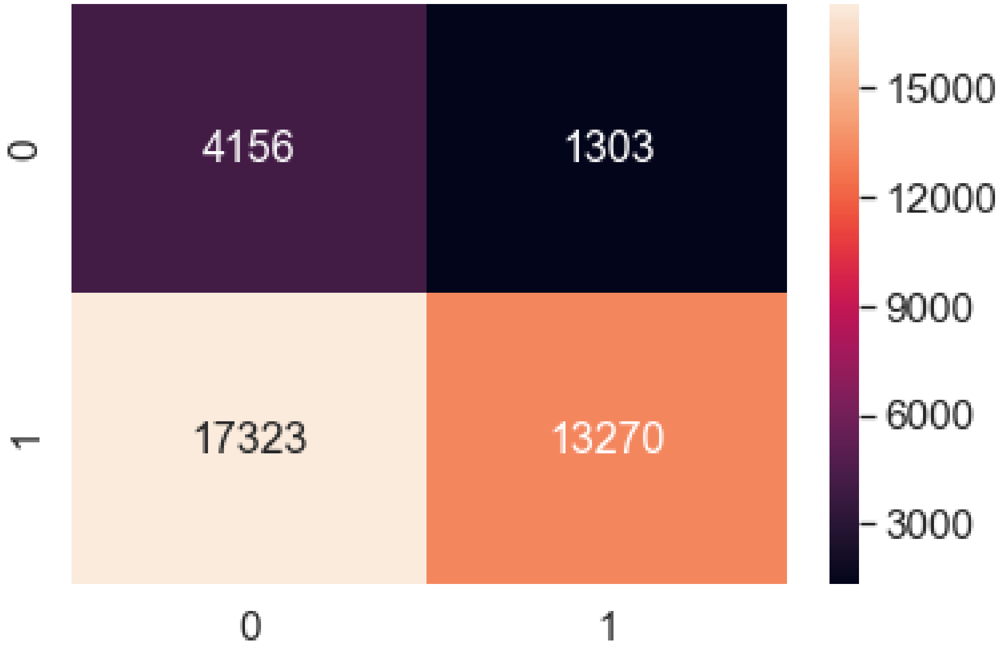
```
========================================================================================
Test confusion matrix
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.935
[[ 4156  1303]
 [17323 13270]]
```

```
In [223]: conf_matr_df_test_5_l1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, t
```

```
the maximum value of tpr*(1-fpr) 0.24999999161092998 for threshold 0.935
```

```
In [224]: sns.set(font_scale=1.4)#for label size
          sns.heatmap(conf_matr_df_test_5_l1, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Out[224]: <matplotlib.axes._subplots.AxesSubplot at 0x1e14ce90630>
```



85 Conclusion

```
In [225]: # http://zetcode.com/python/prettytable/

          from prettytable import PrettyTable

          #If you get a ModuleNotFoundError error , install prettytable using: pip3 install pr

          x = PrettyTable()
          x.field_names = ["Vectorizer", "Model", "Penalty","Alpha:Hyper Parameter", "AUC"]

          x.add_row(["BOW", "Linear SVM","L2 performs better than L1", 0.3, 0.647])
          x.add_row(["TFIDF", "Linear SVM", "L1 performs better than L2",0.0001, 0.667])
          x.add_row(["AVG W2V", "Linear SVM", "L1 & L2 both have similar effects", "L1:0.00005
          x.add_row(["TFIDF W2V", "Linear SVM", "Neither L1 or L2", "L1:0.0005 & L2:6.0", "L1:0
          x.add_row(["TRUNCATED SVD", "Linear SVM", "L1 & L2 both have similar effects", "L1:0


          print(x)
```

```
+---------------+------------+------------------------------------+-----------------------+-----
|   Vectorizer  |   Model    |              Penalty               | Alpha:Hyper Parameter |
+---------------+------------+------------------------------------+-----------------------+-----
|      BOW      | Linear SVM |     L2 performs better than L1     |          0.3          |
|     TFIDF     | Linear SVM |     L1 performs better than L2     |         0.0001          |
|    AVG W2V    | Linear SVM | L1 & L2 both have similar effects | L1:0.00005 & L2:0.005 |  L1
|   TFIDF W2V   | Linear SVM |          Neither L1 or L2          |   L1:0.0005 & L2:6.0  | L1:0
| TRUNCATED SVD | Linear SVM | L1 & L2 both have similar effects |  L1:0.0001 & L2:0.18  |  L1
+---------------+------------+-----------------------------------+-----------------------+----
```