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	Descr
`project_id`	A unique identifier for the proposed project. **Example:** `p0`

Feature	Descr
project_title	Title of the project. **Exar** • Art Will Make You Ha • First Grade
project_grade_category	Grade level of students for which the project is targeted. One of the fol enumerated v • Grades Pr • Grades • Grades • Grades
project_subject_categories	One or more (comma-separated) subject categories for the project fr following enumerated list of v • Applied Lear • Care & Hu • Health & Sp • History & Ci • Literacy & Lang • Math & Sci • Music & The • Special N • Wa **Exam** • Music & The • Literacy & Language, Math & Sci
school_state	State where school is located (Two-letter U.S. posta (https://en.wikipedia.org/wiki/List_of_U.S._state_abbreviations#Postal_co **Exampl**

Feature	Descr
project_subject_subcategories	One or more (comma-separated) subject subcategories for the p **Exam** • Lite • Literature & Writing, Social Scie
project_resource_summary	An explanation of the resources needed for the project. **Exa** • My students need hands on literacy materials to ma sensory needs!</
project_essay_1	First application
project_essay_2	Second application
project_essay_3	Third application
project_essay_4	Fourth application
project_submitted_datetime	Datetime when project application was submitted. **Example:** 2016-0 12:43:56
teacher_id	A unique identifier for the teacher of the proposed project. **Exa** bdf8baa8fedef6bfeec7ae4ff1c1
teacher_prefix	Teacher's title. One of the following enumerated v • • • • • • Teac
teacher_number_of_previously_posted_projects	Number of project applications previously submitted by the same te **Examp**

* 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."
- **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.

Some code blocks are taken from previous assignments. And some used the code present in original file ('3_DonorsChoose_KNN.ipynb') which is mentioned in comments.

In [8]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

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

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

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

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

from tqdm import tqdm
import os
```

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

1.1 Reading Data

In [9]:
```
project_data = pd.read_csv('train_data.csv')
resource_data = pd.read_csv('resources.csv')
```

Taking only 50K points as KNN Classifier runs lot slower with many points

In [10]:
```
import random
project_data = project_data.loc[random.sample(list(project_data.index), 50000)]
```

In [11]:
```
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 [12]:
```
# 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[12]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_g
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	

In [13]:
```
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[13]:

	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

1.2 preprocessing of `project_subject_categories`

In [14]:
```
catogories = list(project_data['project_subject_categories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

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

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

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

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

1.3 preprocessing of project_subject_subcategories

In [15]:
```
sub_catogories = list(project_data['project_subject_subcategories'].values)
# remove special characters from list of strings python: https://stackoverflow.com/a/473019

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

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

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

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

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

1.3 Text preprocessing

In [16]:
```
# merge two column text dataframe:
project_data["essay"] = project_data["project_essay_1"].map(str) +\
                        project_data["project_essay_2"].map(str) + \
                        project_data["project_essay_3"].map(str) + \
                        project_data["project_essay_4"].map(str)
```

In [17]:
```
project_data.head(2)
```

Out[17]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_g
55660	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	
76127	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	

In [18]:
```
#### 1.4.2.3 Using Pretrained Models: TFIDF weighted W2V
```

In [19]:
```
# printing some random reviews
print(project_data['essay'].values[0])
print("="*50)
print(project_data['essay'].values[150])
print("="*50)
print(project_data['essay'].values[1000])
print("="*50)
print(project_data['essay'].values[20000])
print("="*50)
```

```
I have been fortunate enough to use the Fairy Tale STEM kits in my classroom as well as t
he STEM journals, which my students really enjoyed.  I would love to implement more of th
e Lakeshore STEM kits in my classroom for the next school year as they provide excellent
and engaging STEM lessons.My students come from a variety of backgrounds, including langu
age and socioeconomic status.  Many of them don't have a lot of experience in science and
engineering and these kits give me the materials to provide these exciting opportunities
for my students.Each month I try to do several science or STEM/STEAM projects.  I would u
se the kits and robot to help guide my science instruction in engaging and meaningful way
s.  I can adapt the kits to my current language arts pacing guide where we already teach
some of the material in the kits like tall tales (Paul Bunyan) or Johnny Appleseed.  The
following units will be taught in the next school year where I will implement these kits:
magnets, motion, sink vs. float, robots.  I often get to these units and don't know If I
am teaching the right way or using the right materials.    The kits will give me addition
al ideas, strategies, and lessons to prepare my students in science.It is challenging to
develop high quality science activities.  These kits give me the materials I need to prov
ide my students with science activities that will go along with the curriculum in my clas
sroom.  Although I have some things (like magnets) in my classroom, I don't know how to u
se them effectively.  The kits will provide me with the right amount of materials and sho
w me how to use them in an appropriate way.
==================================================
My students love to learn through technology! Multiple iPad's are used throughout the lea
rning day.I have 23 energetic first grade students eager to get their hands on an iPad. W
e currently have 4 iPads in our classroom, as well as 4 desktop computers. Our school has
generously provided these iPads for student use. We are lucky to have such a great PTA!I
want my students familiar with technology, and I want them to have these tools to be succ
```

essful. While using our classroom iPads, the covers have a lot of wear and tear, as well as the computer mouse pads. In order to protect the technology, we need new materials to keep our technology clean and safe.The iPad charging station will dramatically improve ou r system to keep technology charged and ready for use! It also provides a safe place to s tore the iPads. My students will help in the routine to keep our technology in the best c ondition possible!

==========

How are the needs of high school science labs different today? It more important for high school students have exposure to digital computer equipment in their Chemistry and Physic s lab classes as computer technology transforms college education and jobs in fields like science and medicine.Our student population is by majority Hispanic (70%), followed by As ian, White, Black, Pacific Islander, and various other groups. Almost all my students are classified as part of our state’s lowest economic category which qualifies them for finan cial assistance such as reduced price lunch and free tutoring programs. For nearly 50% of my students, the primary language that their families speak at home is not English. Many of our students were classified as ESL students (English as a Second Language) when they began high school, but they have now been reclassified as English Proficient. Since we ar e not a private school, our science lab programs truly survive from donations or grants, and the state and local district education funds that reach the classroom are insufficien t to keep up with even the minimal technological standards.If you have ever been in a Che mistry or Physics classroom or observed one on TV, you likely saw students working togeth er to perform an experiment while constantly and carefully reading and recording the dat a. Thermometers, timers, pH testers, colorimeters, and conductivity testers are important tools for Chemistry and Physics. But as technology is progressing it is becoming a necess ity for students of science, engineering, and medicine, to operate modernized computer-li nked tools. It is foundational that students understand how to perform the classic scienc e experiments, but by using digital, computer- interfaced science lab equipment that coll ects and analyzes data by computer. The probes that I am requesting connect to computers or tablets. In Chemistry or Physics labs, students will be able to test liquid solutions for conductivity, light wavelength absorbance, or temperature.Thanks to DonorsChoose, for a five years now, I have been able to add technology to all my science classes, little by little, for students to share. Any and all equipment we receive will benefit all my class es - Chemistry and Physics students of all levels. Anything you can do to help expand my science program is appreciated.

==========

The great essayist James Baldwin once said, \"Children have never been very good at liste

```
ning to their elders, but they have never failed to imitate them\". My Kinders are truly
amazing. They are full of energy and have an excessive thirst for learning. My kindergart
en class is the very first school or classroom experience that they have ever had.\r\n\r
\nOur school is one of the lowest performing schools in the city and is located in a high
poverty area. These facts do not deter my students from wanting to achieve. They deserve
to have access to resources that will enhance their curiosity as learners. My students ar
e committed, energetic and resilient.\r\n\r\nThank youNurturing individual learning style
s are essential to a motivated kindergarten class. These materials will help my students
by  making our learning environment inviting while directly nurturing different learning
styles. I want to cater to individual learning styles and needs. My bright eyed kindergar
teners need to be motivated and engaged in the learning process. These tools are the perf
ect assets needed in order to foster a rigorous and engaging classroom environment. \r\n
\r\nWe are in a part of the city where needed school resources are extremely limited to o
ur students. These materials will create an environment that will keep the attention of a
ny learner.nannan
==================================================
```

In [20]:

```python
# 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 [21]:
```
sent = decontracted(project_data['essay'].values[20000])
print(sent)
print("="*50)
```

```
The great essayist James Baldwin once said, \"Children have never been very good at liste
ning to their elders, but they have never failed to imitate them\". My Kinders are truly
amazing. They are full of energy and have an excessive thirst for learning. My kindergart
en class is the very first school or classroom experience that they have ever had.\r\n\r
\nOur school is one of the lowest performing schools in the city and is located in a high
poverty area. These facts do not deter my students from wanting to achieve. They deserve
to have access to resources that will enhance their curiosity as learners. My students ar
e committed, energetic and resilient.\r\n\r\nThank youNurturing individual learning style
s are essential to a motivated kindergarten class. These materials will help my students
by  making our learning environment inviting while directly nurturing different learning
styles. I want to cater to individual learning styles and needs. My bright eyed kindergar
teners need to be motivated and engaged in the learning process. These tools are the perf
ect assets needed in order to foster a rigorous and engaging classroom environment. \r\n
\r\nWe are in a part of the city where needed school resources are extremely limited to o
ur students. These materials will create an environment that will keep the attention of a
ny learner.nannan
==================================================
```

In [22]:
```
# \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)
```

```
The great essayist James Baldwin once said,  Children have never been very good at listen
ing to their elders, but they have never failed to imitate them . My Kinders are truly am
azing. They are full of energy and have an excessive thirst for learning. My kindergarten
class is the very first school or classroom experience that they have ever had.    Our sc
hool is one of the lowest performing schools in the city and is located in a high poverty
area. These facts do not deter my students from wanting to achieve. They deserve to have
access to resources that will enhance their curiosity as learners. My students are commit
ted, energetic and resilient.    Thank youNurturing individual learning styles are essent
ial to a motivated kindergarten class. These materials will help my students by  making o
ur learning environment inviting while directly nurturing different learning styles. I wa
nt to cater to individual learning styles and needs. My bright eyed kindergarteners need
to be motivated and engaged in the learning process. These tools are the perfect assets n
eeded in order to foster a rigorous and engaging classroom environment.     We are in a p
art of the city where needed school resources are extremely limited to our students. Thes
e materials will create an environment that will keep the attention of any learner.nannan
```

In [23]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
print(sent)
```

```
The great essayist James Baldwin once said Children have never been very good at listenin
g to their elders but they have never failed to imitate them My Kinders are truly amazing
They are full of energy and have an excessive thirst for learning My kindergarten class i
s the very first school or classroom experience that they have ever had Our school is one
of the lowest performing schools in the city and is located in a high poverty area These
facts do not deter my students from wanting to achieve They deserve to have access to res
ources that will enhance their curiosity as learners My students are committed energetic
and resilient Thank youNurturing individual learning styles are essential to a motivated
kindergarten class These materials will help my students by making our learning environme
nt inviting while directly nurturing different learning styles I want to cater to individ
ual learning styles and needs My bright eyed kindergarteners need to be motivated and eng
aged in the learning process These tools are the perfect assets needed in order to foster
a rigorous and engaging classroom environment We are in a part of the city where needed s
chool resources are extremely limited to our students These materials will create an envi
ronment that will keep the attention of any learner nannan
```

In [24]:
```
# 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'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they'
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'l
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had',
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'u
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'd
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over',
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', '
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'v
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now',
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'do
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn'
            'won', "won't", 'wouldn', "wouldn't", "nan", "nannan"]
```

In [25]:
```
# Combining all the above stundents
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(project_data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e.lower() for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays.append(sent.lower().strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 50000/50
000 [00:40<00:00, 1231.10it/s]
```

In [26]:
```
# after preprocesing
preprocessed_essays[20000]
```

Out[26]:
```
'great essayist james baldwin said children never good listening elders never failed imit
ate kinders truly amazing full energy excessive thirst learning kindergarten class first
school classroom experience ever school one lowest performing schools city located high p
overty area facts not deter students wanting achieve deserve access resources enhance cur
iosity learners students committed energetic resilient thank younurturing individual lear
ning styles essential motivated kindergarten class materials help students making learnin
g environment inviting directly nurturing different learning styles want cater individual
learning styles needs bright eyed kindergarteners need motivated engaged learning process
tools perfect assets needed order foster rigorous engaging classroom environment part cit
y needed school resources extremely limited students materials create environment keep at
tention learner'
```

1.4 Preprocessing of `project_title`

In [27]:
```
# similarly you can preprocess the titles also
```

Following Code blocks provided by me.

In [28]:
```
# Code took from original code provided.
# Also function used from original code.
preprocessed_titles = []

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

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/500
00 [00:01<00:00, 26909.93it/s]
```

In [29]:
```
preprocessed_titles[20000]
```

Out[29]:
```
'flexible seating essentials'
```

Following Code blocks present in original notebook.

1.5 Preparing data for models

In [30]:
```
project_data.columns
```

Out[30]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', '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',
       'clean_categories', 'clean_subcategories', 'essay'],
      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
```

1.5.1 Vectorizing Categorical data

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

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

In [31]:
```
# 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, bina
categories_one_hot = vectorizer.fit_transform(project_data['clean_categories'].values)
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",categories_one_hot.shape)
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeed
s', 'Health_Sports', 'Math_Science', 'Literacy_Language']
Shape of matrix after one hot encodig  (50000, 9)
```

In [32]:
```
# we use count vectorizer to convert the values into one
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False,
sub_categories_one_hot = vectorizer.fit_transform(project_data['clean_subcategories'].value
print(vectorizer.get_feature_names())
print("Shape of matrix after one hot encodig ",sub_categories_one_hot.shape)
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricu
lar', 'Civics_Government', 'ForeignLanguages', 'Warmth', 'Care_Hunger', 'NutritionEducati
on', 'PerformingArts', 'SocialSciences', 'CharacterEducation', 'TeamSports', 'Other', 'Co
llege_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopmen
t', 'ESL', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'Appli
edSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
Shape of matrix after one hot encodig  (50000, 30)
```

In [33]:
```
# Please do the similar feature encoding with state, teacher_prefix and project_grade_categ
```

Following Code blocks provided by me.

In [34]:
```
# Code took from original code provided.
states = project_data['school_state'].unique()
vectorizer = CountVectorizer(vocabulary=list(states), lowercase=False, binary=True)
vectorizer.fit(project_data['school_state'].values)
print(vectorizer.get_feature_names())

school_state_one_hot = vectorizer.transform(project_data['school_state'].values)
print("Shape of matrix after one hot encoding", school_state_one_hot.shape)
```

```
['CA', 'UT', 'GA', 'WA', 'OH', 'SC', 'FL', 'MI', 'NY', 'MD', 'MS', 'AZ', 'OK', 'PA', 'N
C', 'CO', 'DC', 'MA', 'IL', 'AL', 'TX', 'TN', 'IN', 'NJ', 'CT', 'AR', 'MO', 'VA', 'WV',
'LA', 'SD', 'ID', 'IA', 'MN', 'WI', 'NM', 'KY', 'OR', 'NV', 'RI', 'KS', 'WY', 'HI', 'NH',
'NE', 'AK', 'ME', 'DE', 'ND', 'MT', 'VT']
Shape of matrix after one hot encoding (50000, 51)
```

There are some NaN's in teacher_prefix column. replacing them with 'Mrs.' as that has high occurance in that column.

In [35]:
```
print("Number of NaN's before replacement in column: ", sum(project_data['teacher_prefix'].
project_data['teacher_prefix'] = project_data['teacher_prefix'].replace(np.nan, 'Mrs.', reg
print("Number of NaN's after replacement in column: ", sum(project_data['teacher_prefix'].i

# Output may show both zeros as I re-run this several times. But there are 3 zeros in origi
```

```
Number of NaN's before replacement in column:  1
Number of NaN's after replacement in column:  0
```

In [36]:
```
# Code took from original code provided.
prefixes = project_data['teacher_prefix'].unique()
vectorizer = CountVectorizer(vocabulary=list(prefixes), lowercase=False, binary=True)
vectorizer.fit(project_data['teacher_prefix'].values)
print(vectorizer.get_feature_names())

teacher_prefix_one_hot = vectorizer.transform(project_data['teacher_prefix'].values)
print("Shape of matrix after one hot encoding", teacher_prefix_one_hot.shape)
```

```
['Mrs.', 'Ms.', 'Mr.', 'Teacher', 'Dr.']
Shape of matrix after one hot encoding (50000, 5)
```

In [37]:
```
grades = project_data['project_grade_category'].unique()
vectorizer = CountVectorizer(vocabulary=list(grades), lowercase=False, binary=True)
vectorizer.fit(project_data['project_grade_category'].values)
print(vectorizer.get_feature_names())

project_grade_category_one_hot = vectorizer.transform(project_data['project_grade_category'
print("Shape of matrix after one hot encoding", project_grade_category_one_hot.shape)
```

```
['Grades PreK-2', 'Grades 3-5', 'Grades 9-12', 'Grades 6-8']
Shape of matrix after one hot encoding (50000, 4)
```

Following Code blocks present in original notebook.

1.5.2 Vectorizing Text data

1.5.2.1 Bag of words

In [38]:
```
# We are considering only the words which appeared in at least 10 documents(rows or project
vectorizer = CountVectorizer(min_df=15)
text_bow = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_bow.shape)
```

```
Shape of matrix after one hot encodig  (50000, 10232)
```

In [39]:
```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
```

Following Code blocks provided by me.

In [40]:
```
# Code took from original code provided.
# We are considering only the words which appeared in at least 5 documents(rows or projects
# Reduced number as title has less words
vectorizer = CountVectorizer(min_df=10)
titles_bow = vectorizer.fit_transform(preprocessed_titles)
print("Shape of matrix after one hot encodig ", titles_bow.shape)
```

```
Shape of matrix after one hot encodig  (50000, 1994)
```

Following Code blocks present in original notebook.

1.5.2.2 TFIDF vectorizer

In [41]:
```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=15)
text_tfidf = vectorizer.fit_transform(preprocessed_essays)
print("Shape of matrix after one hot encodig ",text_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (50000, 10232)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [42]:
```
'''
# Reading glove vectors in python: https://stackoverflow.com/a/38230349/4084039
def loadGloveModel(gloveFile):
    print ("Loading Glove Model")
    f = open(gloveFile,'r', encoding="utf8")
    model = {}
    for line in tqdm(f):
        splitLine = line.split()
        word = splitLine[0]
        embedding = np.array([float(val) for val in splitLine[1:]])
        model[word] = embedding
    print ("Done.",len(model)," words loaded!")
    return model
model = loadGloveModel('glove.42B.300d.txt')

# ============================
Output:

Loading Glove Model
1917495it [06:32, 4879.69it/s]
Done. 1917495  words loaded!

# ============================

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

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

inter_words = set(model.keys()).intersection(words)
```

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

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


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

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


'''
```

...

In [43]:
```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickl
# make sure you have the glove_vectors file
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [44]:
```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors.append(vector)

print(len(avg_w2v_vectors))
print(len(avg_w2v_vectors[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50
000 [00:18<00:00, 2726.23it/s]

50000
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [45]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_essays)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [46]:
```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentenc
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # gettin
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors.append(vector)

print(len(tfidf_w2v_vectors))
print(len(tfidf_w2v_vectors[0]))
```

```
100%|████████████████████████████████████████████████████████████████| 50000/5
0000 [04:46<00:00, 174.56it/s]

50000
300
```

In [47]:
```
# Similarly you can vectorize for title also
```

Following Code blocks provided by me.

In [48]:
```
# Code took from original code provided.
# tfidf of project titles
vectorizer = TfidfVectorizer(min_df=10)
titles_tfidf = vectorizer.fit_transform(preprocessed_titles)
print("Shape of matrix after one hot encodig ",titles_tfidf.shape)
```

```
Shape of matrix after one hot encodig  (50000, 1994)
```

In [49]:
```
# Code took from original code provided.
# avg-w2v for project titles
avg_w2v_titles = []
for sentence in tqdm(preprocessed_titles):
    vector = np.zeros(300)
    cnt_words =0;
    for word in sentence.split():
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_titles.append(vector)

print(len(avg_w2v_titles))
print(len(avg_w2v_titles[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/500
00 [00:02<00:00, 20348.19it/s]

50000
300
```

In [50]:
```
# Code took from original code provided.
tfidf_model = TfidfVectorizer()
tfidf_model.fit(preprocessed_titles)
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [51]:
```
# Code took from original code provided.
# tfidf-w2v for project titles
tfidf_w2v_titles = []
for sentence in tqdm(preprocessed_titles):
    vector = np.zeros(300)
    tf_idf_weight =0
    for word in sentence.split():
        if (word in glove_words) and (word in tfidf_words):
            vec = model[word]
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split()))
            vector += (vec * tf_idf)
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_titles.append(vector)

print(len(tfidf_w2v_titles))
print(len(tfidf_w2v_titles[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 50000/50
000 [00:10<00:00, 4616.35it/s]

50000
300
```

Following Code blocks present in original notebook.

1.5.3 Vectorizing Numerical features

In [52]:
```
price_data = resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index
project_data = pd.merge(project_data, price_data, on='id', how='left')
```

In [53]:
```
# check this one: https://www.youtube.com/watch?v=0HOqOcln3Z4&t=530s
# standardization sklearn: https://scikit-learn.org/stable/modules/generated/sklearn.prepro
from sklearn.preprocessing import StandardScaler

# price_standardized = standardScalar.fit(project_data['price'].values)
# this will rise the error
# ValueError: Expected 2D array, got 1D array instead: array=[725.05 213.03 329.   ... 399.
# Reshape your data either using array.reshape(-1, 1)

price_scalar = StandardScaler()
price_scalar.fit(project_data['price'].values.reshape(-1,1)) # finding the mean and standar
print(f"Mean : {price_scalar.mean_[0]}, Standard deviation : {np.sqrt(price_scalar.var_[0])

# Now standardize the data with above maen and variance.
price_standardized = price_scalar.transform(project_data['price'].values.reshape(-1, 1))
```

```
Mean : 298.2917768, Standard deviation : 364.8587347086088
```

In [54]:
```
price_standardized
```

Out[54]:
```
array([[ 1.1696533 ],
       [-0.23368435],
       [ 0.50087392],
       ...,
       [-0.42463497],
       [-0.08146105],
       [ 0.27601977]])
```

Following Code blocks provided by me.

In [55]:
```
warnings.filterwarnings("ignore")
# Code took from original code provided
scalar = StandardScaler()
scalar.fit(project_data['teacher_number_of_previously_posted_projects'].values.reshape(-1,
print(f"Mean : {scalar.mean_[0]}, Standard deviation : {np.sqrt(scalar.var_[0])}")

# Now standardize the data with above maen and variance.
previously_posted_projects_standardized = \
                scalar.transform(project_data['teacher_number_of_previously_posted_projects
print(previously_posted_projects_standardized)
```

```
Mean : 11.15184, Standard deviation : 27.576510015127006
[[ 1.51752923]
 [-0.25934536]
 [-0.33187086]
 ...
 [-0.22308262]
 [-0.29560811]
 [-0.40439635]]
```

Following Code blocks present in original notebook.

1.5.4 Merging all the above features

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

In [56]:
```
print(categories_one_hot.shape)
print(sub_categories_one_hot.shape)
print(text_bow.shape)
print(price_standardized.shape)
```

```
(50000, 9)
(50000, 30)
(50000, 10232)
(50000, 1)
```

In [57]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
# with the same hstack function we are concatinating a sparse matrix and a dense matirx :)
X = hstack((categories_one_hot, sub_categories_one_hot, text_bow, price_standardized))
X.shape
```

Out[57]:
```
(50000, 10272)
```

Assignment 3: 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 (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-

characteristic-curve-roc-curve-and-auc-1/) 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 (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points


[Task-2]

- Select top 2000 features from feature Set 2 using `SelectKBest` (https://scikit-learn.org/stable/modules/generated/sklearn.feature_selection.SelectKBest.html) 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 (http://zetcode.com/python/prettytable/)

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. (https://soundcloud.com/applied-ai-course/leakage-bow-and-tfidf)

2. K Nearest Neighbor

Some code blocks are taken from previous assignments. And some used the code present in original file ('3_DonorsChoose_KNN.ipynb') which is mentioned in comments.

Following Code blocks provided by me.

Adding a column `summary_numeric_bool` instead of `project_resource_summary` column which tells if resource summary has a number in it

In [58]:
```
# ref: https://stackoverflow.com/questions/4138202/using-isdigit-for-floats
def nums_in_str(text):
    """
    Returns list of numbers present in the given string. Numbers := floats ints etc.
    """
    result = []
    for s in text.split():
        try:
            x = float(s)
            result.append(x)
        except:
            continue
    return result
```

In [59]:
```
print(nums_in_str('HE44LLo 56 are -89 I 820.353 in -78.39 what .293 about 00'))
```

```
[56.0, -89.0, 820.353, -78.39, 0.293, 0.0]
```

In [60]:
```
numbers_in_summary = np.array([len(nums_in_str(s)) for s in project_data['project_resource_
project_data['summary_numeric_bool'] = list(map(int, numbers_in_summary>0))
```

Taking Relevant columns as X (input data to model) and y (output class label)

In [61]:
```
project_data.columns
```

Out[61]:
```
Index(['Unnamed: 0', 'id', 'teacher_id', 'teacher_prefix', 'school_state',
       'Date', 'project_grade_category', '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',
       'clean_categories', 'clean_subcategories', 'essay', 'price', 'quantity',
       'summary_numeric_bool'],
      dtype='object')
```

In [62]:
```
project_data.head(2)
```

Out[62]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_
0	8393	p205479	2bf07ba08945e5d8b2a3f269b2b3cfe5	Mrs.	CA	2016-04-27 00:27:36	Grad
1	37728	p043609	3f60494c61921b3b43ab61bdde2904df	Ms.	UT	2016-04-27 00:31:25	G

2 rows × 21 columns

In [63]:
```
# Categorical and numerical columns are listed below.
X_columns = ['teacher_prefix', 'school_state', 'project_grade_category', 'summary_numeric_b
             'teacher_number_of_previously_posted_projects', 'clean_categories', 'clean_sub
             'price', 'quantity']
X = project_data[X_columns]
y = project_data['project_is_approved']
```

Adding preprocessed_essays and preprocessed_titles as columns to X before splitting

In [64]:
```
X['essay'] = preprocessed_essays
X['project_title'] = preprocessed_titles
X_columns.append('essay')
X_columns.append('project_title')
print('final columns used in input data are: ', X_columns)
```

```
final columns used in input data are:  ['teacher_prefix', 'school_state', 'project_grade_
category', 'summary_numeric_bool', 'teacher_number_of_previously_posted_projects', 'clean
_categories', 'clean_subcategories', 'price', 'quantity', 'essay', 'project_title']
```

Things that I changed about data and model.

- **Did not take entire dataset because of time issues. i.e When I am searching for optimal K it takes so many hours to give the result.**
- **Restricted K to be less than 60 even though In previous submission K=101 gave better results**

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

In [65]:
```
# please write all the code with proper documentation, and proper titles for each subsectio
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your cod
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

In [66]:
```
# Code took from SAMPLE_SOLUTION notebook
# splitting into 60-20-20 ratio for train-cv-test data
from sklearn.model_selection import train_test_split
X_train_cv, X_test, y_train_cv, y_test = train_test_split(X, y, test_size=0.20, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train_cv, y_train_cv, test_size=0.25, str
```

In [67]:
```
print(X_train.shape)
print(X_cv.shape)
print(X_test.shape)
print('='*30)
print(y_train.shape)
print(y_cv.shape)
print(y_test.shape)
```

```
(30000, 11)
(10000, 11)
(10000, 11)
==============================
(30000,)
(10000,)
(10000,)
```

2.2 Make Data Model Ready: encoding numerical, categorical features

In [68]:
```
# please write all the code with proper documentation, and proper titles for each subsectio
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your cod
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

numerical columns

- teacher_number_of_previously_posted_projects
- price
- quantity

Leaving summary_numeric_bool as it is because it only has 0's and 1's in it.

categorical columns

- teacher_prefix
- school_state
- project_grade_category
- clean_categories
- clean_subcategories

Normalizing teacher_number_of_previously_posted_projects column

In [69]:
```
warnings.filterwarnings("ignore")
# Code took from original Code provided.
scaler = StandardScaler()
scaler.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
print(f"Mean : {scaler.mean_[0]}, Standard deviation : {np.sqrt(scaler.var_[0])}")
```

```
Mean : 11.015, Standard deviation : 26.876525848157286
```

In [70]:
```
warnings.filterwarnings("ignore")
X_train_tnppp_norm = scaler.transform(X_train['teacher_number_of_previously_posted_projects
X_cv_tnppp_norm = scaler.transform(X_cv['teacher_number_of_previously_posted_projects'].val
X_test_tnppp_norm = scaler.transform(X_test['teacher_number_of_previously_posted_projects']
```

Normalizing price column

In [71]:
```
# Code took from original Code provided.
scaler = StandardScaler()
scaler.fit(X_train['price'].values.reshape(-1,1))
print(f"Mean : {scaler.mean_[0]}, Standard deviation : {np.sqrt(scaler.var_[0])}")
```

```
Mean : 297.6274733333333, Standard deviation : 359.8038006435303
```

In [72]:
```
X_train_price_norm = scaler.transform(X_train['price'].values.reshape(-1,1))
X_cv_price_norm = scaler.transform(X_cv['price'].values.reshape(-1,1))
X_test_price_norm = scaler.transform(X_test['price'].values.reshape(-1,1))
```

Normalizing quantity column

In [73]:
```
warnings.filterwarnings("ignore")
# Code took from original Code provided.
scaler = StandardScaler()
scaler.fit(X_train['quantity'].values.reshape(-1,1))
print(f"Mean : {scaler.mean_[0]}, Standard deviation : {np.sqrt(scaler.var_[0])}")
```

```
Mean : 16.8555, Standard deviation : 25.703909295734245
```

In [74]:
```
warnings.filterwarnings("ignore")
X_train_quant_norm = scaler.transform(X_train['quantity'].values.reshape(-1,1))
X_cv_quant_norm = scaler.transform(X_cv['quantity'].values.reshape(-1,1))
X_test_quant_norm = scaler.transform(X_test['quantity'].values.reshape(-1,1))
```

Encoding teacher_prefix column

In [75]:
```
# Code took from SAMPLE_SOLUTION notebook.
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values)
print(vectorizer.get_feature_names())
```

```
['dr', 'mr', 'mrs', 'ms', 'teacher']
```

In [76]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_prefix_ohe = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_prefix_ohe = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_prefix_ohe = vectorizer.transform(X_test['teacher_prefix'].values)

print(X_train_prefix_ohe.shape, y_train.shape)
print(X_cv_prefix_ohe.shape, y_cv.shape)
print(X_test_prefix_ohe.shape, y_test.shape)
```

```
(30000, 5) (30000,)
(10000, 5) (10000,)
(10000, 5) (10000,)
```

Encoding school_state column

In [77]:
```
# Code took from SAMPLE_SOLUTION notebook.
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values)
print(vectorizer.get_feature_names())
```

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

In [78]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_school_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_school_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_school_ohe = vectorizer.transform(X_test['school_state'].values)

print(X_train_school_ohe.shape, y_train.shape)
print(X_cv_school_ohe.shape, y_cv.shape)
print(X_test_school_ohe.shape, y_test.shape)
```

```
(30000, 51) (30000,)
(10000, 51) (10000,)
(10000, 51) (10000,)
```

Encoding project_grade_category column

In [79]:
```
# Code took from original Code provided.
grades = X_train['project_grade_category'].unique()
vectorizer = CountVectorizer(vocabulary=list(grades), lowercase=False, binary=True)
vectorizer.fit(X_train['project_grade_category'].values)
print(vectorizer.get_feature_names())
```

```
['Grades 6-8', 'Grades 3-5', 'Grades PreK-2', 'Grades 9-12']
```

In [80]:
```
# Code took from SAMPLE_SOLUTION notebook.
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(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)
```

```
(30000, 4) (30000,)
(10000, 4) (10000,)
(10000, 4) (10000,)
```

Encoding clean_categories column

In [81]:
```
# Code took from original Code provided.
vectorizer = CountVectorizer(vocabulary=list(sorted_cat_dict.keys()), lowercase=False, bina
vectorizer.fit(X_train['clean_categories'].values)
print(vectorizer.get_feature_names())
```

```
['Warmth', 'Care_Hunger', 'History_Civics', 'Music_Arts', 'AppliedLearning', 'SpecialNeed
s', 'Health_Sports', 'Math_Science', 'Literacy_Language']
```

In [82]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_categ_ohe = vectorizer.transform(X_train['clean_categories'].values)
X_cv_categ_ohe = vectorizer.transform(X_cv['clean_categories'].values)
X_test_categ_ohe = vectorizer.transform(X_test['clean_categories'].values)

print(X_train_categ_ohe.shape, y_train.shape)
print(X_cv_categ_ohe.shape, y_cv.shape)
print(X_test_categ_ohe.shape, y_test.shape)
```

```
(30000, 9) (30000,)
(10000, 9) (10000,)
(10000, 9) (10000,)
```

Encoding clean_subcategories column

In [83]:
```
# Code took from original Code provided.
vectorizer = CountVectorizer(vocabulary=list(sorted_sub_cat_dict.keys()), lowercase=False,
vectorizer.fit(X_train['clean_subcategories'].values)
print(vectorizer.get_feature_names())
```

```
['Economics', 'CommunityService', 'FinancialLiteracy', 'ParentInvolvement', 'Extracurricu
lar', 'Civics_Government', 'ForeignLanguages', 'Warmth', 'Care_Hunger', 'NutritionEducati
on', 'PerformingArts', 'SocialSciences', 'CharacterEducation', 'TeamSports', 'Other', 'Co
llege_CareerPrep', 'Music', 'History_Geography', 'Health_LifeScience', 'EarlyDevelopmen
t', 'ESL', 'Gym_Fitness', 'EnvironmentalScience', 'VisualArts', 'Health_Wellness', 'Appli
edSciences', 'SpecialNeeds', 'Literature_Writing', 'Mathematics', 'Literacy']
```

In [84]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_subcat_ohe = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_subcat_ohe = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_subcat_ohe = vectorizer.transform(X_test['clean_subcategories'].values)

print(X_train_subcat_ohe.shape, y_train.shape)
print(X_cv_subcat_ohe.shape, y_cv.shape)
print(X_test_subcat_ohe.shape, y_test.shape)
```

```
(30000, 30) (30000,)
(10000, 30) (10000,)
(10000, 30) (10000,)
```

Combining categorical and numerical data for further use.

In [85]:
```
from scipy.sparse import hstack
cat_num_train = hstack((X_train_tnppp_norm, X_train_price_norm, X_train_quant_norm,\
                        np.array(X_train['summary_numeric_bool']).reshape(-1, 1),\
                        X_train_prefix_ohe, X_train_grade_ohe, X_train_school_ohe, X_train_
cat_num_cv = hstack((X_cv_tnppp_norm, X_cv_price_norm, X_cv_quant_norm,\
                     np.array(X_cv['summary_numeric_bool']).reshape(-1, 1),\
                     X_cv_prefix_ohe, X_cv_grade_ohe, X_cv_school_ohe, X_cv_categ_ohe, X_cv
cat_num_test = hstack((X_test_tnppp_norm, X_test_price_norm, X_test_quant_norm,\
                       np.array(X_test['summary_numeric_bool']).reshape(-1, 1),\
                       X_test_prefix_ohe, X_test_grade_ohe, X_test_school_ohe, X_test_categ
```

In [86]:
```
print(cat_num_train.shape, y_train.shape)
print(cat_num_cv.shape, y_cv.shape)
print(cat_num_test.shape, y_test.shape)
```

```
(30000, 103) (30000,)
(10000, 103) (10000,)
(10000, 103) (10000,)
```

2.3 Make Data Model Ready: encoding eassay, and project_title

In [87]:
```
# please write all the code with proper documentation, and proper titles for each subsectio
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your cod
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

Converting essay column to vector using Bag of Words (BoW).

In [88]:
```
# Code took from original Code provided.
vectorizer = CountVectorizer(min_df=10)
vectorizer.fit(X_train['essay'].values)
print(len(vectorizer.get_feature_names()))
```

```
9925
```

In [89]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_essay_bow = vectorizer.transform(X_train['essay'].values)
X_cv_essay_bow = vectorizer.transform(X_cv['essay'].values)
X_test_essay_bow = vectorizer.transform(X_test['essay'].values)

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

```
(30000, 9925) (30000,)
(10000, 9925) (10000,)
(10000, 9925) (10000,)
```

Converting essay column to vector using TFIDF Vectorizer.

In [90]:
```
# Code took from original Code provided.
vectorizer = TfidfVectorizer(min_df=10)
vectorizer.fit(X_train['essay'].values)
print(len(vectorizer.get_feature_names()))
```

```
9925
```

In [91]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_essay_tfidf = vectorizer.transform(X_train['essay'].values)
X_cv_essay_tfidf = vectorizer.transform(X_cv['essay'].values)
X_test_essay_tfidf = vectorizer.transform(X_test['essay'].values)

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

```
(30000, 9925) (30000,)
(10000, 9925) (10000,)
(10000, 9925) (10000,)
```

Converting `essay` column to vector using Average Word2Vec.

Creating function to return average word2vec vectors given sentences

In [92]:
```
 # Code took from original Code provided.
def avg_w2v(arr):
    """
    Returns array of vectors given array of sentences. Array of vectors are created by Aver
    words is taken from 'glove_vectors' file.
    """
    avg_w2v_vectors = []
    for sentence in tqdm(arr):
        vector = np.zeros(300)
        cnt_words = 0
        for word in sentence.split():
            if word in glove_words:
                vector += model[word]
                cnt_words += 1
        if cnt_words != 0:
            vector /= cnt_words
        avg_w2v_vectors.append(vector)
    return avg_w2v_vectors
```

In [93]:
```
X_train_essay_avgw2v = np.array(avg_w2v(X_train['essay'].values))
X_cv_essay_avgw2v = np.array(avg_w2v(X_cv['essay'].values))
X_test_essay_avgw2v = np.array(avg_w2v(X_test['essay'].values))

print(X_train_essay_avgw2v.shape, y_train.shape)
print(X_cv_essay_avgw2v.shape, y_cv.shape)
print(X_test_essay_avgw2v.shape, y_test.shape)
```

```
100%|████████████████████████████████████████████████████████████████████| 30000/3
0000 [00:32<00:00, 915.18it/s]
100%|████████████████████████████████████████████████████████████████████| 10000/10
000 [00:08<00:00, 1198.79it/s]
100%|████████████████████████████████████████████████████████████████████| 10000/1
0000 [00:13<00:00, 749.99it/s]

(30000, 300) (30000,)
(10000, 300) (10000,)
(10000, 300) (10000,)
```

Converting `essay` column to vector using TFIDF weighted Word2Vec.

Creating function to return tfidf weighted word2vec vectors given sentences and idf dictionary for words

In [94]:
```
# Code took from original Code provided.
def tfidf_w2v(arr, idf_dict):
    """
    Returns array of vectors given array of sentences and dictionary containing IDF values
    Array of vectors are created by TFIDF weighted Word2Vec method and vectors for words is
    """
    tfidf_w2v_vectors = []
    for sentence in tqdm(arr):
        vector = np.zeros(300)
        tf_idf_weight = 0;
        for word in sentence.split():
            if (word in glove_words) and (word in idf_dict):
                vec = model[word]
                tf_idf = idf_dict[word]/len(sentence.split())
                vector += (vec * tf_idf)
                tf_idf_weight += tf_idf
        if tf_idf_weight != 0:
            vector /= tf_idf_weight
        tfidf_w2v_vectors.append(vector)
    return tfidf_w2v_vectors
```

Getting idf values for the words in X_train.essay data

In [95]:
```
# Code took from original Code provided.
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['essay'])
# 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_)))
```

In [96]:
```
X_train_essay_tfidfw2v = np.array(tfidf_w2v(X_train['essay'].values, dictionary))
X_cv_essay_tfidfw2v = np.array(tfidf_w2v(X_cv['essay'].values, dictionary))
X_test_essay_tfidfw2v = np.array(tfidf_w2v(X_test['essay'].values, dictionary))

print(X_train_essay_tfidfw2v.shape, y_train.shape)
print(X_cv_essay_tfidfw2v.shape, y_cv.shape)
print(X_test_essay_tfidfw2v.shape, y_test.shape)
```

```
100%|████████████████████████████████████████████████████████████████████| 30000/3
0000 [03:46<00:00, 132.20it/s]
100%|████████████████████████████████████████████████████████████████████| 10000/1
0000 [01:16<00:00, 131.34it/s]
100%|████████████████████████████████████████████████████████████████████| 10000/1
0000 [01:13<00:00, 135.62it/s]

(30000, 300) (30000,)
(10000, 300) (10000,)
(10000, 300) (10000,)
```

Converting `project_title` column to vector using Bag of Words (BoW).

In [97]:
```
# Code took from original Code provided.
vectorizer = CountVectorizer(min_df=5)
vectorizer.fit(X_train['project_title'].values)
print(len(vectorizer.get_feature_names()))
```

```
2367
```

In [98]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_title_bow = vectorizer.transform(X_train['project_title'].values)
X_cv_title_bow = vectorizer.transform(X_cv['project_title'].values)
X_test_title_bow = vectorizer.transform(X_test['project_title'].values)

print(X_train_title_bow.shape, y_train.shape)
print(X_cv_title_bow.shape, y_cv.shape)
print(X_test_title_bow.shape, y_test.shape)
```

```
(30000, 2367) (30000,)
(10000, 2367) (10000,)
(10000, 2367) (10000,)
```

Converting `project_title` column to vector using TFIDF Vectorizer.

In [99]:
```
# Code took from original Code provided.
vectorizer = TfidfVectorizer(min_df=5)
vectorizer.fit(X_train['project_title'].values)
print(len(vectorizer.get_feature_names()))
```

```
2367
```

In [100]:
```
# Code took from SAMPLE_SOLUTION notebook.
X_train_title_tfidf = vectorizer.transform(X_train['project_title'].values)
X_cv_title_tfidf = vectorizer.transform(X_cv['project_title'].values)
X_test_title_tfidf = vectorizer.transform(X_test['project_title'].values)

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

```
(30000, 2367) (30000,)
(10000, 2367) (10000,)
(10000, 2367) (10000,)
```

Converting `project_title` column to vector using Average Word2Vec.

Can use avg_w2v function

In [101]:
```
X_train_title_avgw2v = np.array(avg_w2v(X_train['project_title'].values))
X_cv_title_avgw2v = np.array(avg_w2v(X_cv['project_title'].values))
X_test_title_avgw2v = np.array(avg_w2v(X_test['project_title'].values))

print(X_train_title_avgw2v.shape, y_train.shape)
print(X_cv_title_avgw2v.shape, y_cv.shape)
print(X_test_title_avgw2v.shape, y_test.shape)
```

```
100%|████████████████████████████████████████████████████████████████████████| 30000/300
00 [00:01<00:00, 17745.83it/s]
100%|████████████████████████████████████████████████████████████████████████| 10000/100
00 [00:00<00:00, 17769.33it/s]
100%|████████████████████████████████████████████████████████████████████████| 10000/100
00 [00:00<00:00, 27621.98it/s]

(30000, 300) (30000,)
(10000, 300) (10000,)
(10000, 300) (10000,)
```

Converting `project_title` column to vector using TFIDF weighted Word2Vec.

Can use tfidf_w2v function but should calculate idf dictionary before using it

In [102]:
```
# Code took from original Code provided.
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['project_title'])
# 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_)))
```

In [103]:
```
X_train_title_tfidfw2v = np.array(tfidf_w2v(X_train['project_title'].values, dictionary))
X_cv_title_tfidfw2v = np.array(tfidf_w2v(X_cv['project_title'].values, dictionary))
X_test_title_tfidfw2v = np.array(tfidf_w2v(X_test['project_title'].values, dictionary))

print(X_train_title_tfidfw2v.shape, y_train.shape)
print(X_cv_title_tfidfw2v.shape, y_cv.shape)
print(X_test_title_tfidfw2v.shape, y_test.shape)
```

```
100%|██████████████████████████████████████████████████████████████████████████| 30000/300
00 [00:02<00:00, 11051.95it/s]
100%|██████████████████████████████████████████████████████████████████████████| 10000/100
00 [00:00<00:00, 11117.44it/s]
100%|██████████████████████████████████████████████████████████████████████████| 10000/100
00 [00:00<00:00, 10667.07it/s]

(30000, 300) (30000,)
(10000, 300) (10000,)
(10000, 300) (10000,)
```

2.4 Appling KNN on different kind of featurization as mentioned in the instructions

Apply KNN on different kind of featurization as mentioned in the instructions

For Every model that you work on make sure you do the step 2 and step 3 of instructions

In [104]:
```
# please write all the code with proper documentation, and proper titles for each subsectio
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your cod

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

Joining processed `essay` and `project_title` arrays with categorical and numerical data to form four types of matrices (BoW, TFIDF, AvgW2V, TFIDFW2V)

In [105]:
```
bow_train = hstack((cat_num_train, X_train_essay_bow, X_train_title_bow)).tocsr()
bow_cv = hstack((cat_num_cv, X_cv_essay_bow, X_cv_title_bow)).tocsr()
bow_test = hstack((cat_num_test, X_test_essay_bow, X_test_title_bow)).tocsr()

tfidf_train = hstack((cat_num_train, X_train_essay_tfidf, X_train_title_tfidf)).tocsr()
tfidf_cv = hstack((cat_num_cv, X_cv_essay_tfidf, X_cv_title_tfidf)).tocsr()
tfidf_test = hstack((cat_num_test, X_test_essay_tfidf, X_test_title_tfidf)).tocsr()

avgw2v_train = np.hstack((cat_num_train.toarray(), X_train_essay_avgw2v, X_train_title_avgw
avgw2v_cv = np.hstack((cat_num_cv.toarray(), X_cv_essay_avgw2v, X_cv_title_avgw2v))
avgw2v_test = np.hstack((cat_num_test.toarray(), X_test_essay_avgw2v, X_test_title_avgw2v))

tfidfw2v_train = np.hstack((cat_num_train.toarray(), X_train_essay_tfidfw2v, X_train_title_
tfidfw2v_cv = np.hstack((cat_num_cv.toarray(), X_cv_essay_tfidfw2v, X_cv_title_tfidfw2v))
tfidfw2v_test = np.hstack((cat_num_test.toarray(), X_test_essay_tfidfw2v, X_test_title_tfid

print('='*30)
print(bow_train.shape)
print(bow_cv.shape)
print(bow_test.shape)
print('='*30)
print(tfidf_train.shape)
print(tfidf_cv.shape)
print(tfidf_test.shape)
print('='*30)
print(avgw2v_train.shape)
print(avgw2v_cv.shape)
print(avgw2v_test.shape)
print('='*30)
print(tfidfw2v_train.shape)
print(tfidfw2v_cv.shape)
print(tfidfw2v_test.shape)
print('='*30)
```

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

```
(30000, 12395)
(10000, 12395)
(10000, 12395)
==============================
(30000, 12395)
(10000, 12395)
(10000, 12395)
==============================
(30000, 703)
(10000, 703)
(10000, 703)
==============================
(30000, 703)
(10000, 703)
(10000, 703)
==============================
```

2.4.1 Applying KNN brute force on BOW, SET 1

In [106]:
```
# Please write all the code with proper documentation
```

Writing several functions to reuse them later

Batch predict function took from SAMPLE_SOLUTION notebook. Function returns prediction in form of probabilities to validation/test data given the fitted classifier

In [107]:
```
# function took from SAMPLE_SOLUTION notebook
def batch_predict(clf, data):
    """
    Given Classifier (which is already fit to train data) and cv/test data as input,
    returns predictions for the data in form of probabilities.
    """
    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    if(tr_loop<data.shape[0]):
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

Function to plot AUC values with respect to hyper-parameter K given train and cross validation data

In [108]:
```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import roc_auc_score

# Code inside function took from SAMPLE_SOLUTION notebook
def auc_vs_K_plot(X_train, y_train, X_cv, y_cv, K):
    """
    Plots the AUC results for different K values on both train and CV data
    Parameters:
    X_train, y_train - data on which KNN classifier has to be trained
    X_cv, y_cv - data which helps to find best K (hyper-parameter)
    K - list of K values on which we have to train the data and plot the results
    """
    train_auc = []
    cv_auc = []
    for i in K:
        neigh = KNeighborsClassifier(n_neighbors=i)
        neigh.fit(X_train, y_train)

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

        train_auc.append(roc_auc_score(y_train, y_train_pred))
        cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

        print(f"K = {i} Done!")

    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 vs hyperparameter K PLOTS for Train and CV data")
    plt.grid()
    plt.show()
```

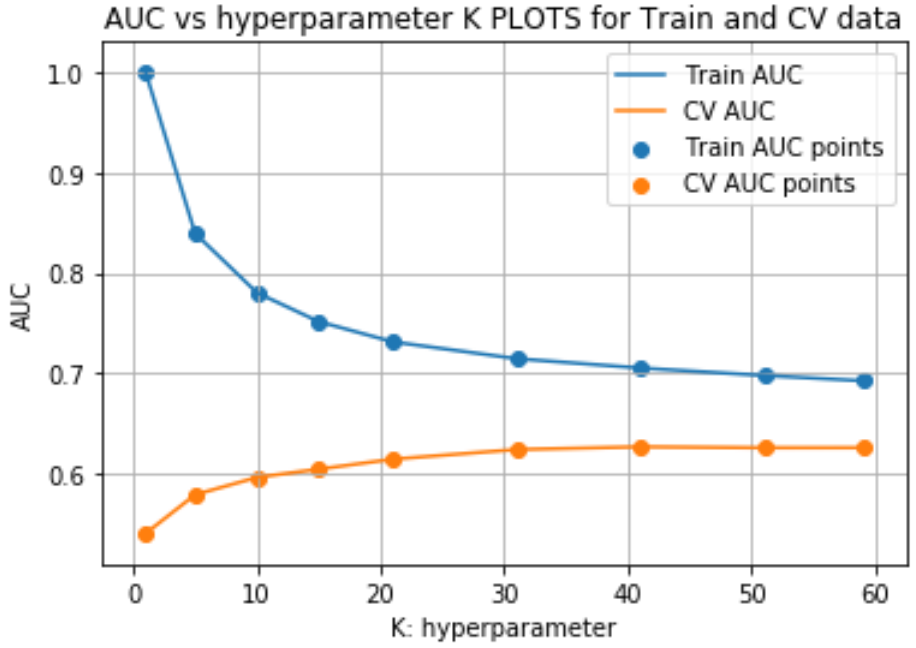
Function to plot ROC curves and plot confusion matrices for train and test data. Function also returns AUC Values for train and test data

In [109]:
```
from sklearn.metrics import roc_curve, auc

# Code inside function took from SAMPLE_SOLUTION notebook
def ROC_conf_mat(X_train, y_train, X_test, y_test, best_K):
    """
    Plots ROC Curve given a K value, Train data and Test data using KNN Classifier as model
    And also prints confusion matrix for train data and test data taking a optimal threshol
    Returns Area Under ROC Curve for Train and Test data which can be taken as performance
    """
    # Plotting ROC Curve code
    neigh = KNeighborsClassifier(n_neighbors=best_K)
    neigh.fit(X_train, y_train)

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

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

    train_auc, test_auc = (auc(train_fpr, train_tpr), auc(test_fpr, test_tpr))

    plt.plot(train_fpr, train_tpr, label="train AUC ="+str(np.round(train_auc, 3)))
    plt.plot(test_fpr, test_tpr, label="test AUC ="+str(np.round(test_auc, 3)))
    plt.legend()
    plt.xlabel("False Positive rate")
    plt.ylabel("True Positive rate")
    plt.title("ROC Curves for Train and Test data")
    plt.grid()
    plt.show()

    # Printing confusion matrices code
    thr_train = tr_thresholds[np.argmax(train_tpr*(1-train_fpr))]
    thr_test = te_thresholds[np.argmax(test_tpr*(1-test_fpr))]

    print(f"\nConfusion matrix for Train data with {thr_train} as threshold:")
```

```
    predictions = []
    for i in y_train_pred:
        if i >= thr_train:
            predictions.append(1)
        else:
            predictions.append(0)
    sns.heatmap(confusion_matrix(y_train, predictions), annot=True)
    plt.show()

    print(f"\nConfusion matrix for Test data with {thr_test} as threshold:")
    predictions = []
    for i in y_test_pred:
        if i >= thr_test:
            predictions.append(1)
        else:
            predictions.append(0)
    sns.heatmap(confusion_matrix(y_test, predictions), annot=True)
    plt.show()

    return (train_auc, test_auc)
```

In [110]:
```
K = [1, 5, 10, 15, 21, 31, 41, 51, 59]
auc_vs_K_plot(bow_train, y_train, bow_cv, y_cv, K)
```

```
K = 1 Done!
K = 5 Done!
K = 10 Done!
K = 15 Done!
K = 21 Done!
K = 31 Done!
K = 41 Done!
K = 51 Done!
K = 59 Done!
```

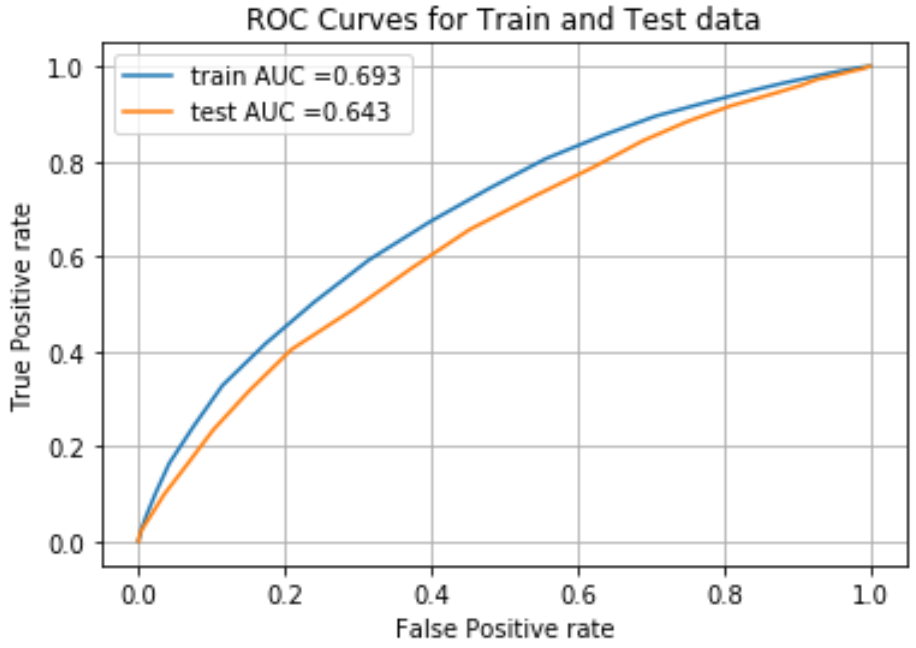


K = 59 looks good as the gap between CV and Train is less and has high validation AUC.

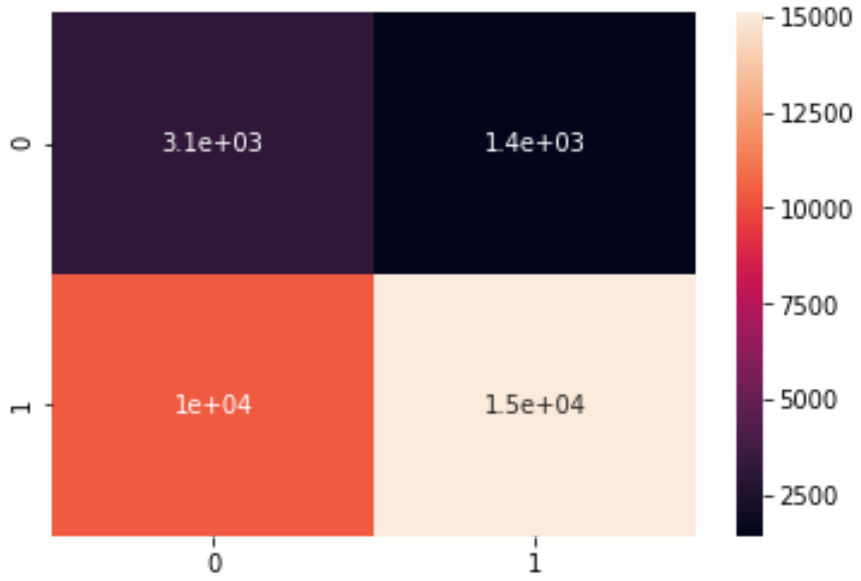
Test AUC's has to be stored for comparing models at last.

In [111]:
```
# Dictionary to store Test AUC's
Test_AUCs = {}
```

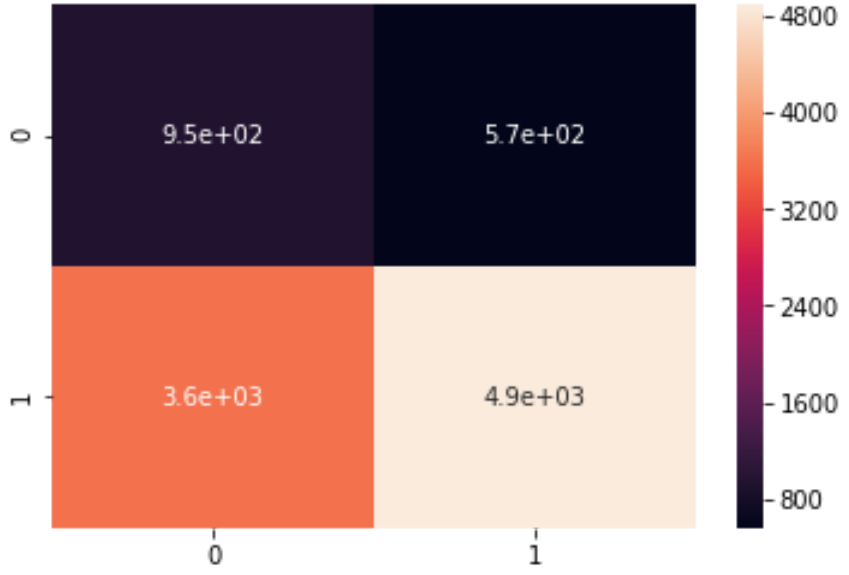
In [133]:
```
ss, Test_AUCs['bow_brute_AUC'] = ROC_conf_mat(bow_train, y_train, bow_test, y_test, 59)
```



Confusion matrix for Train data with 0.8135593220338984 as threshold:



Confusion matrix for Test data with 0.8135593220338984 as threshold:



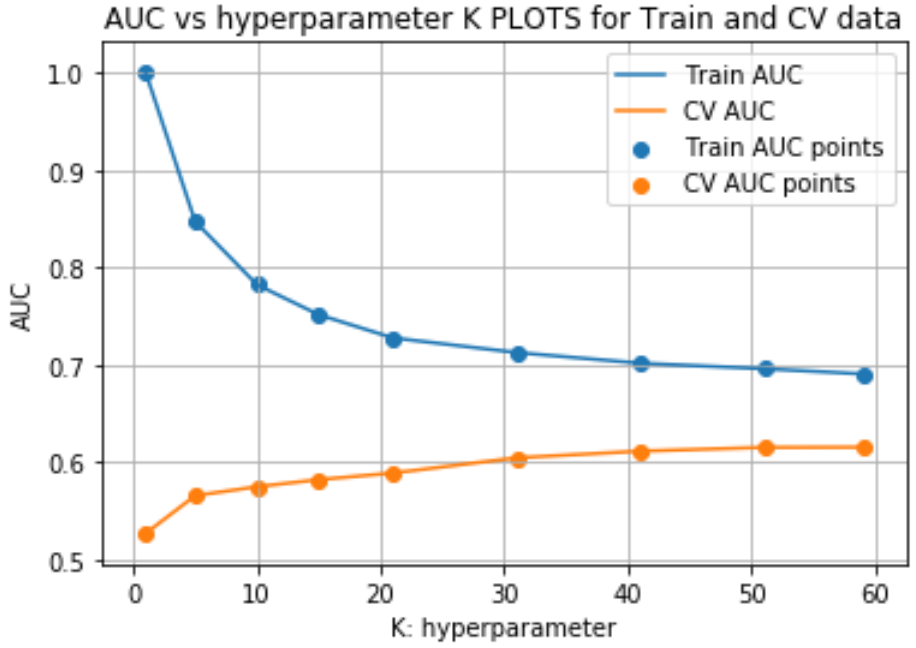
We will reuse `auc_vs_K_plot` and `ROC_conf_mat` functions for following data

2.4.2 Applying KNN brute force on TFIDF, SET 2

In [113]:
```
# Please write all the code with proper documentation
```

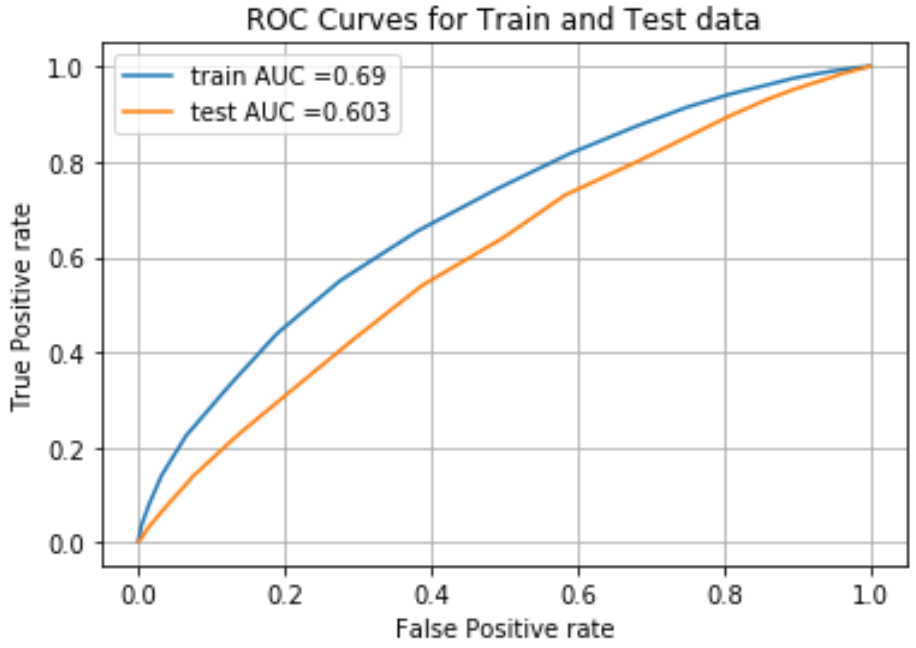
In [114]:
```
K = [1, 5, 10, 15, 21, 31, 41, 51, 59]
auc_vs_K_plot(tfidf_train, y_train, tfidf_cv, y_cv, K)
```

```
K = 1 Done!
K = 5 Done!
K = 10 Done!
K = 15 Done!
K = 21 Done!
K = 31 Done!
K = 41 Done!
K = 51 Done!
K = 59 Done!
```

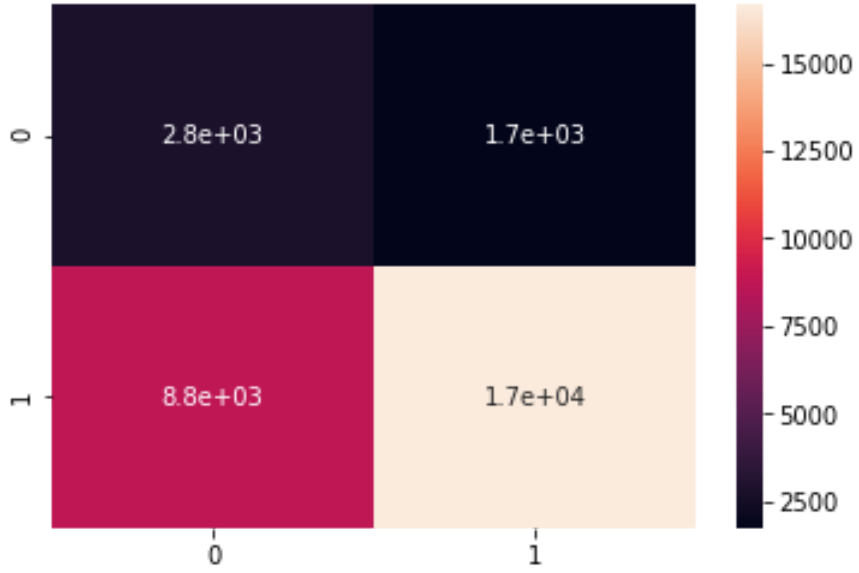


Here K = 59 seems to be good

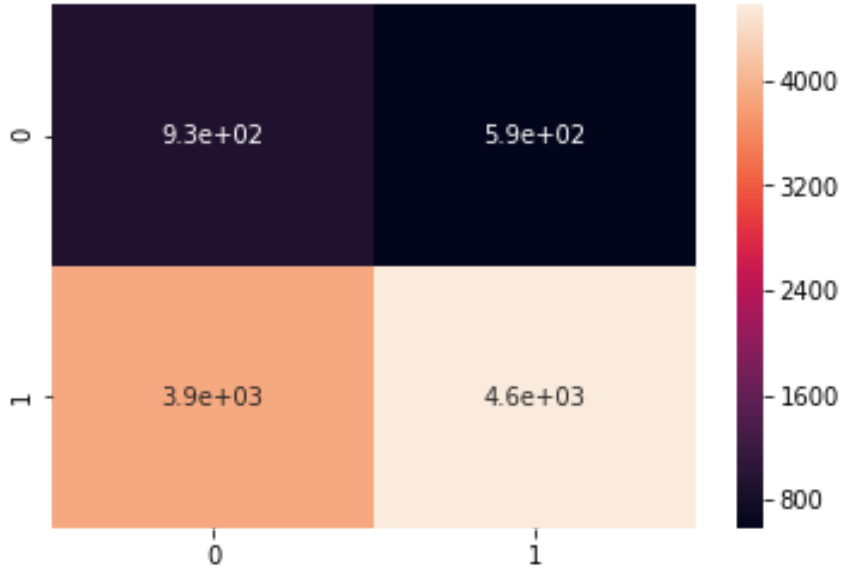
In [115]:
```
ss, Test_AUCs['tfidf_brute_AUC'] = ROC_conf_mat(tfidf_train, y_train, tfidf_test, y_test, 5
```



Confusion matrix for Train data with 0.847457627118644 as threshold:



Confusion matrix for Test data with 0.864406779661017 as threshold:

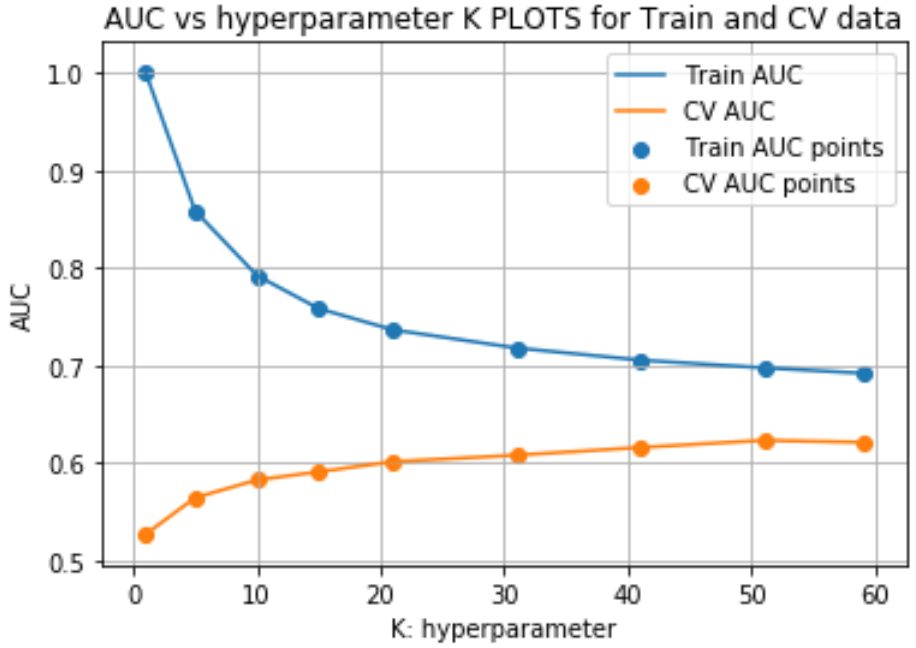


2.4.3 Applying KNN brute force on AVG W2V, SET 3

In [116]:
```
# Please write all the code with proper documentation
```

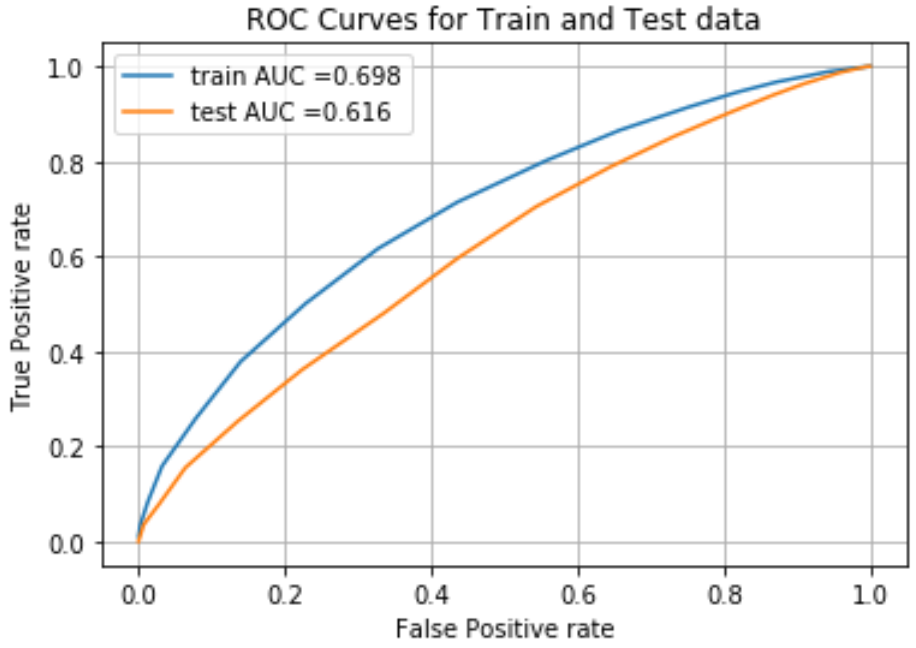
In [117]:
```
K = [1, 5, 10, 15, 21, 31, 41, 51, 59]
auc_vs_K_plot(avgw2v_train, y_train, avgw2v_cv, y_cv, K)
```

```
K = 1 Done!
K = 5 Done!
K = 10 Done!
K = 15 Done!
K = 21 Done!
K = 31 Done!
K = 41 Done!
K = 51 Done!
K = 59 Done!
```

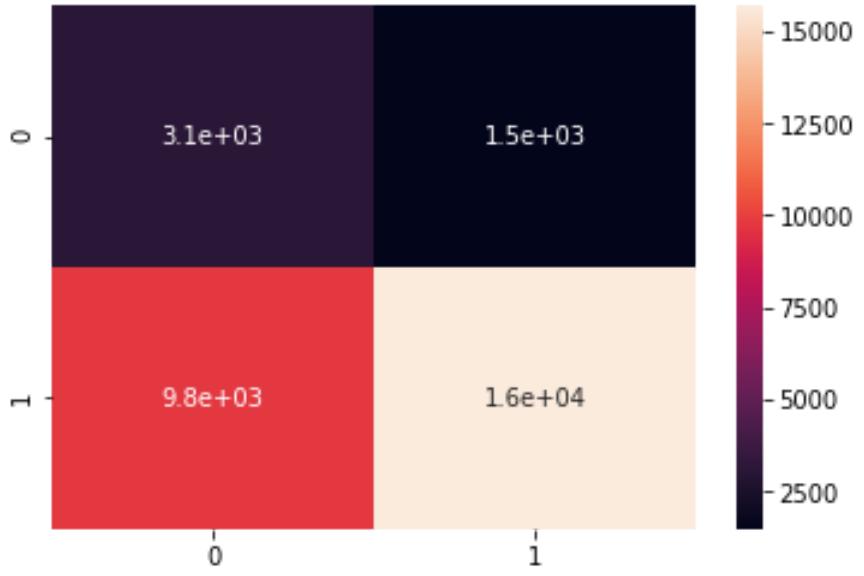


Taking K = 50 as best hyperparameter.

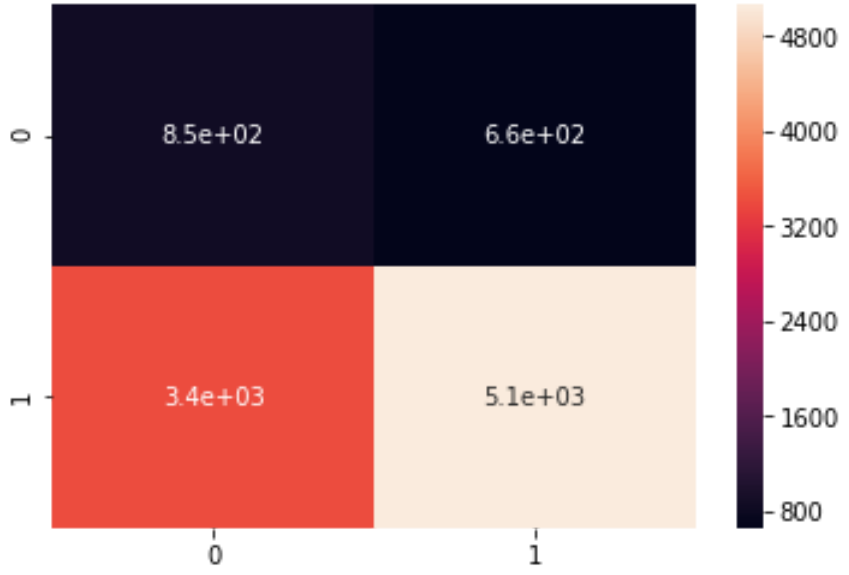
In [130]:
```
ss, Test_AUCs['avgw2v_brute_AUC'] = ROC_conf_mat(avgw2v_train, y_train, avgw2v_test, y_test
```



Confusion matrix for Train data with 0.86 as threshold:



Confusion matrix for Test data with 0.86 as threshold:

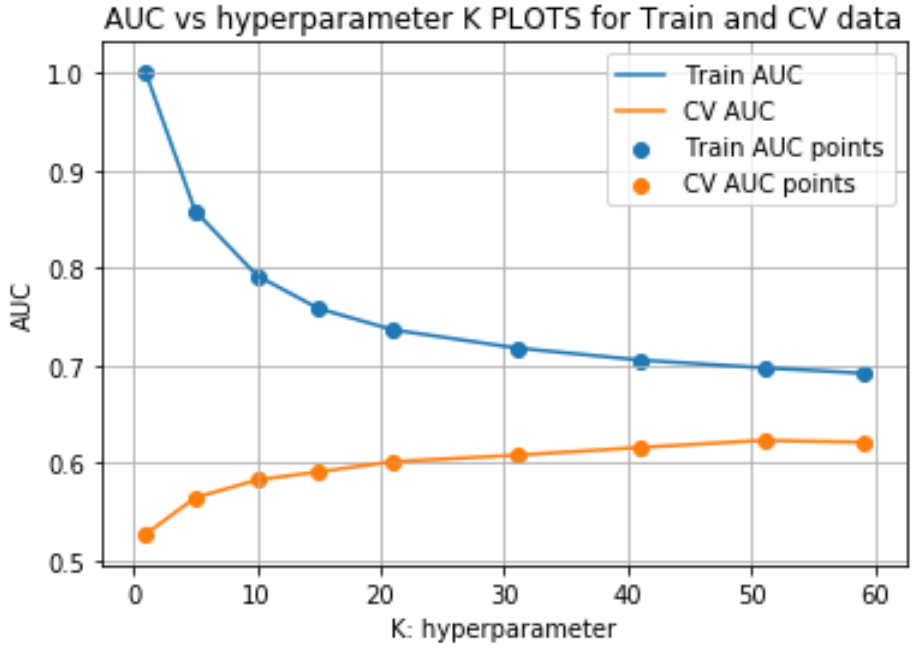


2.4.4 Applying KNN brute force on TFIDF W2V, SET 4

In [119]:
```
# Please write all the code with proper documentation
```

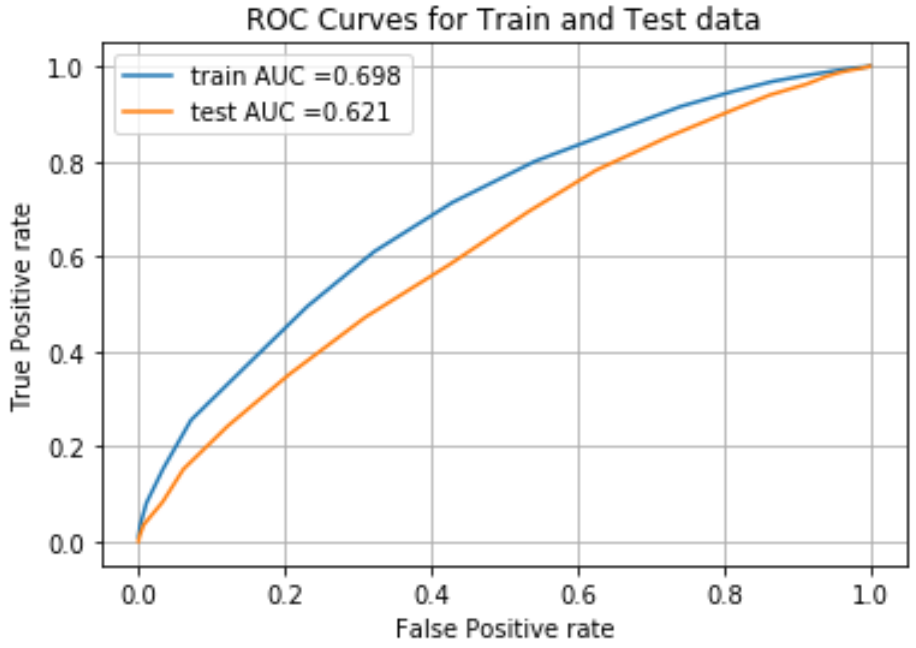
In [120]:
```
K = [1, 5, 10, 15, 21, 31, 41, 51, 59]
auc_vs_K_plot(avgw2v_train, y_train, avgw2v_cv, y_cv, K)
```

```
K = 1 Done!
K = 5 Done!
K = 10 Done!
K = 15 Done!
K = 21 Done!
K = 31 Done!
K = 41 Done!
K = 51 Done!
K = 59 Done!
```

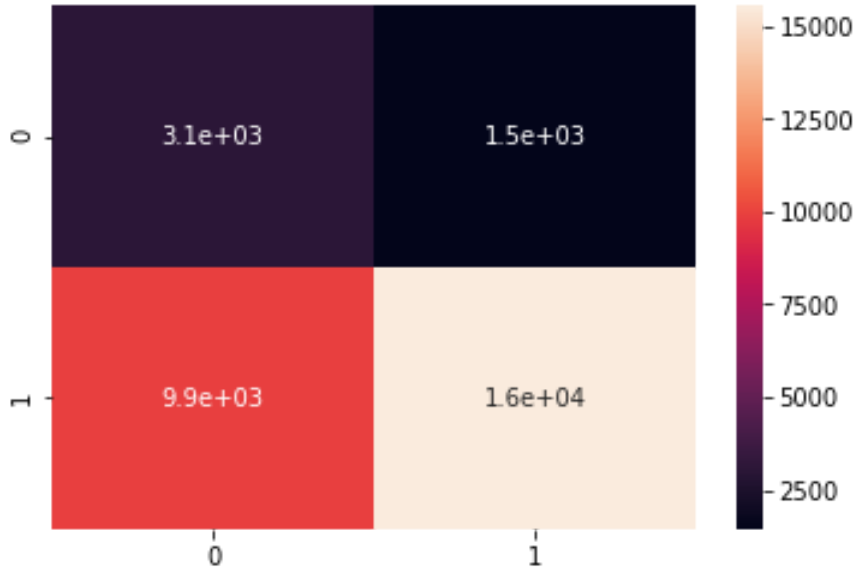


Here too K = 50 seems good.

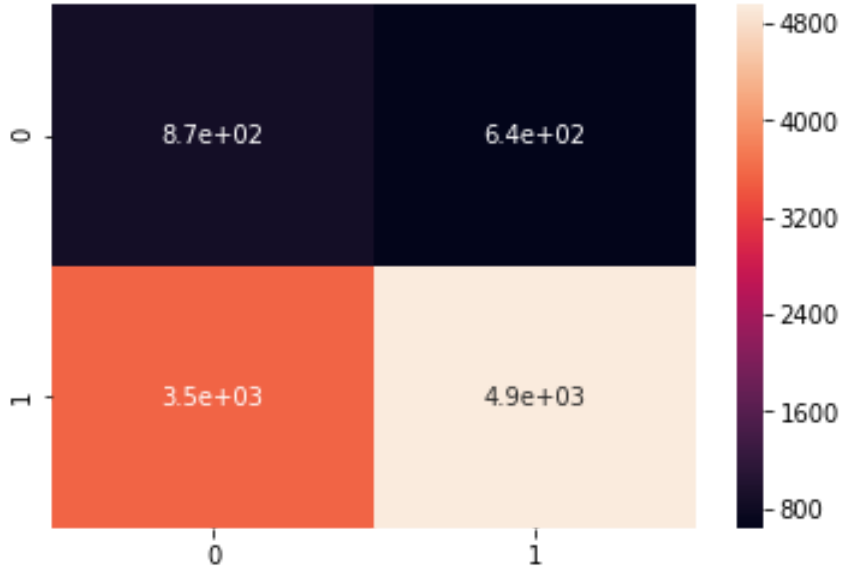
In [131]:
```
ss, Test_AUCs['tfidfw2v_brute_AUC'] = ROC_conf_mat(tfidfw2v_train, y_train, tfidfw2v_test,
```



Confusion matrix for Train data with 0.86 as threshold:



Confusion matrix for Test data with 0.86 as threshold:



AUC vs K plots for AvgW2V and TFIDFW2V took so many hours to produce

2.5 Feature selection with `SelectKBest`

In [123]:
```
# please write all the code with proper documentation, and proper titles for each subsectio
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your cod

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

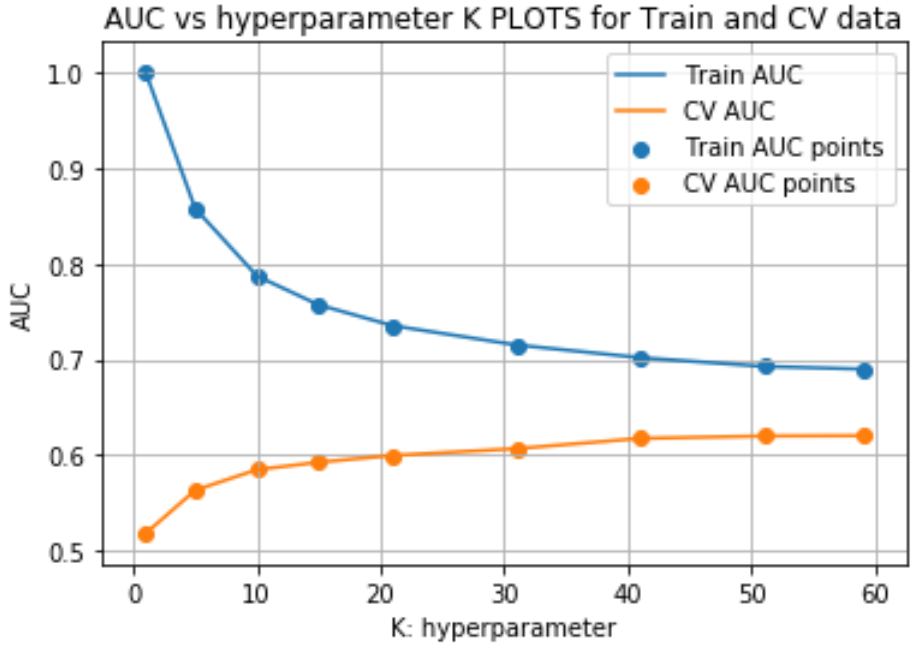
Doing SelectKBest for TDIDF vectorized data and doing the analysis

In [124]:
```
warnings.filterwarnings("ignore")
from sklearn.feature_selection import SelectKBest, chi2
kbestmodel = SelectKBest(k=2000)
kbestmodel.fit(tfidf_train, y_train)

tfidf_train_kbest = kbestmodel.transform(tfidf_train)
tfidf_cv_kbest = kbestmodel.transform(tfidf_cv)
tfidf_test_kbest = kbestmodel.transform(tfidf_test)

print(tfidf_train_kbest.shape)
print(tfidf_cv_kbest.shape)
print(tfidf_test_kbest.shape)
```

```
(30000, 2000)
(10000, 2000)
(10000, 2000)
```

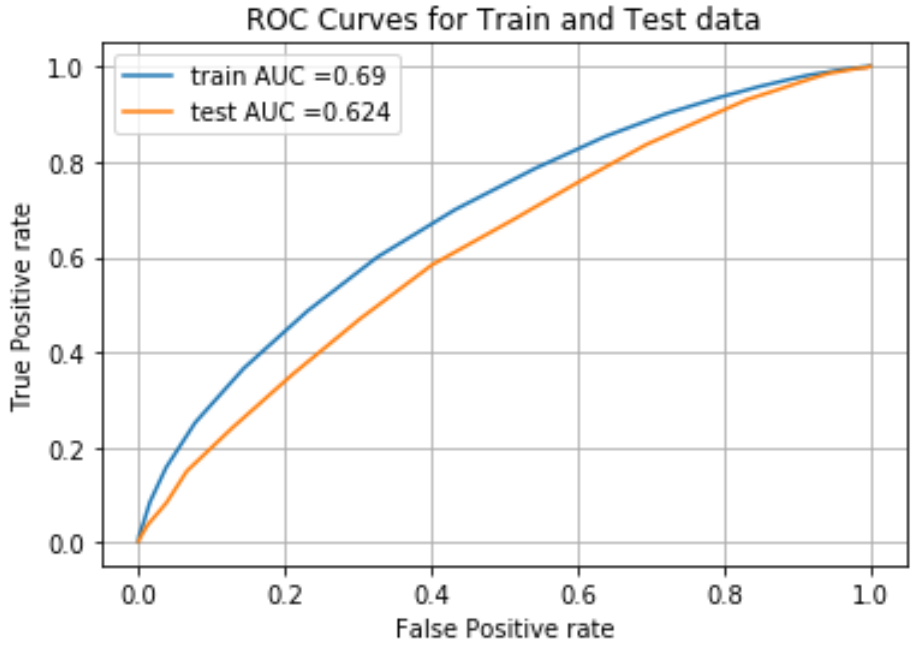
In [125]:
```
K = [1, 5, 10, 15, 21, 31, 41, 51, 59]
auc_vs_K_plot(tfidf_train_kbest, y_train, tfidf_cv_kbest, y_cv, K)
```

```
K = 1 Done!
K = 5 Done!
K = 10 Done!
K = 15 Done!
K = 21 Done!
K = 31 Done!
K = 41 Done!
K = 51 Done!
K = 59 Done!
```

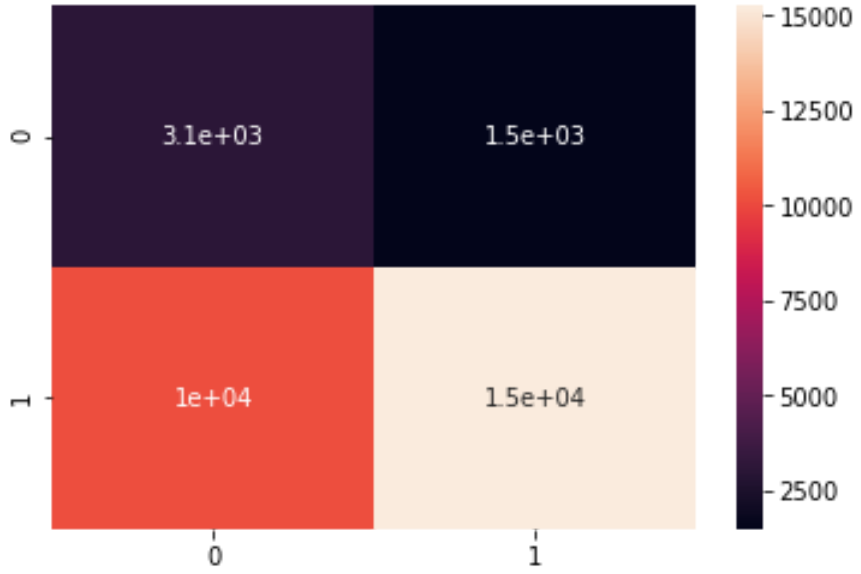


K = 50 or 59 seems good.

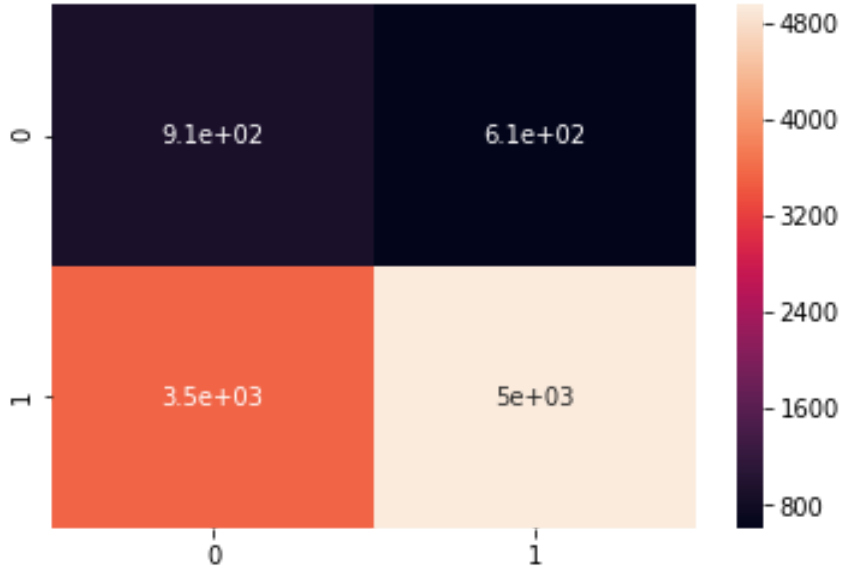
In [126]:
```
ss, Test_AUCs['tfidf_kbest_AUC'] = ROC_conf_mat(tfidf_train_kbest, y_train, tfidf_test_kbes
```



Confusion matrix for Train data with 0.864406779661017 as threshold:



Confusion matrix for Test data with 0.864406779661017 as threshold:



3. Conclusions

In [127]:
```
# Please compare all your models using Prettytable library
```

Here is a table showing all results

In [134]:
```
from prettytable import PrettyTable
table = PrettyTable()
table.field_names = ['Vectorizer', 'Model', 'HyperParameter', 'AUC']
table.add_row(['Bag of Words', 'Brute', '59', Test_AUCs['bow_brute_AUC']])
table.add_row(['TFIDF', 'Brute', '59', Test_AUCs['tfidf_brute_AUC']])
table.add_row(['Average W2V', 'Brute', '50', Test_AUCs['avgw2v_brute_AUC']])
table.add_row(['TFIDF weighted W2V', 'Brute', '50', Test_AUCs['tfidfw2v_brute_AUC']])
table.add_row(['TFIDF', 'Best 2000 cols', '59', Test_AUCs['tfidf_kbest_AUC']])
print(table)
```

```
+--------------------+----------------+----------------+--------------------+
|     Vectorizer     |     Model      | HyperParameter |        AUC         |
+--------------------+----------------+----------------+--------------------+
|    Bag of Words    |     Brute      |       59       | 0.6427887302578225 |
|       TFIDF        |     Brute      |       59       | 0.6028543090019078 |
|    Average W2V     |     Brute      |       50       | 0.6160973645979801 |
| TFIDF weighted W2V |     Brute      |       50       | 0.6209552870431415 |
|       TFIDF        | Best 2000 cols |       59       | 0.6242023683806212 |
+--------------------+----------------+----------------+--------------------+
```

SUMMARY:

- **Here Bag of words seems to be doing better than other models.**
- **TFIDF with less columns (2000 columns) doing better than TFIDF with all columns. So considering less columns might improve some of our results.**

- **And the scores that I got are not satisfactory. The gap in AUC vs K plot seems to be reducing with increase in K and didnt reach its minimum.**
- **To increase performance we may have to take all data points (I only considered 50K points due to time issues).**

In [ ]: