# DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there are three main problems they need to solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible
- How to increase the consistency of project vetting across different volunteers to improve the experience for teachers
- How to focus volunteer time on the applications that need the most assistance

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

## About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

| Feature | Description |
| --- | --- |
| **`project_id`** | A unique identifier for the proposed project. **Example:** `p036502` |
| **`project_title`** | Title of the project. **Examples:**<br>• `Art Will Make You Happy!`<br>• `First Grade Fun` |
| **`project_grade_category`** | Grade level of students for which the project is targeted. One of the following enumerated values:<br>• `Grades PreK-2`<br>• `Grades 3-5`<br>• `Grades 6-8`<br>• `Grades 9-12` |
| **`project_subject_categories`** | One or more (comma-separated) subject categories for the project from the following enumerated list of values:<br>• `Applied Learning`<br>• `Care & Hunger`<br>• `Health & Sports`<br>• `History & Civics`<br>• `Literacy & Language`<br>• `Math & Science`<br>• `Music & The Arts`<br>• `Special Needs`<br>• `Warmth`<br>**Examples:**<br>• `Music & The Arts`<br>• `Literacy & Language, Math & Science` |
| **`school_state`** | State where school is located (Two-letter U.S. postal code). **Example:** `WY` |
| **`project_subject_subcategories`** | One or more (comma-separated) subject subcategories for the project. **Examples:**<br>• `Literacy` |

| Feature | Description |
| --- | --- |
| | • `Literature & Writing, Social Sciences` |
| **`project_resource_summary`** | An explanation of the resources needed for the project. **Example:**<br>• `My students need hands on literacy materials to manage sensory needs!` |
| **`project_essay_1`** | First application essay* |
| **`project_essay_2`** | Second application essay* |
| **`project_essay_3`** | Third application essay* |
| **`project_essay_4`** | Fourth application essay* |
| **`project_submitted_datetime`** | Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245` |
| **`teacher_id`** | A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56` |
| **`teacher_prefix`** | Teacher's title. One of the following enumerated values:<br>• `nan`<br>• `Dr.`<br>• `Mr.`<br>• `Mrs.`<br>• `Ms.`<br>• `Teacher.` |
| **`teacher_number_of_previously_posted_projects`** | Number of project applications previously submitted by the same teacher. **Example:** `2` |

* See the section **Notes on the Essay Data** for more details about these features.

Additionally, the `resources.csv` data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

| Feature | Description |
| --- | --- |
| **`id`** | A `project_id` value from the `train.csv` file. **Example:** `p036502` |
| **`description`** | Desciption of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25` |
| **`quantity`** | Quantity of the resource required. **Example:** `3` |
| **`price`** | Price of the resource required. **Example:** `9.95` |

**Note:** Many projects require multiple resources. The `id` value corresponds to a `project_id` in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

| Label | Description |
| --- | --- |
| `project_is_approved` | A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the project was not approved, and a value of `1` indicates the project was approved. |

## Notes on the Essay Data

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

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

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

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."

your neighborhood, and your school are all helpful.

- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

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

In [1]:

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

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

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

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

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

from tqdm import tqdm
import os

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

from sklearn.metrics import accuracy_score
```

## 1.1 Reading Data

In [2]:

```
project_data = pd.read_csv('train_data.csv', nrows=50000)
resource_data = pd.read_csv('resources.csv')
```

In [3]:

```
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 (50000, 17)
--------------------------------------------------
The attributes of data : ['Unnamed: 0' 'id' 'teacher_id' 'teacher_prefix' 'school_state'
 'project_submitted_datetime' 'project_grade_category'
 'project_subject_categories' 'project_subject_subcategories'
 'project_title' 'project_essay_1' 'project_essay_2' 'project_essay_3'
 'project_essay_4' 'project_resource_summary'
 'teacher_number_of_previously_posted_projects' 'project_is_approved']
```

In [4]:

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


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


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


project_data.head(2)
```

Out[4]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | Date | project_grade_categ |
|---|---|---|---|---|---|---|---|
| **473** | 100660 | p234804 | cbc0e38f522143b86d372f8b43d4cff3 | Mrs. | GA | 2016-04-27 00:53:00 | Grades PreK-2 |
| **41558** | 33679 | p137682 | 06f6e62e17de34fcf81020c77549e1d5 | Mrs. | WA | 2016-04-27 01:05:25 | Grades 3-5 |

In [5]:

```
print("Number of data points in train data", resource_data.shape)
print(resource_data.columns.values)
resource_data.head(2)
```

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

Out[5]:

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

In [6]:

```
project_grade_category = []

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

In [7]:

```
project_grade_category[0:5]
```

Out[7]:

```
['Grades_PreK-2', 'Grades_6-8', 'Grades_6-8', 'Grades_PreK-2', 'Grades_PreK-2']
```

In [8]:

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

In [9]:

```
project_data["project_grade_category"] = project_grade_category
```

In [10]:

```
project_data.head(5)
```

Out[10]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | Date | project_subject_ca |
|---|---|---|---|---|---|---|---|
| **473** | 100660 | p234804 | cbc0e38f522143b86d372f8b43d4cff3 | Mrs. | GA | 2016-04-27 00:53:00 | Applied Learning |
| **41558** | 33679 | p137682 | 06f6e62e17de34fcf81020c77549e1d5 | Mrs. | WA | 2016-04-27 01:05:25 | Literacy & Language |
| **29891** | 146723 | p099708 | c0a28c79fe8ad5810da49de47b3fb491 | Mrs. | CA | 2016-04-27 01:10:09 | Math & Science, Hist Civics |
| **23374** | 72317 | p087808 | 598621c141cda5fb184ee7e8ccdd3fcc | Ms. | CA | 2016-04-27 02:04:15 | Literacy & Language |
| **49228** | 57854 | p099430 | 4000cfe0c8b2df75a218347c1765e283 | Ms. | IL | 2016-04-27 07:19:44 | Literacy & Language |

## 1.2 preprocessing of `project_subject_categories`

In [11]:

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

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
cat_list = []
for i in categories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & H
unger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Scienc
e"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i
.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math &
Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())
```

```
project_data['clean_categories'] = cat_list
project_data.drop(['project_subject_categories'], axis=1, inplace=True)

from collections import Counter
my_counter = Counter()
for word in project_data['clean_categories'].values:
    my_counter.update(word.split())

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

## 1.3 preprocessing of `project_subject_subcategories`

In [12]:

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

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

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

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

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

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

## 1.4 Introducing new feature "Number of Words in Title"

In [13]:

```
title_word_count = []
```

In [14]:

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

In [15]:

```
project_data["title_word_count"] = title_word_count
```

In [16]:

```
project_data.head(5)
```

Out[16]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | Date | project_title | proje |
|---|---|---|---|---|---|---|---|---|
| **473** | 100660 | p234804 | cbc0e38f522143b86d372f8b43d4cff3 | Mrs. | GA | 2016-04-27 00:53:00 | Flexible Seating for Flexible Learning | I rece article giving |
| **41558** | 33679 | p137682 | 06f6e62e17de34fcf81020c77549e1d5 | Mrs. | WA | 2016-04-27 01:05:25 | Going Deep: The Art of Inner Thinking! | My st crave they e obsta |
| **29891** | 146723 | p099708 | c0a28c79fe8ad5810da49de47b3fb491 | Mrs. | CA | 2016-04-27 01:10:09 | Breakout Box to Ignite Engagement! | It's the schoo Routir |
| **23374** | 72317 | p087808 | 598621c141cda5fb184ee7e8ccdd3fcc | Ms. | CA | 2016-04-27 02:04:15 | iPad for Learners | Never societ chang Techr |
| **49228** | 57854 | p099430 | 4000cfe0c8b2df75a218347c1765e283 | Ms. | IL | 2016-04-27 07:19:44 | A flexible classroom for flexible minds! | My st yearn classr enviro |

## 1.5 Combine 4 Project essays into 1 Essay

In [17]:

```
# 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)
```

## 1.6 Introducing new feature "Number of Words in Essay"

In [18]:

```
essay_word_count = []
```

In [19]:

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

In [20]:

```
project_data["essay_word_count"] = essay_word_count
```

In [21]:

```
project_data.head(5)
```

Out[21]:

| | Unnamed: 0 | id | teacher_id | teacher_prefix | school_state | Date | project_title | proje |
|---|---|---|---|---|---|---|---|---|
| **473** | 100660 | p234804 | cbc0e38f522143b86d372f8b43d4cff3 | Mrs. | GA | 2016-04-27 00:53:00 | Flexible Seating for Flexible Learning | I rece article giving |
| **41558** | 33679 | p137682 | 06f6e62e17de34fcf81020c77549e1d5 | Mrs. | WA | 2016-04-27 01:05:25 | Going Deep: The Art of Inner Thinking! | My stu crave they e obsta |
| **29891** | 146723 | p099708 | c0a28c79fe8ad5810da49de47b3fb491 | Mrs. | CA | 2016-04-27 01:10:09 | Breakout Box to Ignite Engagement! | It's the schoo Routir |
| **23374** | 72317 | p087808 | 598621c141cda5fb184ee7e8ccdd3fcc | Ms. | CA | 2016-04-27 02:04:15 | iPad for Learners | Never societ chang Techr |
| **49228** | 57854 | p099430 | 4000cfe0c8b2df75a218347c1765e283 | Ms. | IL | 2016-04-27 07:19:44 | A flexible classroom for flexible minds! | My stu yearn classr enviro |

## 1.7 Test - Train Split

In [22]:

```
# 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['project_is_approved'],
                                                    test_size=0.33, stratify = project_data['projec
is_approved'])
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [23]:

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

## 1.8 Text preprocessing

In [24]:

```
# printing some random reviews

print(X_train['essay'].values[0])
print("="*50)
print(X_train['essay'].values[500])
print("="*50)
print(X_train['essay'].values[1000])
print("="*50)
print(X_train['essay'].values[10000])
print("="*50)
print(X_train['essay'].values[20000])
```

```
print(X_train['essay'].values[20000])
print("="*50)
```

My students are pretty awesome 6th graders. They come from low income families, but they do not le
t that stop them from trying their best to succeed. There is great community within and around the
school. My 6th graders have a community project every year. Some have done topics on bullying, oth
ers have done special needs awareness to help students with special needs be integrated into the r
egular population. We have had students create murals with the help of art teachers. We are workin
g hard to have all of our ELs reclassified by the 6th grade and we have been awarded the Gold Ribb
on School award, specifically for our Resource center's great work in the school.The materials tha
t are requested will be used for an art class in the 6th grade. This is the first year we are impl
ementing such a class.  \r\nStudents in the class will explore all elements of art, including, but
not limited to: paint, oil, clay, photography, music, and drawing.  Art is an extremely important
part of academia, and there are so many ways to include other academics within art. In our urban a
rea, these students need an outlet to express their feelings. Teaching them proper art techniques
may pique their interest in school and will help further their joy to learn!\r\nnannan
==================================================
My students come to class daily ready to work and play. Parents work hard to try to give their
students everything they can. We are located in a rural section of the foothills of North
Carolina. Our school is a Title I funded school with 100% of our students receiving free breakfast
and lunch. It is my goal that every child enjoys learning and grows to be a very successful
citizen. The best way for this to be done is including the family in education. It takes a village
to raise a child. \r\nIn my first grade class students need a lot of practicing to read. With lots
of practicing a classroom must have many ways to keep reading exciting. What would be better to 7
year olds than to get to read with a mini flashlight on Fridays. I have 21 students, 10 girls and
11 boys,  these mini flashlights, community helper books, and magazines would allow more
opportunities for these students to practice reading. The batteries would allow the flashlights to
shine bright all year.\r\nWith the 100 words magazines students could read and then use their flas
hlights to go on a word hunt around the room.  Making learning intriguing at a young age will incr
ease the chances of a student being successsful. \r\nnannan
==================================================
My students are bright and full of enthusiasm.  However, often students living in urban areas are
surrounded with situations that sometimes do not allow for a broader understanding of their peers
in other countries.  At International Studies Learning Center we aim to broaden the horizon for ou
r students. Students are encouraged to feel that they are global citizens.  I hope to expose my st
udents to students of different nations through 21 century learning practices.  It is more
essential now than ever that we guide young people towards understanding, tolerance and respecting
people who are different from ourselves, whether that be racially, ethnically or in any other way.
\r\n\r\nThey often need a positive means to channel their energy and creative ways in which to exp
ress themselves. We are an urban area public school in an industrial of greater Los Angeles. Our s
tudents qualify for the Federal free lunch program due to income levels.  These students are full
of positive potential.  We just need a bit of help from you.\r\n\r\nYour generosity will allow stu
dents to engage in their learning and expand their academic speaking and knowledge about various c
ultures around the world. They will use SKYPE using the laptop I've requested and contact other st
udents around the world in the hopes of better understanding their place in the world. The hope is
that my students will be able to create and craft a future that is global and not solely confined
to their neighborhoods.\r\n\r\nThis project is important to me because I've seen how limited some
of my students are in terms of their exposure to various cultures around the world.  Empowering st
udents to develop tolerance, respect and appreciation for other cultures is vitally important.  As
we have seen in recent events all over the world, building a bridge across cultures can lead to pe
ace and civility.\r\nnannan
==================================================
My 20 1st grade students are highly motivated to learn, explore and engage in their road to a succ
essful education! As a teacher in a low-income/high poverty school district, my students are faced
with several challenges both in and out of the classroom. Despite the many challenges they face, I
am looking to keep things simple and provide my students with creative and meaningful learning exp
eriences. \r\n\r\n\"Tell me and I forget, Teach me and I remember, Involve me and I learn\" --Benj
amin Franklin \r\n\r\nEach and every child that enters my classroom is more than just a student. T
hey become a part of my heart and I am beyond blessed to be given the opportunity to love these ki
ds and broaden their little minds. Many of my students are being raised in single parent
households and receive a free lunch based on their socioeconomic status. These things may prevent
them from getting ahead early in life and may not provide them with the life experiences many of u
s see as \"typical\". I sometimes take for granted some of the things they have never experienced.
Despite their diverse backgrounds, we ALL have the same goal...TO LEARN and love learning!I am a p
revious 5th grade year teacher new to 1st grade. My kiddos need exciting, hands-on learning activi
ties at their level to entice their minds and motivate them to learn. A main focus area of 1st gra
de is phonics and learning to read fluently.\r\n\r\nWe do stations daily on our classroom and we a
re always needing fun ways to learn how to READ! \r\n\r\nThe reality is when we were in the early
elementary grades, it was probably the \"norm\" for an entire school to only have a handful of com
puters, centralized in a lab and used only sparingly. Today’s kids have grown up in a technology-r
ich environment. By the time they reach elementary school, sitting at a desk copying figures from
a chalkboard is not playing into their strengths as students. Passive learning definitely still
has its place, as kids need to memorize facts and figures just as ever before. But more and more w
e have turned to interactive learning to inspire students and keep the teacher-student
relationship vital. \r\n\r\nMy kiddos would benefit in so many ways from having these new
interactive activities in our classroom. They need to be able to get up and wiggle around the room
and \"play\" while they work. These activities I have chosen will do just that and allow my kiddos

```
a new and exciting avenue for learning.nannan
==================================================
Bonjour! My students are learning French for the first time and are very happy and excited about i
t!\r\nThese high school students are already bilingual in Spanish and English and now have the cha
nce to study a new foreign language: French! \r\n\r\nMy students are from the highest
poverty.\r\nLearning foreign languages is a valuable job skill. In addition to Spanish, our studen
ts will now know French!\r\nWho knows which of our students will go on to the university, receive
scholarships, pursue work for the UN, the military, various domestic and overseas jobs, and/or pur
sue careers in translation fields?We are requesting various texts in French, children's music in
French and stories to translate, as well as the Rosetta Stone computer program in
French.\r\n\r\nFrench is the language of the UN, as well as 20 areas around the world.\r\n\r\nWe b
elieve that a multi-faceted approach to learning a language is the best way to learn. We teach lis
tening to, speaking, reading and writing in French. \r\n\r\nWith over 85% of our students in pover
ty at our school, let's work together to help these children find a way to better-paying jobs thro
ugh better, increased education. You can make a huge, life-long difference in a child's life!
\r\n\r\nnannan
==================================================
```

In [25]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

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

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

In [26]:

```
sent = decontracted(X_train['essay'].values[20000])
print(sent)
print("="*50)
```

```
Bonjour! My students are learning French for the first time and are very happy and excited about i
t!\r\nThese high school students are already bilingual in Spanish and English and now have the cha
nce to study a new foreign language: French! \r\n\r\nMy students are from the highest
poverty.\r\nLearning foreign languages is a valuable job skill. In addition to Spanish, our studen
ts will now know French!\r\nWho knows which of our students will go on to the university, receive
scholarships, pursue work for the UN, the military, various domestic and overseas jobs, and/or pur
sue careers in translation fields?We are requesting various texts in French, children is music in
French and stories to translate, as well as the Rosetta Stone computer program in
French.\r\n\r\nFrench is the language of the UN, as well as 20 areas around the world.\r\n\r\nWe b
elieve that a multi-faceted approach to learning a language is the best way to learn. We teach lis
tening to, speaking, reading and writing in French. \r\n\r\nWith over 85% of our students in pover
ty at our school, let is work together to help these children find a way to better-paying jobs thr
ough better, increased education. You can make a huge, life-long difference in a child is life! \r
\n\r\nnannan
==================================================
```

In [27]:

```
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
Bonjour! My students are learning French for the first time and are very happy and excited about i
t!  These high school students are already bilingual in Spanish and English and now have the chanc
e to study a new foreign language: French!     My students are from the highest poverty.  Learning
foreign languages is a valuable job skill. In addition to Spanish, our students will now know Fren
```

```
ch!  Who knows which of our students will go on to the university, receive scholarships, pursue wo
rk for the UN, the military, various domestic and overseas jobs, and/or pursue careers in translat
ion fields?We are requesting various texts in French, children is music in French and stories to t
ranslate, as well as the Rosetta Stone computer program in French.    French is the language of th
e UN, as well as 20 areas around the world.    We believe that a multi-faceted approach to
learning a language is the best way to learn. We teach listening to, speaking, reading and writing
in French.     With over 85% of our students in poverty at our school, let is work together to hel
p these children find a way to better-paying jobs through better, increased education. You can mak
e a huge, life-long difference in a child is life!     nannan
```

In [28]:

```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
Bonjour My students are learning French for the first time and are very happy and excited about it
These high school students are already bilingual in Spanish and English and now have the chance to
study a new foreign language French My students are from the highest poverty Learning foreign lang
uages is a valuable job skill In addition to Spanish our students will now know French Who knows w
hich of our students will go on to the university receive scholarships pursue work for the UN the
military various domestic and overseas jobs and or pursue careers in translation fields We are req
uesting various texts in French children is music in French and stories to translate as well as th
e Rosetta Stone computer program in French French is the language of the UN as well as 20 areas ar
ound the world We believe that a multi faceted approach to learning a language is the best way to
learn We teach listening to speaking reading and writing in French With over 85 of our students in
poverty at our school let is work together to help these children find a way to better paying jobs
through better increased education You can make a huge life long difference in a child is life nan
nan
```

In [29]:

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

### 1.8.1 Preprocessed Train data (Text)

In [30]:

```
# Combining all the above

from tqdm import tqdm
preprocessed_essays_train = []
# tqdm is for printing the status bar
```

```
for sentence in tqdm(X_train['essay'].values):
    sent = decontracted(sentence)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_train.append(sent.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445 [00:
24<00:00, 914.59it/s]
```

In [31]:

```
# after preprocesing
preprocessed_essays_train[1000]
```

Out[31]:

```
'students bright full enthusiasm however often students living urban areas surrounded situations s
ometimes not allow broader understanding peers countries international studies learning center aim
broaden horizon students students encouraged feel global citizens hope expose students students di
fferent nations 21 century learning practices essential ever guide young people towards
understanding tolerance respecting people different whether racially ethnically way often need pos
itive means channel energy creative ways express urban area public school industrial greater los a
ngeles students qualify federal free lunch program due income levels students full positive potent
ial need bit help generosity allow students engage learning expand academic speaking knowledge var
ious cultures around world use skype using laptop requested contact students around world hopes be
tter understanding place world hope students able create craft future global not solely confined n
eighborhoods project important seen limited students terms exposure various cultures around world
empowering students develop tolerance respect appreciation cultures vitally important seen recent
events world building bridge across cultures lead peace civility nannan'
```

### 1.8.2 Preprocessed Test data (Text)

In [32]:

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

```
100%|████████████████████████████████████████████████████████████████| 16500/16500 [00:
22<00:00, 728.85it/s]
```

In [33]:

```
# after preprocesing
preprocessed_essays_test[1000]
```

Out[33]:

```
'students racially economically mixed group predominately rural school district many students enri
chment activities far anything enhance life experience help create caring successful adult want gi
ve students every opportunity increase abilities life noticed teaching career economically disadva
ntaged homes not get opportunities growth students job music teacher give opportunities music
classes try hands possible not learning music play perform music plan 10 ukuleles offer school enr
ichment class grade 3 8 students enrichment classes offered three 8 week sessions throughout
school year music create music live music hands experience playing real instruments students
increase brain power concentration skills addition instruments curriculum able better serve
culturally diverse community children nannan'
```

### 1.8.3 Preprocessed Cross Validation data (Text)

In [34]:

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

```
100%|██████████████████████████████████████████████████████████████████████████| 11055/11055 [00:14<00:00, 753.30it/s]
```

In [35]:

```
# after preprocesing
preprocessed_essays_cv[1000]
```

Out[35]:

```
'special education teacher serving students grades kindergarten third important students variety tools help successful students range not age also learning styles important options classroom students fine gross motor learning deficits comfortable using alternative seating arrangement sitting floor using stools around 48 students school english language learners 72 free reduced lunch school values outdoor learning keeping school garden students tend seven total special education classes ranging learning centers severely handicap medically fragile important students access appropriate educational tools best fit individual needs students need clean space library area floor allow sit position comfortable students class not always work well sitting chair desk important give opportunity work position comfortable classroom rug side small group students individual student work aid use whole class lessons stations small group work donation would give students opportunity experiment work environment best individual needs not would benefit individual students learn better away desk would also give students opportunity stretch play carpet mornings would use carpet way gather learn calendar weather count days school nannan'
```

## 1.9 Preprocessing of Project_title

In [36]:

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

```
Flexible Seating for Flexible Learning
==================================================
Elmo for Math Instruction
==================================================
Comfy Carpet for Creative Learning
==================================================
Wiggle, Waggle, Wobble: Hocus Focus!
==================================================
```

### 1.9.1 Preprocessing of Project Title for Train data

In [37]:

```
preprocessed_titles_train = []
```

```
for titles in tqdm(X_train["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)
    preprocessed_titles_train.append(title.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 22445/22445
[00:00<00:00, 23048.07it/s]
```

In [38]:

```
preprocessed_titles_train[1000]
```

Out[38]:

```
'students led project using skype global outreach'
```

### 1.9.2 Preprocessing of Project Title for Test data

In [39]:

```
preprocessed_titles_test = []

for titles in tqdm(X_test["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)
    preprocessed_titles_test.append(title.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 16500/16500
[00:00<00:00, 25626.26it/s]
```

In [40]:

```
preprocessed_titles_test[1000]
```

Out[40]:

```
'school enrichment ukuleles'
```

### 1.9.3 Preprocessing of Project Title for Cross Validation data

In [41]:

```
preprocessed_titles_cv = []

for titles in tqdm(X_cv["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)
    preprocessed_titles_cv.append(title.lower().strip())
```

```
100%|████████████████████████████████████████████████████████████████| 11055/11055
[00:00<00:00, 24607.12it/s]
```

In [42]:

```
preprocessed_titles_cv[1000]
```

Out[42]:

```
'alternative seating for a learning center'
```

## 1.9.4 Project_grade preprocessing

In [60]:

```
project_data['project_grade_category'][:4]
```

Out[60]:

```
473      Grades_PreK-2
41558       Grades_6-8
29891       Grades_6-8
23374    Grades_PreK-2
Name: project_grade_category, dtype: object
```

In [61]:

```
project_data['project_grade_category'] = project_data['project_grade_category'].str.replace(" ", "_
")
project_data['project_grade_category'].value_counts()
```

Out[61]:

```
Grades_PreK-2    20316
Grades_3-5       16968
Grades_6-8        7750
Grades_9-12       4966
Name: project_grade_category, dtype: int64
```

## 1.9.5 Preprocessing teacher_prefix

In [62]:

```
project_data['teacher_prefix'][:4]
```

Out[62]:

```
473      Mrs.
41558    Mrs.
29891    Mrs.
23374     Ms.
Name: teacher_prefix, dtype: object
```

In [63]:

```
project_data['teacher_prefix'] = project_data['teacher_prefix'].str.replace(".","")
project_data['teacher_prefix'].value_counts()
```

Out[63]:

```
Mrs        26140
Ms         17936
Mr          4859
Teacher     1061
Dr             2
Name: teacher_prefix, dtype: int64
```

## 1.10 Preparing data for models

In [43]:

```
project_data.columns
```

Out[43]:

```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', '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',
       'project_grade_category', 'clean_categories', 'clean_subcategories',
       'title_word_count', 'essay', 'essay_word_count'],
      dtype='object')
```

we are going to consider

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

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

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

### Vectorizing Categorical data

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

## One Hot Encode - Clean Categories of Projects

In [64]:

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

from sklearn.feature_extraction.text import CountVectorizer

vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, binary=True
)
vectorizer.fit(X_train['clean_categories'].values)

categories_one_hot_train = vectorizer.transform(X_train['clean_categories'].values)
categories_one_hot_test = vectorizer.transform(X_test['clean_categories'].values)
categories_one_hot_cv = vectorizer.transform(X_cv['clean_categories'].values)

print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",categories_one_hot_test.shape)
print("Shape of matrix of CV data after one hot encoding ",categories_one_hot_cv.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeeds',
'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix of Train data after one hot encoding  (22445, 9)
Shape of matrix of Test data after one hot encoding  (16500, 9)
Shape of matrix of CV data after one hot encoding  (11055, 9)
```

## One Hot Encode - Clean Sub-Categories of Projects

In [65]:

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

vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False, binary=
```

```
True)
vectorizer.fit(X_train['clean_subcategories'].values)

sub_categories_one_hot_train = vectorizer.transform(X_train['clean_subcategories'].values)
sub_categories_one_hot_test = vectorizer.transform(X_test['clean_subcategories'].values)
sub_categories_one_hot_cv = vectorizer.transform(X_cv['clean_subcategories'].values)


print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding ",sub_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",sub_categories_one_hot_test.shape)
print("Shape of matrix of Cross Validation data after one hot encoding ",sub_categories_one_hot_cv
.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricular',
'Civics_Government', 'ForeignLanguages', 'NutritionEducation', 'Warmth', 'Care_Hunger',
'SocialSciences', 'PerformingArts', 'CharacterEducation', 'TeamSports', 'Other',
'College_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopment', 'ESL
', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'AppliedSciences',
'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
Shape of matrix of Train data after one hot encoding  (22445, 30)
Shape of matrix of Test data after one hot encoding  (16500, 30)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 30)
```

## One Hot Encode - School States

In [66]:

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

In [67]:

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

In [68]:

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

vectorizer = CountVectorizer(vocabulary=list(sorted_school_state_cat_dict.keys()), lowercase=False
, binary=True)
vectorizer.fit(X_train['school_state'].values)

school_state_categories_one_hot_train = vectorizer.transform(X_train['school_state'].values)
school_state_categories_one_hot_test = vectorizer.transform(X_test['school_state'].values)
school_state_categories_one_hot_cv = vectorizer.transform(X_cv['school_state'].values)

print(vectorizer.get_feature_names())

print("Shape of matrix of Train data after one hot encoding
",school_state_categories_one_hot_train.shape)
print("Shape of matrix of Test data after one hot encoding ",school_state_categories_one_hot_test.
shape)
print("Shape of matrix of Cross Validation data after one hot encoding
",school_state_categories_one_hot_cv.shape)
```

```
['VT', 'WY', 'ND', 'MT', 'RI', 'NH', 'SD', 'NE', 'AK', 'DE', 'WV', 'ME', 'NM', 'HI', 'DC', 'KS', 'I
D', 'IA', 'AR', 'CO', 'MN', 'OR', 'MS', 'KY', 'NV', 'MD', 'TN', 'CT', 'AL', 'UT', 'WI', 'VA', 'AZ',
'NJ', 'OK', 'MA', 'LA', 'WA', 'MO', 'IN', 'OH', 'PA', 'MI', 'GA', 'SC', 'IL', 'NC', 'FL', 'TX', 'NY
', 'CA']
Shape of matrix of Train data after one hot encoding  (22445, 51)
Shape of matrix of Test data after one hot encoding  (16500, 51)
Shape of matrix of Cross Validation data after one hot encoding  (11055, 51)
```

## One Hot Encode - Project Grade Category

In [69]:

```
#This step is to intialize a vectorizer with vocab from train data
from collections import Counter
my_counter4 = Counter()
for word in X_train['project_grade_category'].values:
    my_counter4.update(word.split())

# dict sort by value python: https://stackoverflow.com/a/613218/4084039
project_grade_category_dict = dict(my_counter4)
sorted_project_grade_category_dict = dict(sorted(project_grade_category_dict.items(), key=lambda
kv: kv[1]))
```

In [70]:

```
vectorizer = CountVectorizer(vocabulary=list(sorted_project_grade_category_dict.keys()), lowercase
=False, binary=True)
vectorizer.fit(X_train['project_grade_category'].values) # fit has to happen only on train data

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

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

```
After vectorizations
(22445, 4) (22445,)
(11055, 4) (11055,)
(16500, 4) (16500,)
['Grades_9-12', 'Grades_6-8', 'Grades_3-5', 'Grades_PreK-2']
====================================================================================================
```

## One Hot Encode - Teacher Prefix

In [71]:

```
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_ohe = vectorizer.transform(X_train['teacher_prefix'].values.astype('U'))
X_cv_teacher_ohe = vectorizer.transform(X_cv['teacher_prefix'].values.astype('U'))
X_test_teacher_ohe = vectorizer.transform(X_test['teacher_prefix'].values.astype('U'))

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

```
After vectorizations
(22445, 5) (22445,)
(11055, 5) (11055,)
(16500, 5) (16500,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
====================================================================================================
```

## 1.11 Vectorizing Text data

# A) Bag of Words (BOW)

### Bag of words - Train Data - Essays

In [59]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).

vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(preprocessed_essays_train)

text_bow_train = vectorizer.transform(preprocessed_essays_train)

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

```
Shape of matrix after one hot encoding  (22445, 8762)
```

### Bag of words - Test Data - Essays

In [62]:

```
text_bow_test = vectorizer.transform(preprocessed_essays_test)
print("Shape of matrix after one hot encoding ",text_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 8774)
```

### Bag of words - Cross Validation Data - Essays

In [63]:

```
text_bow_cv = vectorizer.transform(preprocessed_essays_cv)
print("Shape of matrix after one hot encoding ",text_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 8774)
```

### Bag of words - Train Data - Titles

In [64]:

```
vectorizer.fit(preprocessed_titles_train)
title_bow_train = vectorizer.transform(preprocessed_titles_train)
print("Shape of matrix after one hot encoding ",title_bow_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 1225)
```

### Bag of words - Test Data - Titles

In [65]:

```
title_bow_test = vectorizer.transform(preprocessed_titles_test)
print("Shape of matrix after one hot encoding ",title_bow_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1225)
```

### Bag of words - Cross Validation Data - Titles

In [66]:

```
title_bow_cv = vectorizer.transform(preprocessed_titles_cv)
print("Shape of matrix after one hot encoding ",title_bow_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 1225)
```

## B) TFIDF vectorizer

### TFIDF - Train Data - Essays

In [67]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(preprocessed_essays_train)

text_tfidf_train = vectorizer.transform(preprocessed_essays_train)
print("Shape of matrix after one hot encoding ",text_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 8774)
```

### TFIDF - Test Data - Essays

In [68]:

```
text_tfidf_test = vectorizer.transform(preprocessed_essays_test)
print("Shape of matrix after one hot encoding ",text_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 8774)
```

### TFIDF - Cross Validation Data - Essays

In [69]:

```
text_tfidf_cv = vectorizer.transform(preprocessed_essays_cv)
print("Shape of matrix after one hot encoding ",text_tfidf_cv.shape)
```

```
Shape of matrix after one hot encoding  (11055, 8774)
```

### TFIDF - Train Data - Titles

In [70]:

```
vectorizer = TfidfVectorizer(min_df=10)

vectorizer.fit(preprocessed_titles_train)
title_tfidf_train = vectorizer.transform(preprocessed_titles_train)
print("Shape of matrix after one hot encoding ",title_tfidf_train.shape)
```

```
Shape of matrix after one hot encoding  (22445, 1225)
```

### TFIDF - Test Data - Titles

In [71]:

```
title_tfidf_test = vectorizer.transform(preprocessed_titles_test)
print("Shape of matrix after one hot encoding ",title_tfidf_test.shape)
```

```
Shape of matrix after one hot encoding  (16500, 1225)
```

### TFIDF - Cross Validation Data - Titles

In [67]:

```
title_tfidf_cv = vectorizer.transform(preprocessed_titles_cv)
print("Shape of matrix after one hot encoding ",title_tfidf_cv.shape)
```

```
('Shape of matrix after one hot encoding ', (11055, 1241))
```

## C) Using Pretrained Models: Avg W2V

In [68]:

```
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039

def loadGloveModel(gloveFile):

    print ("Loading Glove Model")

    f = open(gloveFile,'r')

    model = {}

    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding

    print ("Done.",len(model)," words loaded!")

    return model
```

In [69]:

```
model = loadGloveModel('glove.42B.300d.txt')
```

```
0it [00:00, ?it/s]
```

```
Loading Glove Model
```

```
1917495it [03:25, 9337.21it/s]
```

```
('Done.', 1917495, ' words loaded!')
```

In [70]:

```
words_train_essays = []

for i in preprocessed_essays_train :
    words_train_essays.extend(i.split(' '))
```

In [71]:

```
## 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', 3089978)
```

In [72]:

```
## 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', 30415)
```

In [73]:

```
## 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 {} which \
is nearly {}% ".format(len(inter_words), np.round((float(len(inter_words))/len(words_train_essay))
*100)))
```

```
The number of words that are present in both glove vectors and our corpus are 28623 which is
nearly 94.0%
```

In [74]:

```
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', 28623)
```

In [75]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-sa
ve-and-load-variables-in-python/

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

In [76]:

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

### Train - Essays

In [77]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_train = [];

for sentence in tqdm(preprocessed_essays_train): # 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%|██████████| 22445/22445 [00:07<00:00, 3160.05it/s]
```

```
22445
300
```

### Test - Essays

In [78]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_test = [];

for sentence in tqdm(preprocessed_essays_test): # 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%|██████████| 16500/16500 [00:04<00:00, 3334.25it/s]
```

```
16500
300
```

### Cross-Validation - Essays

In [79]:

```
# average Word2Vec
# compute average word2vec for each review.

avg_w2v_vectors_cv = [];

for sentence in tqdm(preprocessed_essays_cv): # 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_cv.append(vector)

print(len(avg_w2v_vectors_cv))
print(len(avg_w2v_vectors_cv[0]))
```

```
100%|██████████| 11055/11055 [00:03<00:00, 3241.93it/s]
```

```
11055
300
```

### Train - Titles

In [80]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_train): # 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%|██████████| 22445/22445 [00:00<00:00, 46451.52it/s]
```

```
22445
300
```

### Test - Titles

In [81]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_test): # 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%|██████████| 16500/16500 [00:00<00:00, 42056.00it/s]
```

```
16500
300
```

### Cross-Validation - Titles

In [82]:

```
# Similarly you can vectorize for title also

avg_w2v_vectors_titles_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_cv): # 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_cv.append(vector)

print(len(avg_w2v_vectors_titles_cv))
print(len(avg_w2v_vectors_titles_cv[0]))
```

```
100%|██████████| 11055/11055 [00:00<00:00, 28212.62it/s]
```

```
11055
300
```

## D) Using Pretrained Models: TFIDF weighted W2V

### Train - Essays

In [83]:

```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays_train)
# 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 [84]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_train): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            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%|██████████| 22445/22445 [00:41<00:00, 537.12it/s]
```

```
22445
300
```

### Test - Essays

In [85]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_test): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
```

```
            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%|██████████| 16500/16500 [00:30<00:00, 539.54it/s]
```

```
16500
300
```

### Cross-Validation - Essays

In [86]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_cv = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_cv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            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_cv.append(vector)

print(len(tfidf_w2v_vectors_cv))
print(len(tfidf_w2v_vectors_cv[0]))
```

```
100%|██████████| 11055/11055 [00:20<00:00, 548.86it/s]
```

```
11055
300
```

### Train - Titles

In [87]:

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles_train)
# 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 [88]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_train = [];

for sentence in tqdm(preprocessed_titles_train): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
```

```
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            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%|██████████| 22445/22445 [00:00<00:00, 26290.73it/s]
```

```
22445
300
```

### Test - Titles

In [89]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_test = [];

for sentence in tqdm(preprocessed_titles_test): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            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%|██████████| 16500/16500 [00:00<00:00, 29146.48it/s]
```

```
16500
300
```

### Cross-Validation - Titles

In [90]:

```
# compute average word2vec for each review.

tfidf_w2v_vectors_titles_cv = [];

for sentence in tqdm(preprocessed_titles_cv): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf
value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf value for each word
            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_cv.append(vector)

print(len(tfidf_w2v_vectors_titles_cv))
print(len(tfidf_w2v_vectors_titles_cv[0]))
```

```
100%|██████████| 11055/11055 [00:00<00:00, 24782.72it/s]
```

```
11055
300
```

## 1.12 Vectorizing Numerical features

### A) Price

In [91]:

```
# https://stackoverflow.com/questions/22407798/how-to-reset-a-dataframes-indexes-for-all-groups-in-one-step
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
price_data.head(2)
```

Out[91]:

| | id | price | quantity |
|---|---|---|---|
| **0** | p000001 | 459.56 | 7 |
| **1** | p000002 | 515.89 | 21 |

In [92]:

```
# 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')
X_cv = pd.merge(X_cv, price_data, on='id', how='left')
```

In [93]:

```
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_cv = normalizer.transform(X_cv['price'].values.reshape(-1,1))
price_test = normalizer.transform(X_test['price'].values.reshape(-1,1))

print("After vectorizations")
print(price_train.shape, y_train.shape)
print(price_cv.shape, y_cv.shape)
print(price_test.shape, y_test.shape)
print("="*100)
```

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

### B) Quantity

In [94]:

```
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_cv = normalizer.transform(X_cv['quantity'].values.reshape(-1,1))
quantity_test = normalizer.transform(X_test['quantity'].values.reshape(-1,1))

print("After vectorizations")
print(quantity_train.shape, y_train.shape)
print(quantity_cv.shape, y_cv.shape)
print(quantity_test.shape, y_test.shape)
print("="*100)
```

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

### C) Number of Projects previously proposed by Teacher

In [95]:

```
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(-1,1))

prev_projects_train = normalizer.transform(X_train['teacher_number_of_previously_posted_projects']
.values.reshape(-1,1))
prev_projects_cv =
normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
prev_projects_test = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].v
alues.reshape(-1,1))

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

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

### D) Title word Count

In [96]:

```
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.reshape(-1,1))
title_word_count_cv = normalizer.transform(X_cv['title_word_count'].values.reshape(-1,1))
title_word_count_test = normalizer.transform(X_test['title_word_count'].values.reshape(-1,1))

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

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

### E) Essay word Count

In [97]:

```
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.reshape(-1,1))
essay_word_count_cv = normalizer.transform(X_cv['essay_word_count'].values.reshape(-1,1))
essay_word_count_test = normalizer.transform(X_test['essay_word_count'].values.reshape(-1,1))

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

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

# Assignment : Apply KNN

1. **[Task-1] Apply KNN(brute force version) on these feature sets**
   - Set 1: categorical, numerical features + project_title(BOW) + preprocessed_essay (BOW)
   - Set 2: categorical, numerical features + project_title(TFIDF)+ preprocessed_essay (TFIDF)
   - Set 3: categorical, numerical features + project_title(AVG W2V)+ preprocessed_essay (AVG W2V)
   - Set 4: categorical, numerical features + project_title(TFIDF W2V)+ preprocessed_essay (TFIDF W2V)
2. **Hyper paramter tuning to find best K**
   - Find the best hyper parameter which results in 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 write your own for loops to do this task
3. **Representation of results**
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, as shown in the figure

- Once you find the best hyper parameter, you need to train your model-M using the best hyper-param. Now, find the AUC on test data and plot the ROC curve on both train and test using model-M.
- Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points

4. **[Task-2]**

   - Select top 2000 features from feature Set 2 using `SelectKBest` and then apply KNN on top of these features

     - ```
       from sklearn.datasets import load_digits
       from sklearn.feature_selection import SelectKBest, chi2
       X, y = load_digits(return_X_y=True)
       X.shape
       X_new = SelectKBest(chi2, k=20).fit_transform(X, y)
       X_new.shape
       ========
       output:
       (1797, 64)
       (1797, 20)
       ```

   - Repeat the steps 2 and 3 on the data matrix after feature selection

5. **Conclusion**

   - You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

**Note: Data Leakage**

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

## Merging all the above features

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

# K Nearest Neighbor

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

In [98]:

```
# 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_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, title_bow_train, text_bow_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, title_bow_test, text_bow_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, title_bow_cv, text_bow_cv)).tocsr()
```

In [99]:
```

```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
((22445, 10144), (22445,))
((11055, 10144), (11055,))
((16500, 10144), (16500,))
====================================================================================================
```

## A) Find the best hyper parameter which results in the maximum AUC value

In [100]:

```
##https://www.kaggle.com/shashank49/donors-choose-knn
## https://github.com/harrismohammed/DonorsChoose.org-knn

def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs

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

    return y_data_pred
```

In [101]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score

"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
a = []
b = []

K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 91]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)

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


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

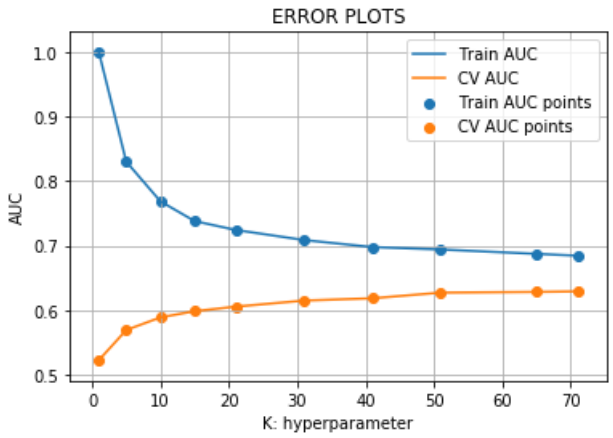
```
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))
    a.append(y_train_pred)
    b.append(y_cv_pred)

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

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

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

```
100%|██████████| 10/10 [10:01<00:00, 60.73s/it]
```




In [ ]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = K[score_t_cv.index(max(score_t_cv))]
print("Maximum AUC score of cv is:" + ' ' + str(max(score_t_cv)))
print("Corresponding k value of cv is:",opt_t_cv, '\n')
best_k=opt_t_cv
print(best_k_1)
```

In [103]:

```
best_k_1 = 91
```

## B) Train model using the best hyper-parameter value

In [104]:

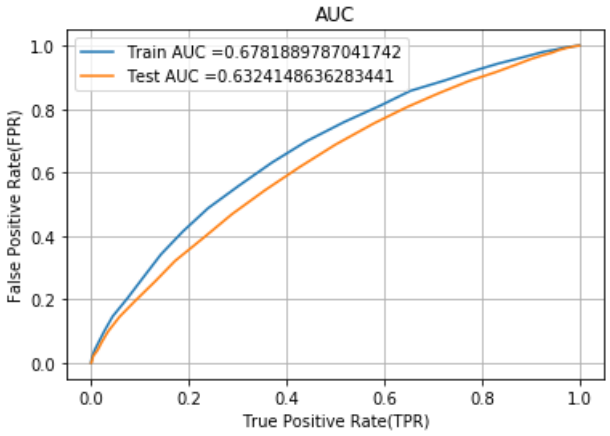
```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc


neigh = KNeighborsClassifier(n_neighbors=best_k_1)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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()
```




## C) Confusion Matrix

In [105]:

```
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.round(t,3))
    predictions = []
    for i in proba:
        if i>=t:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

### Train Data

In [106]:

```
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, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24970479143862234, 'for threshold', 0.78)
[[ 1672  1791]
 [ 4582 14400]]
```

In [107]:

```
conf_matr_df_train = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

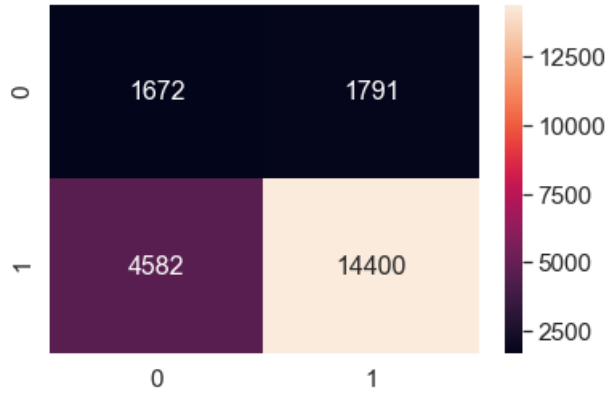
```
('the maximum value of tpr*(1-fpr)', 0.24970479143862234, 'for threshold', 0.78)
```

In [159]:

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

Out[159]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a5c60d1d0>
```




## Test Data

In [109]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

Test confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24999984572938835, 'for threshold', 0.802)
[[1461 1085]
 [5351 8603]]
```

In [110]:

```
conf_matr_df_test = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_
fpr, test_fpr)), range(2),range(2))
```

```
('the maximum value of tpr*(1-fpr)', 0.24999984572938835, 'for threshold', 0.802)
```

In [160]:

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

Out[160]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a5cc77e50>
```


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

In [111]:

```
# 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_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, text_tfidf_train, title_tfidf_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, text_tfidf_test, title_tfidf_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, text_tfidf_cv, title_tfidf_cv)).tocsr()
```

In [112]:

```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
((22445, 10144), (22445,))
((11055, 10144), (11055,))
((16500, 10144), (16500,))
====================================================================================================
```

## A) Find the best hyper parameter which results in the maximum AUC value

In [113]:

```
train_auc = []
cv_auc = []
K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]
for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)

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

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

```
100%|██████████| 12/12 [12:28<00:00, 62.13s/it]
```

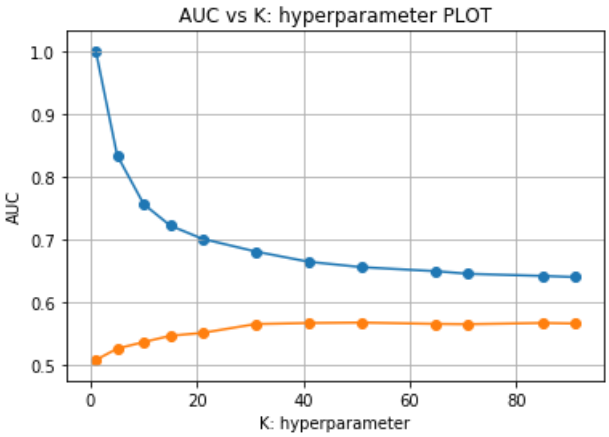
In [114]:

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

plt.scatter(K, train_auc, label='Train AUC points')
```

```
plt.scatter(K, cv_auc, label='CV AUC points')

plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("AUC vs K: hyperparameter PLOT")
plt.grid()
plt.show()
```




In [ ]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = K[score_t_cv.index(max(score_t_cv))]
best_k=opt_t_cv
print(best_k_2)
```

In [118]:

```
best_k_2 = 85
```

## B) Train model using the best hyper-parameter value

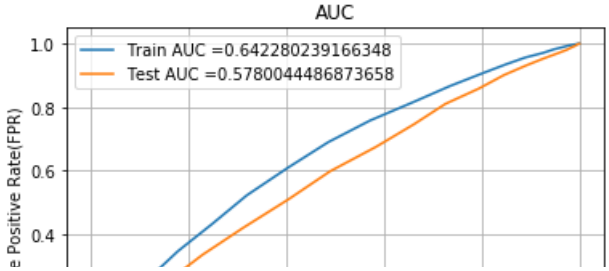
In [119]:

```
neigh = KNeighborsClassifier(n_neighbors=best_k_2)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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()
```




## C) Confusion Matrix

### Train Data

In [120]:

```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24978734393513072, 'for threshold', 0.835)
[[ 1782  1681]
 [ 5896 13086]]
```

In [121]:

```
conf_matr_df_train_1 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

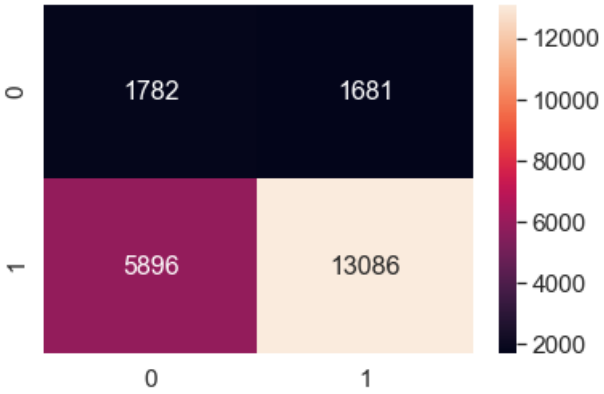
```
('the maximum value of tpr*(1-fpr)', 0.24978734393513072, 'for threshold', 0.835)
```

In [161]:

```
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[161]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a5dbd4750>
```




### Test Data

In [122]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

```
Test confusion matrix
('the maximum value of tpr*(1-fpr)', 0.2498875367241191, 'for threshold', 0.847)
[[1300 1246]
 [5614 8340]]
```

In [123]:

```
conf_matr_df_test_1 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
```

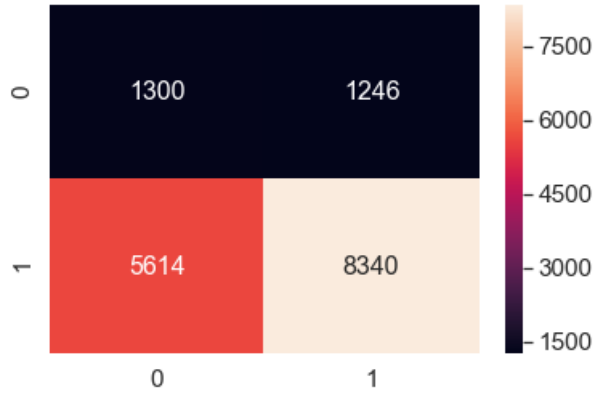
```
('the maximum value of tpr*(1-fpr)', 0.2498875367241191, 'for threshold', 0.847)
```

In [162]:

```
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[162]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a28534ad0>
```




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

In [124]:

```
# 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_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, avg_w2v_vectors_train,
avg_w2v_vectors_titles_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, avg_w2v_vectors_test, avg_w2v_vectors_titles_test)).
tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, avg_w2v_vectors_cv, avg_w2v_vectors_titles_cv)).tocsr()
```

In [125]:

```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
```

```
((22445, 705), (22445,))
((11055, 705), (11055,))
((16500, 705), (16500,))
==========================================================================================================
```

## A) Find the best hyper parameter which results in the maximum AUC value

In [126]:

```
train_auc = []
cv_auc = []

K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)

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

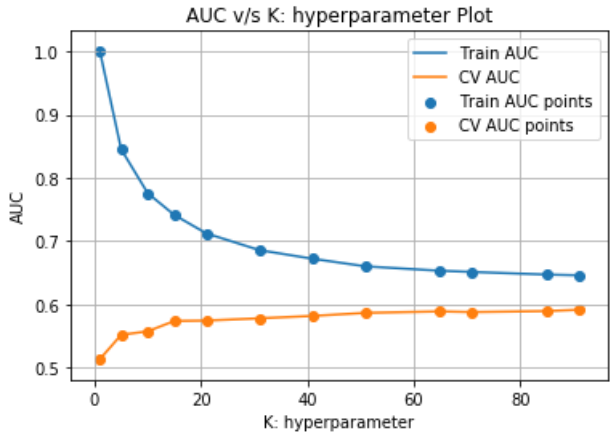
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

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

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

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

```
100%|██████████| 12/12 [2:48:53<00:00, 837.87s/it]
```




In [ ]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = K[score_t_cv.index(max(score_t_cv))]
best_k=opt_t_cv
print(best_k_3)
```

In [129]:

```
best_k_3 = 91
```

```
best_k_3 = 91
```

## B) Train model using the best hyper-parameter value

In [130]:

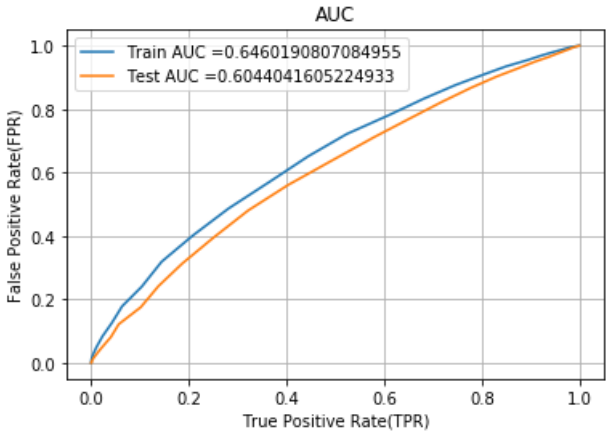
```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

neigh = KNeighborsClassifier(n_neighbors=best_k_3)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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()
```




## C) Confusion Matrix

### Train Data

In [131]:

```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24944612694956267, 'for threshold', 0.835)
[[ 1650  1813]
 [ 5285 13697]]
```

In [132]:

```
conf_matr_df_train_2 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

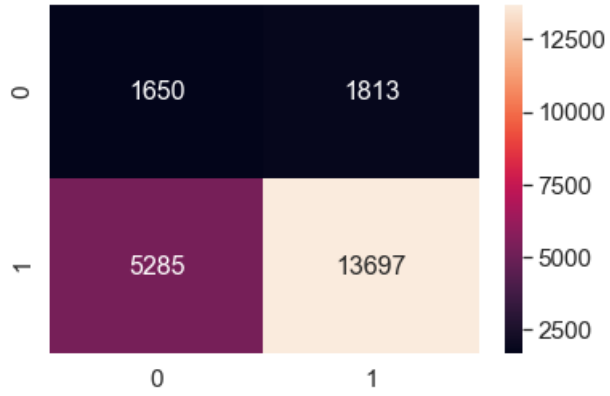
('the maximum value of tpr*(1-fpr)', 0.24944612694956267, 'for threshold', 0.835)

In [163]:

```
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[163]:

<matplotlib.axes._subplots.AxesSubplot at 0x1a2869dad0>




## Test Data

In [133]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

Test confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24998133325599237, 'for threshold', 0.846)
[[1284 1262]
 [5023 8931]]
```

In [134]:

```
conf_matr_df_test_2 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
```

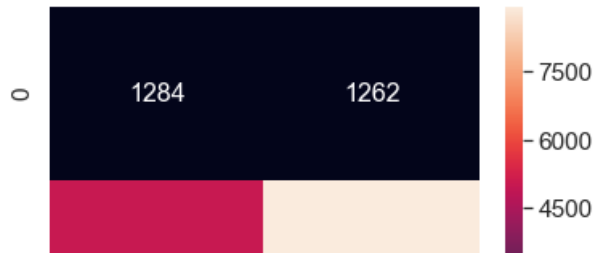
('the maximum value of tpr*(1-fpr)', 0.24998133325599237, 'for threshold', 0.846)

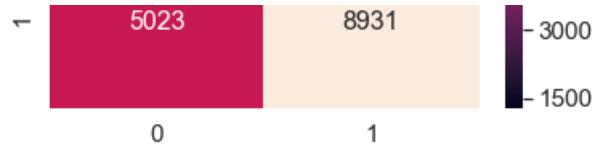
In [164]:

```
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[164]:

<matplotlib.axes._subplots.AxesSubplot at 0x1a5d22a890>






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

In [135]:

```
# 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_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, tfidf_w2v_vectors_train, tfidf_w2v_vectors_titles_train)).
tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, tfidf_w2v_vectors_test,
tfidf_w2v_vectors_titles_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, tfidf_w2v_vectors_cv, tfidf_w2v_vectors_titles_cv)).tocsr()
```

In [136]:

```
print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
((22445, 705), (22445,))
((11055, 705), (11055,))
((16500, 705), (16500,))
====================================================================================================
```

## A) Find the best hyper parameter which results in the maximum AUC value

In [137]:

```
train_auc = []
cv_auc = []

K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr, y_train)

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

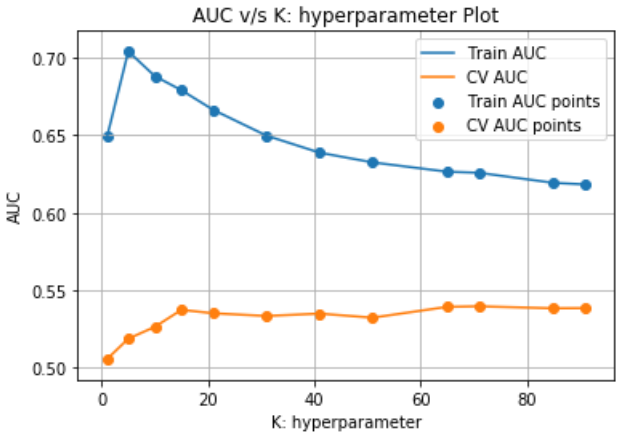
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

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

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

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

```
100%|██████████| 12/12 [07:01<00:00, 35.24s/it]
```




In [ ]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = K[score_t_cv.index(max(score_t_cv))]
best_k=opt_t_cv
print(best_k_4)
```

In [140]:

```
best_k_4 = 85
```

## B) Train model using the best hyper-parameter value

In [141]:

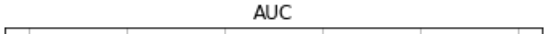
```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

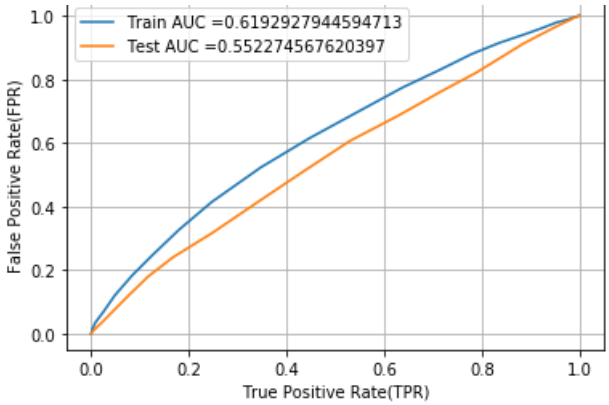
neigh = KNeighborsClassifier(n_neighbors=best_k_4)
neigh.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr)
y_test_pred = batch_predict(neigh, 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()
```






## C) Confusion Matrix

### Train Data

In [142]:

```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

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

Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24808609541617674, 'for threshold', 0.835)
[[ 1580  1883]
 [ 5773 13209]]
```

In [143]:

```
conf_matr_df_train_3 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

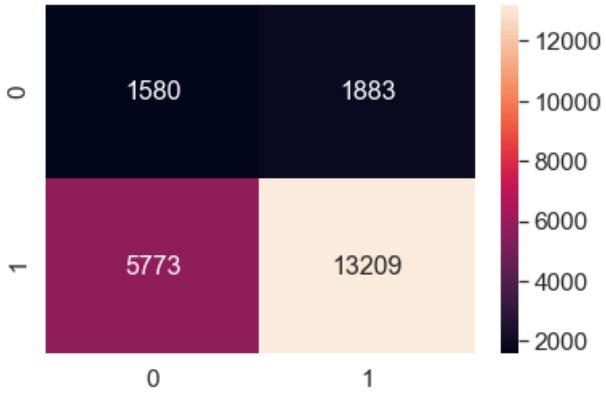
```
('the maximum value of tpr*(1-fpr)', 0.24808609541617674, 'for threshold', 0.835)
```

In [165]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_3, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[165]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a29c18450>
```




### Test Data

In [144]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

Test confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24908532954362433, 'for threshold', 0.847)
[[1196 1350]
 [5489 8465]]
```

In [145]:

```
conf_matr_df_test_3 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
```

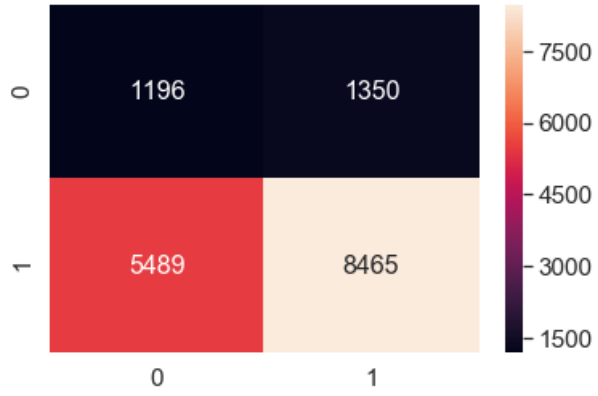
```
('the maximum value of tpr*(1-fpr)', 0.24908532954362433, 'for threshold', 0.847)
```

In [166]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_3, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[166]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a37b4b490>
```




## 2.5 Feature selection with `SelectKBest`

In [146]:

```
X_tr = hstack((categories_one_hot_train, sub_categories_one_hot_train,
school_state_categories_one_hot_train, project_grade_categories_one_hot_train,
teacher_prefix_categories_one_hot_train, price_train, quantity_train, prev_projects_train, title_wo
rd_count_train, essay_word_count_train, text_tfidf_train, title_tfidf_train)).tocsr()
X_te = hstack((categories_one_hot_test, sub_categories_one_hot_test,
school_state_categories_one_hot_test, project_grade_categories_one_hot_test,
teacher_prefix_categories_one_hot_test, price_test, quantity_test, prev_projects_test,
title_word_count_test, essay_word_count_test, text_tfidf_test, title_tfidf_test)).tocsr()
X_cr = hstack((categories_one_hot_cv, sub_categories_one_hot_cv,
school_state_categories_one_hot_cv, project_grade_categories_one_hot_cv,
teacher_prefix_categories_one_hot_cv, price_cv, quantity_cv, prev_projects_cv, title_word_count_cv,
essay_word_count_cv, text_tfidf_cv, title_tfidf_cv)).tocsr()
```

In [147]:

```
from sklearn.feature_selection import SelectKBest, chi2

X_tr_new = SelectKBest(chi2, k=2000).fit_transform(X_tr, y_train)
X_te_new = SelectKBest(chi2, k=2000).fit_transform(X_te, y_test)
X_cr_new = SelectKBest(chi2, k=2000).fit_transform(X_cr, y_cv)
```

In [148]:

```
print("Final Data matrix")
print(X_tr_new.shape, y_train.shape)
print(X_cr_new.shape, y_cv.shape)
print(X_te_new.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
((22445, 2000), (22445,))
((11055, 2000), (11055,))
((16500, 2000), (16500,))
====================================================================================================
```

## A) Find the best hyper parameter which results in the maximum AUC value

In [149]:

```
train_auc = []
cv_auc = []

K = [1, 5, 10, 15, 21, 31, 41, 51, 65, 71, 85, 91]

for i in tqdm(K):
    neigh = KNeighborsClassifier(n_neighbors=i)
    neigh.fit(X_tr_new, y_train)

    y_train_pred = batch_predict(neigh, X_tr_new)
    y_cv_pred = batch_predict(neigh, X_cr_new)

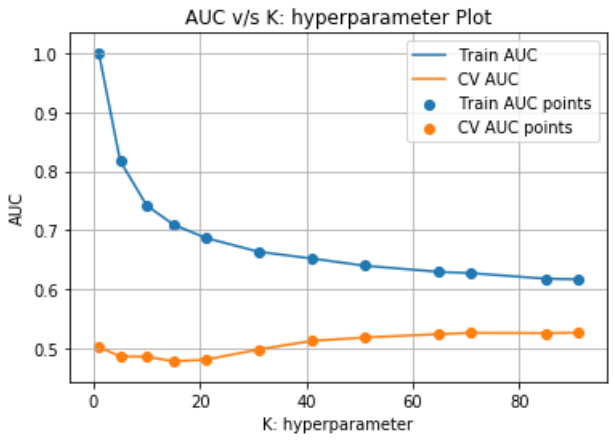
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

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

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

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

```
100%|██████████| 12/12 [07:14<00:00, 37.44s/it]
```



In [ ]:

```
score_t_cv = [x for x in cv_auc]
opt_t_cv = K[score_t_cv.index(max(score_t_cv))]
best_k=opt_t_cv
print(best_k_5)
```

In [151]:

```
best_k_5 = 85
```

## B) Train model using the best hyper-parameter value

In [152]:

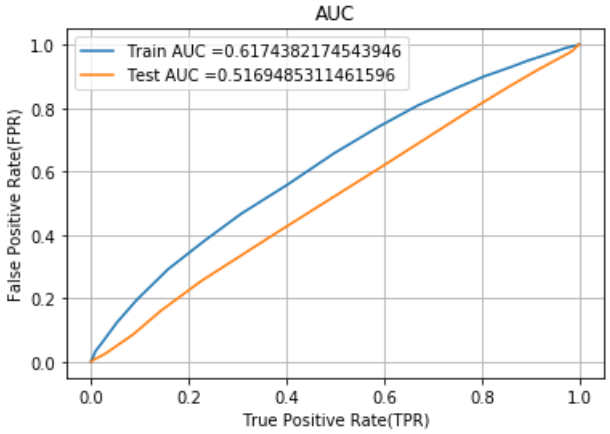
```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve

neigh = KNeighborsClassifier(n_neighbors=best_k_5)
neigh.fit(X_tr_new, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

y_train_pred = batch_predict(neigh, X_tr_new)
y_test_pred = batch_predict(neigh, X_te_new)

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()
```




## C) Confusion Matrix

### Train Data

In [153]:

```
print("="*100)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds, train_fpr, train_fpr)))
```

==========

```
Train confusion matrix
('the maximum value of tpr*(1-fpr)', 0.24999397533548212, 'for threshold', 0.835)
[[ 1740  1723]
 [ 6498 12484]]
```

In [154]:

```
conf_matr_df_train_4 = pd.DataFrame(confusion_matrix(y_train, predict(y_train_pred, tr_thresholds,
train_fpr, train_fpr)), range(2),range(2))
```

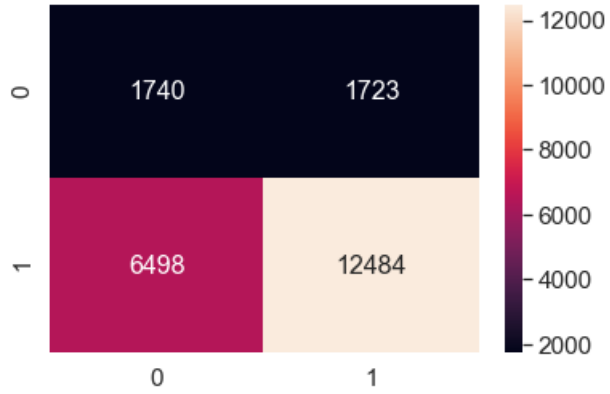
```
('the maximum value of tpr*(1-fpr)', 0.24999397533548212, 'for threshold', 0.835)
```

In [167]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_train_4, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[167]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a28b6b810>
```




## Test Data

In [155]:

```
print("="*100)
print("Test confusion matrix")
print(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, test_fpr, test_fpr)))
```

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

Test confusion matrix
('the maximum value of tpr*(1-fpr)', 0.23941024813502257, 'for threshold', 0.847)
[[ 1971   575]
 [10393  3561]]
```

In [156]:

```
conf_matr_df_test_4 = pd.DataFrame(confusion_matrix(y_test, predict(y_test_pred, tr_thresholds, tes
t_fpr, test_fpr)), range(2),range(2))
```

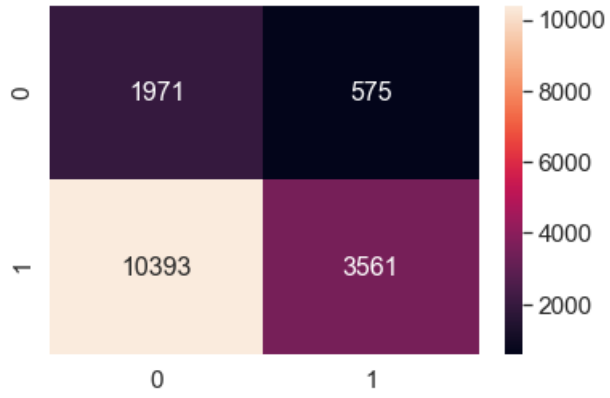
```
('the maximum value of tpr*(1-fpr)', 0.23941024813502257, 'for threshold', 0.847)
```

In [168]:

```
sns.set(font_scale=1.4)#for label size
sns.heatmap(conf_matr_df_test_4, annot=True,annot_kws={"size": 16}, fmt='g')
```

Out[168]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a5c8d74d0>
```




# 3. Conclusions

In [158]:

```
# Compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

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

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

x.add_row(["BOW", "Brute", 91, 0.63])
x.add_row(["TFIDF", "Brute", 85, 0.57])
x.add_row(["AVG W2V", "Brute", 91, 0.6])
x.add_row(["TFIDF W2V", "Brute", 85, 0.55])
x.add_row(["TFIDF", "Top 2000", 85, 0.51])

print(x)
```

```
+------------+----------+-----------------+------+
| Vectorizer |  Model   | Hyper Parameter | AUC  |
+------------+----------+-----------------+------+
|    BOW     |  Brute   |        91       | 0.63 |
|   TFIDF    |  Brute   |        85       | 0.57 |
|  AVG W2V   |  Brute   |        91       | 0.6  |
| TFIDF W2V  |  Brute   |        85       | 0.55 |
|   TFIDF    | Top 2000 |        85       | 0.51 |
+------------+----------+-----------------+------+
```

# defferentiate betwenn fit (), fit_transform() and transform () in previous suggestion .

### 1. fit () - It learns the dictionary internally

### 2.transform() - It applies the learned vocalbulary to give the output , (BOW in this case) or document-term

### 3. fit_term () - combination of fit and transform() in one go