Assignment 6: Apply NB

1. **Apply Multinomial NB on these feature sets**

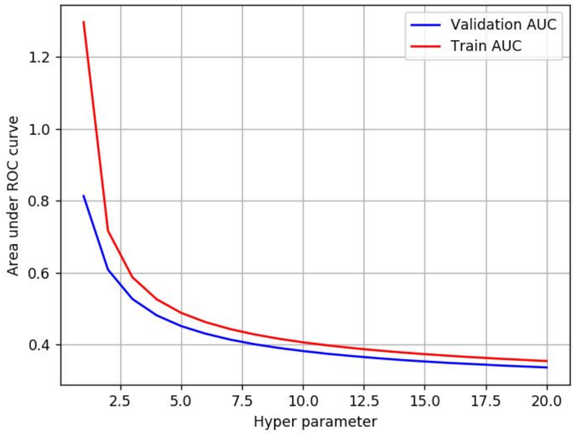
   - Set 1: categorical, numerical features + preprocessed_eassay (BOW)
   - Set 2: categorical, numerical features + preprocessed_eassay (TFIDF)

2. **The hyper paramter tuning(find best alpha:smoothing parameter)**

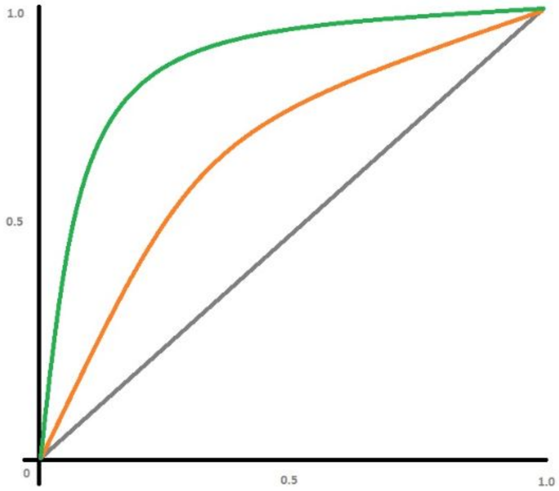
   - Find the best hyper parameter which will give the maximum AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) value
   - find the best hyper paramter using k-fold cross validation(use GridsearchCV or RandomsearchCV)/simple cross validation data (write for loop to iterate over hyper parameter values)
   -

3. **Representation of results**

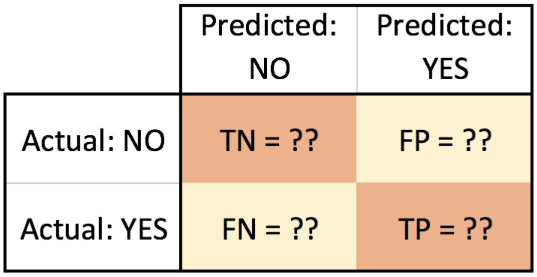
   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure



   - Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.

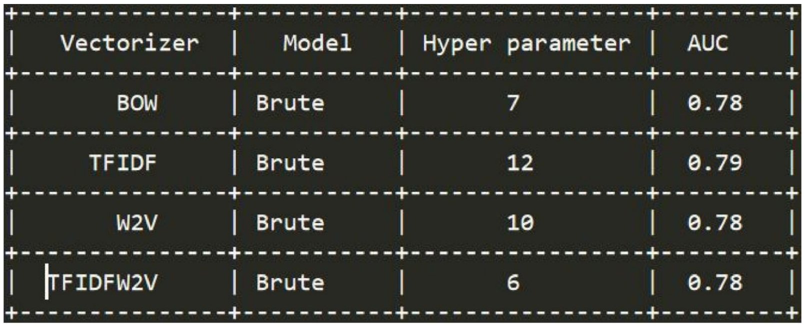


   - Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points



	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

4. fine the top 20 features from either from feature Set 1 or feature Set 2 using absolute values of \`feature_log_prob_ \` parameter of \`MultinomialNB\` (https://scikit-learn.org/stable/modules/generated/sklearn.naive_bayes.MultinomialNB.html) and print their corresponding feature names
5. You need to summarize the results at the end of the notebook, summarize it in the table format



```
+--------------+----------+------------------+---------+
|   Vectorizer  |   Model   | Hyper parameter |   AUC    |
+--------------+----------+------------------+---------+
|      BOW      | Brute     |        7         |  0.78    |
+--------------+----------+------------------+---------+
|     TFIDF     | Brute     |        12        |  0.79    |
+--------------+----------+------------------+---------+
|      W2V      | Brute     |        10        |  0.78    |
+--------------+----------+------------------+---------+
|  TFIDFW2V     | Brute     |        6         |  0.78    |
+--------------+----------+------------------+---------+
```

2. Naive Bayes

1.1 Loading Data

In [1]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import numpy as np
import nltk
import matplotlib.pyplot as plt
import seaborn as sns
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
import pandas
data = pandas.read_csv('preprocessed_data.csv' , nrows = 55000)
```

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

In [2]:

```
y = data['project_is_approved'].values
X = data.drop(['project_is_approved'], axis=1)
X.head(1)
```

Out[2]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	clean_ca
0	ca	mrs	grades_prek_2	53	math

In [3]:

```
# train test
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y
```

In [4]:

```
features_list1 = []
features_list2 = []
```

1.3 Make Data Model Ready: encoding eassay, and project_title

In [5]:

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

print("="*100)
# BOW
vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['essay'].values)

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("After vectorizations")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
print("="*100)
features_list1 = features_list1 + vectorizer.get_feature_names()

#tfidf
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df = 10 , ngram_range = (1,4) , max_features = 5000)
vectorizer.fit(X_train['essay'])
X_train_essay_tfidf = vectorizer.transform(X_train['essay'])
X_cv_essay_tfidf = vectorizer.transform(X_cv['essay'])
X_test_essay_tfidf = vectorizer.transform(X_test['essay'])

features_list2 = features_list2 + vectorizer.get_feature_names()
```

```
(24689, 8) (24689,)
(12161, 8) (12161,)
(18150, 8) (18150,)
========================================================================================
============
After vectorizations
(24689, 5000) (24689,)
(12161, 5000) (12161,)
(18150, 5000) (18150,)
========================================================================================
============
```

1.4 Make Data Model Ready: encoding numerical, categorical features

In [6]:

```
# school_state encoding
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values)


X_train_state_ohe = vectorizer.transform(X_train['school_state'].values)
X_cv_state_ohe = vectorizer.transform(X_cv['school_state'].values)
X_test_state_ohe = vectorizer.transform(X_test['school_state'].values)

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

features_list1 = features_list1 + vectorizer.get_feature_names()
features_list2 = features_list2 + vectorizer.get_feature_names()
```

```
After vectorizations
(24689, 51) (24689,)
(12161, 51) (12161,)
(18150, 51) (18150,)
['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', 't
x', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
========================================================================================
============
```

In [7]:

```
# teacher_prefix encoding
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values)


X_train_teacher_ohe = vectorizer.transform(X_train['teacher_prefix'].values)
X_cv_teacher_ohe = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_teacher_ohe = vectorizer.transform(X_test['teacher_prefix'].values)

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

features_list1 = features_list1 + vectorizer.get_feature_names()
features_list2 = features_list2 + vectorizer.get_feature_names()
```

```
After vectorizations
(24689, 5) (24689,)
(12161, 5) (12161,)
(18150, 5) (18150,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
========================================================================================
============
```

In [8]:

```
# project_grade_category encoding
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values)


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)

features_list1 = features_list1 + vectorizer.get_feature_names()
features_list2 = features_list2 + vectorizer.get_feature_names()
```

```
After vectorizations
(24689, 4) (24689,)
(12161, 4) (12161,)
(18150, 4) (18150,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
========================================================================================
============
```

In [9]:

```
# clean_categories encoding
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values)


X_train_clean_cat = vectorizer.transform(X_train['clean_categories'].values)
X_cv_clean_cat = vectorizer.transform(X_cv['clean_categories'].values)
X_test_clean_cat = vectorizer.transform(X_test['clean_categories'].values)

print("After vectorizations")
print(X_train_clean_cat.shape, y_train.shape)
print(X_cv_clean_cat.shape, y_cv.shape)
print(X_test_clean_cat.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)

features_list1 = features_list1 + vectorizer.get_feature_names()
features_list2 = features_list2 + vectorizer.get_feature_names()
```

```
After vectorizations
(24689, 7) (24689,)
(12161, 7) (12161,)
(18150, 7) (18150,)
['appliedlearning', 'health_sports', 'history_civics', 'literacy_language', 'math_scienc
e', 'music_arts', 'specialneeds']
========================================================================================
============
```

In [10]:
```
# clean_subcategories encoding
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values)

X_train_clean_subcat = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_clean_subcat = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_clean_subcat = vectorizer.transform(X_test['clean_subcategories'].values)

print("After vectorizations")
print(X_train_clean_subcat.shape, y_train.shape)
print(X_cv_clean_subcat.shape, y_cv.shape)
print(X_test_clean_subcat.shape, y_test.shape)
print(vectorizer.get_feature_names())
print("="*100)

features_list1 = features_list1 + vectorizer.get_feature_names()
features_list2 = features_list2 + vectorizer.get_feature_names()
```

```
After vectorizations
(24689, 28) (24689,)
(12161, 28) (12161,)
(18150, 28) (18150,)
['appliedsciences', 'charactereducation', 'civics_government', 'college_careerprep', 'co
mmunityservice', 'earlydevelopment', 'economics', 'environmentalscience', 'esl', 'extrac
urricular', 'financialliteracy', 'foreignlanguages', 'gym_fitness', 'health_lifescienc
e', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'mathemati
cs', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'soc
ialsciences', 'specialneeds', 'teamsports', 'visualarts']
========================================================================================
============
```

In [11]:
```
# for price encoding
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

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

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



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

features_list1 = features_list1 + vectorizer.get_feature_names()
features_list2 = features_list2 + vectorizer.get_feature_names()
```

```
After vectorizations
(24689, 1) (24689,)
(12161, 1) (12161,)
(18150, 1) (18150,)
========================================================================================
============
```

In [12]:

```
 teacher_number_of_previously_posted_projects encoding
sklearn.preprocessing import Normalizer
lizer = Normalizer()

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

in_prev_post_norm = normalizer.transform(X_train['teacher_number_of_previously_posted_project
prev_post_norm = normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].va
t_prev_post_norm = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'



("After vectorizations")
(X_train_prev_post_norm.shape, y_train.shape)
(X_cv_prev_post_norm.shape, y_cv.shape)
(X_test_prev_post_norm.shape, y_test.shape)
("="*100)

res_list1 = features_list1 + vectorizer.get_feature_names()
res_list2 = features_list2 + vectorizer.get_feature_names()
```

```
After vectorizations
(24689, 1) (24689,)
(12161, 1) (12161,)
(18150, 1) (18150,)
==========================================================================================
============
```

In [13]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_bow, X_train_state_ohe, X_train_teacher_ohe, X_train_grade_ohe,
X_cr = hstack((X_cv_essay_bow, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe,X_cv_clean_c
X_te = hstack((X_test_essay_bow, X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe,X_te

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
(24689, 5097) (24689,)
(12161, 5097) (12161,)
(18150, 5097) (18150,)
==========================================================================================
============
```

In [ ]:

1.5 Appling NB on different kind of featurization as mentioned in the instructions

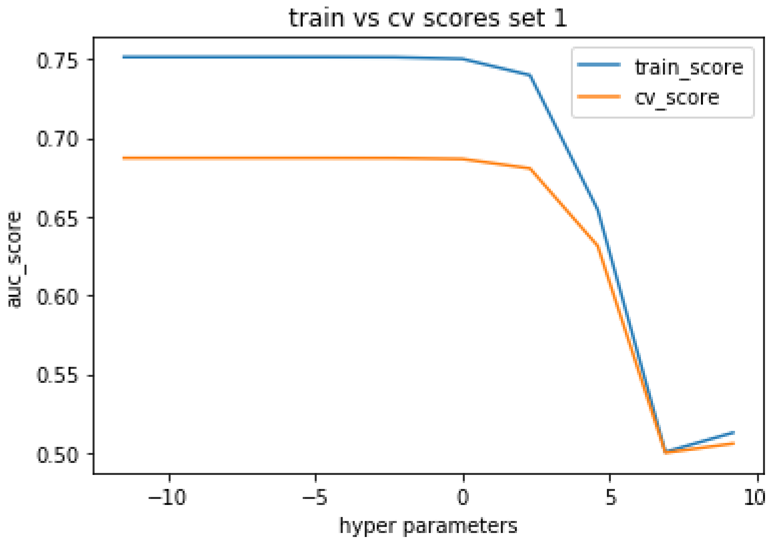
Apply NB on different kind of featurization as mentioned in the instructions

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

In [15]:

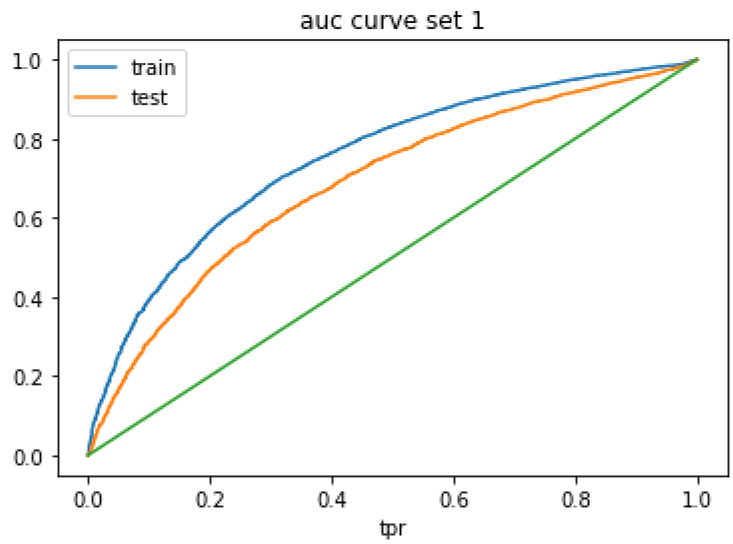
```
import math
from sklearn.naive_bayes import MultinomialNB as mnb
from sklearn.metrics import roc_auc_score
alphas = []
train_scores = []
cv_scores = []
init = [10**i for i in range(-5 , 5 , 1)]
for a in init:
    alphas.append(math.log(a))
    model = mnb(alpha = a,class_prior = [0.5 , 0.5])
    model.fit(X_tr , y_train)
    train_proba = model.predict_proba(X_tr)
    cv_proba = model.predict_proba(X_cr)
    train_score = roc_auc_score(y_train , train_proba[:,1])
    cv_score = roc_auc_score(y_cv,cv_proba[:,1])
    train_scores.append(train_score)
    cv_scores.append(cv_score)

plt.plot(alphas , train_scores , label = 'train_score')
plt.plot(alphas , cv_scores , label = 'cv_score')
plt.title('train vs cv scores set 1')
plt.xlabel('hyper parameters')
plt.ylabel('auc_score')
plt.legend()
plt.show()
```



In [16]:

```
from sklearn import metrics
model = mnb(alpha = 10**-5 , class_prior = [0.5 , 0.5])
model.fit(X_tr , y_train)
proba = model.predict_proba(X_tr)
fpr, tpr, thresholds = metrics.roc_curve(y_train, proba[:,1])
proba = model.predict_proba(X_te)
plt.plot(fpr , tpr , label = 'train')
fpr, tpr, thresholds = metrics.roc_curve(y_test ,proba[:,1])
plt.plot(fpr , tpr , label = 'test')
plt.xlabel('fpr')
plt.xlabel('tpr')
plt.title('auc curve set 1')
plt.plot([0,1],[0,1])
plt.legend()
plt.show()
set1_auc = metrics.auc(fpr , tpr)
```



In [17]:

```
from sklearn.metrics import confusion_matrix
print("Set 1\n",confusion_matrix(y_test, model.predict(X_te)))
```

```
Set 1
 [[ 1724  1177]
 [ 4801 10448]]
```

modelling for set 2

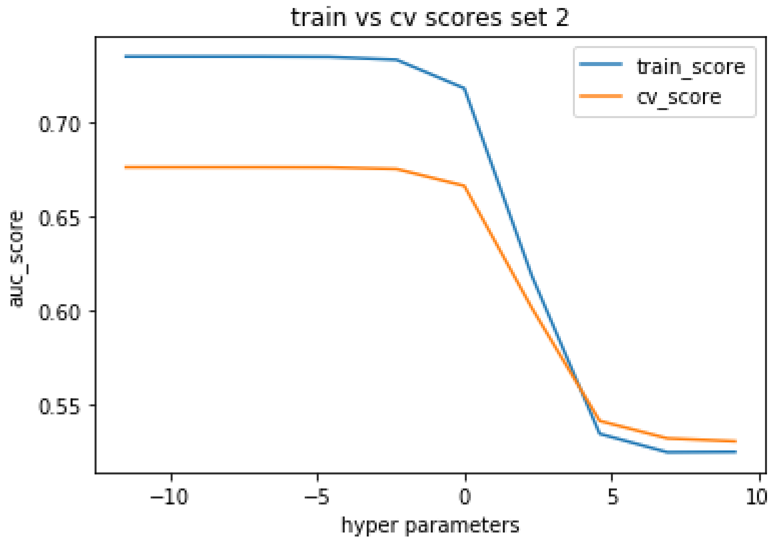
In [18]:

```
X_tr = hstack((X_train_essay_tfidf, X_train_state_ohe, X_train_teacher_ohe, X_train_grade_oh
X_cr = hstack((X_cv_essay_tfidf, X_cv_state_ohe, X_cv_teacher_ohe, X_cv_grade_ohe,X_cv_clean
X_te = hstack((X_test_essay_tfidf, X_test_state_ohe, X_test_teacher_ohe, X_test_grade_ohe,X_
```

In [19]:

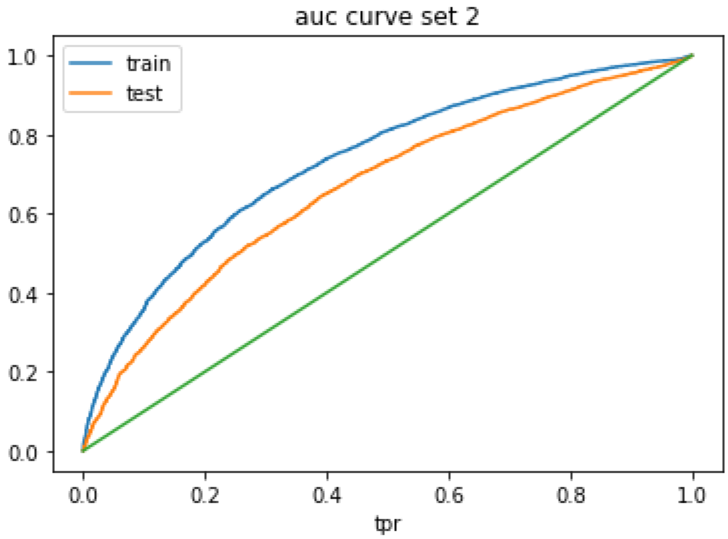
```
from sklearn.naive_bayes import MultinomialNB as mnb
from sklearn.metrics import roc_auc_score
alphas = []
train_scores = []
cv_scores = []
init = [10**i for i in range(-5, 5 , 1)]
for a in init:
    alphas.append(math.log(a))
    model = mnb(alpha = a , class_prior = [0.5 , 0.5])
    model.fit(X_tr , y_train)
    train_proba = model.predict_proba(X_tr)
    cv_proba = model.predict_proba(X_cr)
    train_score = roc_auc_score(y_train , train_proba[:,1])
    cv_score = roc_auc_score(y_cv,cv_proba[:,1])
    train_scores.append(train_score)
    cv_scores.append(cv_score)

plt.plot(alphas , train_scores , label = 'train_score')
plt.plot(alphas , cv_scores , label = 'cv_score')
plt.title('train vs cv scores set 2')
plt.xlabel('hyper parameters')
plt.ylabel('auc_score')
plt.legend()
plt.show()
```



In [20]:

```
from sklearn import metrics
model2 = mnb(alpha = 10**-5 , class_prior = [0.5 , 0.5])
model2.fit(X_tr , y_train)
proba = model2.predict_proba(X_tr)
fpr, tpr, thresholds = metrics.roc_curve(y_train, proba[:,1])
proba = model2.predict_proba(X_te)
plt.plot(fpr , tpr , label = 'train')
fpr, tpr, thresholds = metrics.roc_curve(y_test ,proba[:,1])
plt.plot(fpr , tpr , label = 'test')
plt.xlabel('fpr')
plt.xlabel('tpr')
plt.title('auc curve set 2')
plt.plot([0,1],[0,1])
plt.legend()
plt.show()
set2_auc = metrics.auc(fpr , tpr)
```



In [22]:

```
from sklearn.metrics import confusion_matrix
print("Set 2\n",confusion_matrix(y_test, model.predict(X_te)))
```

```
Set 2
 [[    0  2901]
 [    0 15249]]
```

most important features in the set 1

In [23]:

```
final_list1 = []
indexes = list(np.argsort(abs(model.feature_log_prob_[0])))[::-1]
for i in range(0,20):
    final_list1.append(features_list1[indexes[i]])
```

In [24]:

```
print("for set 1",final_list1)
```

```
for set 1 ['wobble cushions', 'balance ball', 'maps', 'erase boards', 'dry erase board
s', 'books allow', 'dash', 'waste', 'pedometers', 'chairs allow', 'edit', 'subscriptio
n', 'classroom rug', 'chairs help', 'dry erase markers', 'these chairs', 'basketballs',
'the wobble', 'balance balls', 'chromebooks classroom']
```

In [27]:

```
final_list2 = []
indexes = list(np.argsort(abs(model.feature_log_prob_[1])))[::-1]
for i in range(0,20):
    final_list2.append(features_list1[indexes[i]])
```

In [28]:

```
print("for set 1",final_list2)
```

```
for set 1 ['dr', 'wy', 'many raised single parent', 'school day by', 'by creative positi
ve', 'by creative positive way', 'early life', 'by creative', 'inspire even', 'creative
positive way hopeful', 'however certainly control experience', 'lives however certainly
control', 'certainly control experience school', 'us see', 'may prevent', 'earliest lear
ners', 'simple provide students creative', 'however certainly control', 'control experie
nce school', 'control experience school day']
```

3. Summary

as mentioned in the step 5 of instructions

In [30]:

```
#copied from here : https://stackoverflow.com/questions/9535954/printing-lists-as-tabular-da
from prettytable import PrettyTable
t = PrettyTable(['Vectorizer', 'model' , 'hyperparameter' , 'auc'])
t.add_row(['BOW', 'Multinomial NB' , '10^-5' ,  set1_auc])
t.add_row(['TF-IDF', 'Multinomial NB' , '10^-5' , set2_auc ])
print(t)
```

```
+------------+----------------+----------------+--------------------+
| Vectorizer |     model      | hyperparameter |        auc         |
+------------+----------------+----------------+--------------------+
|    BOW     | Multinomial NB |     10^-5      | 0.6880042472707848 |
|   TF-IDF   | Multinomial NB |     10^-5      | 0.667914141961807  |
+------------+----------------+----------------+--------------------+
```

In [31]:

Out[31]:

```
array([[0.00312095],
       [0.02344104],
       [0.00098585],
       ...,
       [0.00125101],
       [0.00106651],
       [0.00067339]])
```

In [ ]: