In [4]:

```
import numpy
from urllib.request import urlopen
import scipy.optimize
import random
import gzip
```

In [5]:

```
from sklearn.linear_model import LinearRegression, LogisticRegression
from sklearn.metrics import mean_squared_error
```

In [64]:

```
from sklearn.metrics import precision_score, confusion_matrix
```

In [77]:

```
import numpy as np
```

In [123]:

```
import matplotlib.pyplot as plt
```

Q2

In [6]:

```
def parseData(fname):
  for l in open(fname):
    yield eval(l)
```

In [7]:

```
print("Reading data...")
# Download from http://cseweb.ucsd.edu/classes/fa19/cse258-a/data/beer_50000.json"
data = list(parseData("fantasy_10000.json"))
print("done")
```

```
Reading data...
done
```

In [8]:

```
def feature(datum):
    return [1, datum]
```

In [9]:

```
X = [feature(len(d['review_text'])) for d in data]
y = [d['rating'] for d in data]
```

In [10]:

```
model = LinearRegression(fit_intercept=False)
model.fit(X,y)
theta = model.coef_
```

In [11]:

```
theta
```

Out[11]:

```
array([3.68568136e+00, 6.87371675e-05])
```

In [12]:

```
y_pred = model.predict(X)
```

In [13]:

```
mean_squared_error(y, y_pred)
```

Out[13]:

```
1.5522086622355378
```

Answer:

In [11]:

```
theta
```

Out[11]:

```
array([3.68568136e+00, 6.87371675e-05])
```

In [13]:

```
mean_squared_error(y, y_pred)
```

Out[13]:

```
1.5522086622355378
```

Q3

In [14]:

```
import dateutil.parser
```

In [15]:

```
t = [dateutil.parser.parse(d['date_added']) for d in data]
```

In [16]:

```
t_weekdays = [[day.weekday()] for day in t]
```

In [17]:

```
t_years = [[day.year] for day in t]
```

In [18]:

```
from sklearn.preprocessing import OneHotEncoder
```

In [19]:

```
enc = OneHotEncoder(drop='first', handle_unknown='error')
```

In [20]:

```
weekdays_onehot = enc.fit_transform(t_weekdays)
```

In [21]:

```
years_onehot = enc.fit_transform(t_years)
```

In [22]:

```
onehot_weekday_array = weekdays_onehot.toarray()
```

In [23]:

```
onehot_weekday_array
```

Out[23]:

```
array([[0., 0., 0., 0., 0., 1.],
       [0., 1., 0., 0., 0., 0.],
       [0., 0., 0., 0., 1., 0.],
       ...,
       [0., 0., 0., 0., 0., 1.],
       [0., 0., 0., 0., 0., 0.],
       [1., 0., 0., 0., 0., 0.]])
```

In [24]:

```
onehot_yearly_array = years_onehot.toarray()
```

In [25]:

```
onehot_yearly_array
```

Out[25]:

```
array([[0., 0., 0., ..., 0., 0., 1.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 1., 0.],
       [0., 0., 0., ..., 0., 1., 0.],
       [0., 0., 0., ..., 1., 0., 0.]])
```

In [26]:

```
onehot_yearly_array[0]
```

Out[26]:

```
array([0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1.])
```

Answer:

In [156]:

```
onehot_weekday_array[0:2]
```

Out[156]:

```
array([[0., 0., 0., 0., 0., 1.],
       [0., 1., 0., 0., 0., 0.]])
```

In [157]:

```
onehot_yearly_array[0:2]
```

Out[157]:

```
array([[0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1.],
       [0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0.]])
```

In [159]:

```
X2[:2] # Full feature vector for first two examples
```

Out[159]:

```
[[1,
  2086,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  1.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  1.0],
 [1,
  1521,
  0.0,
  1.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  0.0,
  1.0,
  0.0,
  0.0,
  0.0]]
```

Q4

a)

In [27]:

```
data2 = []
```

In [28]:

```
review_lens = [len(d['review_text']) for d in data]
```

In [29]:

```
for review_len, t_weekday in zip(review_lens, t_weekdays):
    data2.append([review_len, t_weekday[0]])
```

In [30]:

```
for datum, t_year in zip(data2, t_years):
    datum.append(t_year[0])
```

In [31]:

```
def feature(datum):
    feat = [1]
    feat.extend(datum)
    return feat
```

In [32]:

```
X = [feature(datum) for datum in data2]
```

In [33]:

```
X1 = X
```

In [34]:

```
model = LinearRegression(fit_intercept=False)
model.fit(X,y)
theta = model.coef_
```

Answer:

In [35]:

```
mean_squared_error(y, model.predict(X))
```

Out[35]:

```
1.5367740498705234
```

b)

In [36]:

```
data3 = []
```

In [37]:

```
for review_len, onehot_weekday in zip(review_lens, onehot_weekday_array):
    temp = []
    temp.append(review_len)
    temp.extend(onehot_weekday)
    data3.append(temp)
```

In [38]:

```
for datum, onehot_year in zip(data3, onehot_yearly_array):
    datum.extend(onehot_year)
```

In [39]:

```
def feature(datum):
    feat = [1]
    feat.extend(datum)
    return feat
```

In [40]:

```
X = [feature(datum) for datum in data3]
```

In [41]:

```
X2 = X
```

In [42]:

```
model = LinearRegression(fit_intercept=False)
model.fit(X,y)
theta = model.coef_
```

In [43]:

```
theta
```

Out[43]:

```
array([ 4.87171479e+00,  5.15709386e-05,  4.89003441e-02,  1.45709798e-01,
        1.06646403e-01,  1.26168316e-01,  3.83417660e-02,  1.02846903e-01,
       -1.58244783e+00, -1.70447417e+00, -1.68316056e+00, -1.67023905e+00,
       -1.62877001e+00, -1.19956705e+00, -1.10444816e+00, -1.09162361e+00,
       -1.20861354e+00, -1.23647487e+00, -1.23331225e+00])
```

Answer:

In [44]:

```
mean_squared_error(y, model.predict(X))
```

Out[44]:

```
1.5123578656428203
```

Q5

a)

In [45]:

```
from sklearn.model_selection import train_test_split
```

In [46]:

```
X_train, X_test, y_train, y_test = train_test_split(X1, y, test_size=0.5, shuffle=True)
```

In [47]:

```
model = LinearRegression(fit_intercept=False)
model.fit(X_train, y_train)
theta = model.coef_
```

In [48]:

```
theta
```

Out[48]:

```
array([-8.53882772e+01,  7.16727621e-05,  9.71171951e-03,  4.42333217e-02])
```

Answer:

In [49]:

```
mean_squared_error(y_test, model.predict(X_test))
```

Out[49]:

```
1.5784109399911184
```

b)

In [50]:

```
X_train, X_test, y_train, y_test = train_test_split(X2, y, test_size=0.5, shuffle=True)
```

In [51]:

```
model = LinearRegression(fit_intercept=False)
model.fit(X_train, y_train)
theta = model.coef_
```

In [52]:

```
theta
```

Out[52]:

```
array([ 4.81474119e+00,  5.82654237e-05,  9.55688967e-02,  1.08274374e-01,
        5.06383234e-02,  1.22931743e-01, -8.61136083e-03,  1.49163465e-01,
       -1.55186154e+00, -1.66152876e+00, -1.65138393e+00, -1.64772306e+00,
       -1.59665629e+00, -1.19758078e+00, -1.01320763e+00, -1.02878821e+00,
       -1.15905286e+00, -1.13496256e+00, -1.18968329e+00])
```

Answer:

In [53]:

```
mean_squared_error(y_test, model.predict(X_test))
```

Out[53]:

```
1.5325127320010243
```

Q7

In [85]:

```
print("Reading data...")
# Download from http://cseweb.ucsd.edu/classes/fa19/cse258-a/data/beer_50000.json"
data = list(parseData("beer_50000.json"))
print("done")
```

```
Reading data...
done
```

In [86]:

```
y = [d['review/overall'] >= 4 for d in data]
```

In [108]:

```
X = [[1, len(d['review/text'])] for d in data]
```

In [210]:

```
model = LogisticRegression(class_weight='balanced')
model.fit(X,y)
y_pred = model.predict(X)
correct = y_pred == y
```

In [211]:

```
TN, FP, FN, TP = confusion_matrix(y, y_pred).ravel()
```

In [212]:

```
ber = 1 - 0.5 * (TP / (TP + FN) + TN / (TN + FP))
```

Answer:

In [213]:

```
TN, FP, FN, TP
```

Out[213]:

```
(10503, 5885, 19411, 14201)
```

In [214]:

```
ber # balanced error rate
```

Out[214]:

```
0.4683031525957275
```

Q8

In [187]:

```
confidences = model.decision_function(X)
sortedByConfidence = list(zip(confidences ,y))
sortedByConfidence.sort(reverse=True)
```

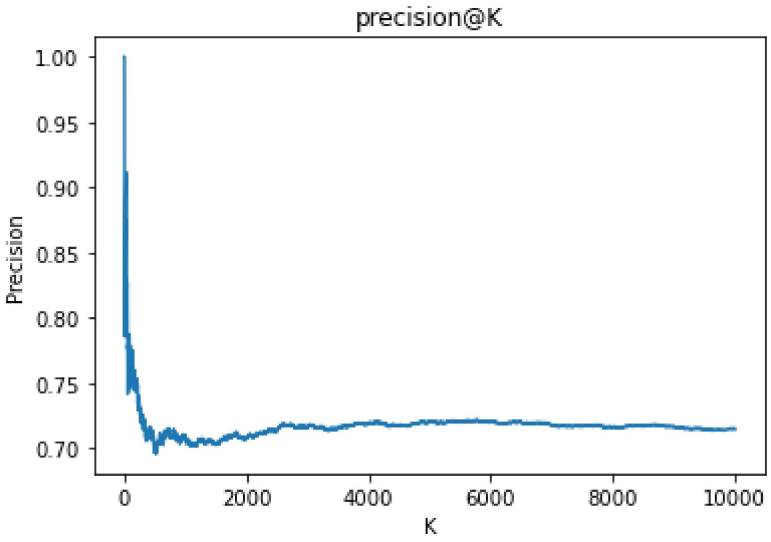
In [188]:

```
precisions_at_k = []
for i in range(1, 10001):
    precisions_at_k.append((sum([datum[1] for datum in sortedByConfidence[:i]]) / i))
```

Answer:

In [189]:

```
plt.plot([i for i in range(1, 10001)], precisions_at_k)
plt.title('precision@K')
plt.xlabel('K')
plt.ylabel('Precision')
plt.show()
```



Q9

In [378]:

```
probs = model.predict_proba(X)
sortedProbs = list(zip(probs ,y))
```

In [379]:

```
sortedProbs = [(abs(datum[0][1] - 0.5), not datum[1])
               if datum[0][1] < 0.5
               else (abs(datum[0][1] - 0.5), datum[1])
               for datum in sortedProbs]
sortedProbs.sort(reverse=True)
```

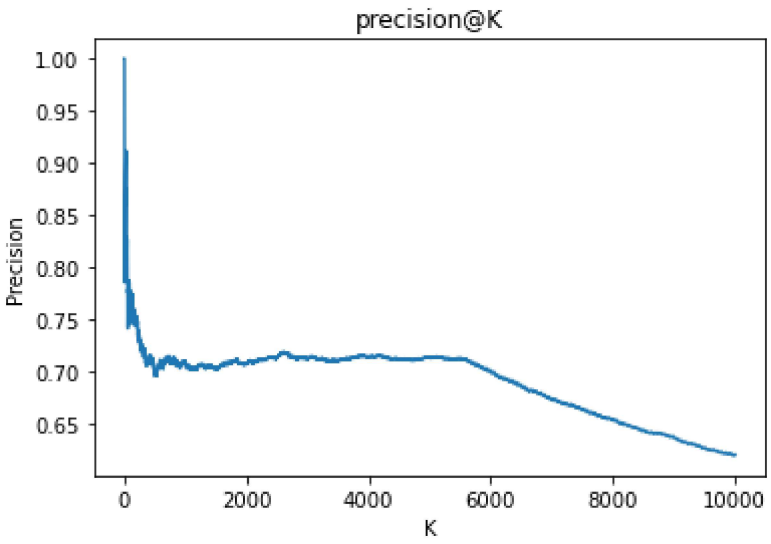
In [380]:

```
precisions_at_k = []
for i in range(1, 10001):
    precisions_at_k.append((sum([datum[1] for datum in sortedProbs[:i]]) / i))
```

Answer:

In [381]:

```
plt.plot([i for i in range(1, 10001)], precisions_at_k)
plt.title('precision@K')
plt.xlabel('K')
plt.ylabel('Precision')
plt.show()
```



In [382]:

```
precisions_at_k[0]
```

Out[382]:

```
1.0
```

In [383]:

```
precisions_at_k[99]
```

Out[383]:

```
0.75
```

In [384]:

```
precisions_at_k[10000 - 1]
```

Out[384]:

```
0.6208
```

Q6

$$y = \theta_0$$

$$MAE(y, \theta_0) = \frac{1}{N} \sum_i^N |y - \theta_0|$$

$$\Rightarrow \frac{\partial MAE(y, \theta_0)}{\partial \theta_0} = \frac{1}{N} \sum_i^N \frac{\partial |y - \theta_0|}{\partial \theta_0}$$

$$\because \frac{d|x|}{dx} = sign(x)$$

$$\Rightarrow \frac{\partial MAE}{\partial \theta_0} = \frac{1}{N} \sum_i^N sign(y - \theta_0)$$

$\Rightarrow$ to find the min $\Rightarrow \frac{\partial MAE}{\partial \theta_0} = 0$

$$\Rightarrow \sum_i^N sign(y - \theta_0) = 0$$

This is equal to zero only when the number of positive items equal the number of negative, which happens when

$$\theta_0 = \text{median}\{y_1, y_2 \dots y_N\}$$