In [2]:
```
##################################################
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## Status: Done
##################################################
```

In [218]:
```
import numpy as np
import pandas as pd
import copy
import matplotlib.pyplot as plt
```

1.9 (a)

Download the file hw1 word counts 05.txt that appears with the homework assignment.

The file contains a list of 5-letter words (including names and proper nouns) and their counts from a large corpus of Wall Street Journal articles (roughly three million sentences).

From the counts in this file compute the prior probability P(w) = COUNT(w)/□w′ COUNT(w′). As a sanity check, print out the fifteen most frequent 5-letter words, as well as the fourteen least frequent 5-letter words. Do your results make sense_

In [303]:
```
data_path = "./data/hw1_word_counts_05_cse250a_fall_2019.txt" # file pat
h in homework folder
data = pd.read_csv(data_path, sep = " ", header = None)
print(data.shape)
```

```
(6535, 2)
```

In [304]:
```
data.columns = ["word", "word_count"]
data.head(5)
```

Out[304]:

	word	word_count
0	AARON	413
1	ABABA	199
2	ABACK	64
3	ABATE	69
4	ABBAS	290

In [305]:
```
print(f'number of nans in give data : {data["word_count"].isna().sum()}'
)
```

```
number of nans in give data : 0
```

Thus, we can go ahead without working on imputation/filling missed values

In [306]:

```
# making sure all letters are upper case two avoid confusion with uppper and lower case words
data["word"] = data["word"].str.upper()
```

In [307]:

```
print(f'number of unique words : {data["word"].nunique()}, number of words : {data.shape[0]}')
```

```
number of unique words : 6535, number of words : 6535
```

Observe that, number of unique words and number of words are same, hence we dont need to do any aggregation, we proceed forward

In [308]:

```
data["word_count"].describe()
```

Out[308]:

```
count       6535.000000
mean        1172.893191
std         7707.131636
min            6.000000
25%           24.000000
50%           61.000000
75%          256.000000
max       273077.000000
Name: word_count, dtype: float64
```

Note that, word cound minimum value is 6, thus, we are considering only values

In [309]:

```
# Calculating prior probability
data["prior_probability"] = data["word_count"]/float(data["word_count"].sum())
data.head(5)
```

Out[309]:

	word	word_count	prior_probability
0	AARON	413	0.000054
1	ABABA	199	0.000026
2	ABACK	64	0.000008
3	ABATE	69	0.000009
4	ABBAS	290	0.000038

In [310]:

```
# Sanity checks to see if the data makes sense
sorted_data = data.sort_values(by = ["word_count"], ascending=False)
sorted_data.head(15)
```

Out[310]:

	word	word_count	prior_probability
5821	THREE	273077	0.035627
5102	SEVEN	178842	0.023333
1684	EIGHT	165764	0.021626
6403	WOULD	159875	0.020858
18	ABOUT	157448	0.020542
5804	THEIR	145434	0.018974
6320	WHICH	142146	0.018545
73	AFTER	110102	0.014365
1975	FIRST	109957	0.014346
1947	FIFTY	106869	0.013943
4158	OTHER	106052	0.013836
2073	FORTY	94951	0.012388
6457	YEARS	88900	0.011598
5806	THERE	86502	0.011286
5250	SIXTY	73086	0.009535

Observe that, most frquent 5 letter words in Wall Street journal are numbers and prepostions which makes sense

In [311]:
```
sorted_data.tail(15)
```

Out[311]:

	word	word_count	prior_probability
4622	RALEY	8	1.043725e-06
5093	SERNA	7	9.132590e-07
5872	TOCOR	7	9.132590e-07
3978	NIAID	7	9.132590e-07
1842	FABRI	7	9.132590e-07
4266	PAXON	7	9.132590e-07
2041	FOAMY	7	9.132590e-07
6443	YALOM	7	9.132590e-07
977	CCAIR	7	9.132590e-07
1107	CLEFT	7	9.132590e-07
3554	MAPCO	6	7.827935e-07
895	CAIXA	6	7.827935e-07
4160	OTTIS	6	7.827935e-07
5985	TROUP	6	7.827935e-07
712	BOSAK	6	7.827935e-07

Observe that, least frquent 5 letter words in Wall Street journal are colloquially/formally very sparingly used words. Note that order of words may be different across different runs as they all have same frequence and hence same probabilituy

1.9 (b)

Consider the following stages of the game.

For each of the following, indicate the best next guess— namely, the letter l that is most likely (probable) to be among the missing letters.

Also report the probability P (Li = l for some i ∈ {1, 2, 3, 4, 5}|E) for your guess l. Your answers should fill in the last two columns of this table. (Some answers are shown so that you can check your work.)

In [312]:
```
incorrectly_guessed = ['A', 'E', 'I', 'O', 'S']
correctly_guessed = ['_','U','_','_','_']
word_length = 5

#Fiding best guess for next letter
```

In [316]:

```
def get_condition_set(correctly_guessed, incorrectly_guessed =[]):
    letters = [i for i in correctly_guessed if i != '_']
    if letters:
        return incorrectly_guessed + list(set([i for i in correctly_guessed if i != '_']))
    else :
        return incorrectly_guessed


# function testing
print(get_condition_set(correctly_guessed,incorrectly_guessed) == ['A', 'E', 'I', 'O', 'S', 'U'])
```

```
True
```

In [317]:

```
def get_word_pattern(correctly_guessed=['_' for i in range(word_length)]):
    return [i for i in zip(range(word_length), correctly_guessed,) if i[1] != '_']

# function testing
print( get_word_pattern(correctly_guessed) == [(1, 'U')])
```

```
True
```

In [318]:

```
def get_pattern_check(word, word_pattern):
    for (index,letter) in word_pattern :
        if (word[index] != letter):
            return False
    return True

# function testing
print(get_pattern_check("MUTRK", get_word_pattern(correctly_guessed)) == True)
print(get_pattern_check("MVTRK", get_word_pattern(correctly_guessed)) == False)
```

```
True
True
```

In [325]:

```
def get_count_list(letter, letter_arr):
    return sum([1 for i in letter_arr if i == letter])

# function testing
get_count_list('U',['_','U','_','_','_']) == 1
```

Out[325]:

```
True
```

In [348]:

```
def does_word_satisfy_condition(word, correctly_guessed, incorrectly_guessed =[]):
    word_pattern = get_word_pattern(correctly_guessed)

    # checking if word has condition set of letters which are already guessed incorrectly
    for i in incorrectly_guessed:
         if (i in word):
                return False

    correctly_guessed_letters = [ j for j in correctly_guessed if j != '_']
    correct_letters_count_arr =list(zip(correctly_guessed_letters,
        [get_count_list(i, correctly_guessed_letters) for i in correctly_guessed_letters]))

    if get_pattern_check(word,word_pattern):
        #print(correct_letters_count_arr)
        for (i,j) in correct_letters_count_arr:
            #print(get_count_list(i, word))
            if get_count_list(i, word) != j:
                return False
        return True

    else :
        return False



    # onece we know, condition set is not present in word, we will now check if we have same patter or not
    return  get_pattern_check(word,word_pattern)

# function testing
print(does_word_satisfy_condition("MUTRK",correctly_guessed,incorrectly_guessed) == True)
print(does_word_satisfy_condition("MUTUK",correctly_guessed,incorrectly_guessed) == False)
print(does_word_satisfy_condition("MVTRK",correctly_guessed,incorrectly_guessed) == False)
```

```
True
True
True
```

In [349]:

```
## Function to get all the required words satifying given condition
def req_set_words(df,
                  correctly_guessed = ["_" for i in range(word_length)],
                  incorrectly_guessed =[]):

    raw_data = copy.deepcopy(df)
    req_data = raw_data[raw_data["word"].map(lambda x :
            does_word_satisfy_condition(x,correctly_guessed,
                                        incorrectly_guessed))].copy()
    return req_data
```

In [ ]:

```
```

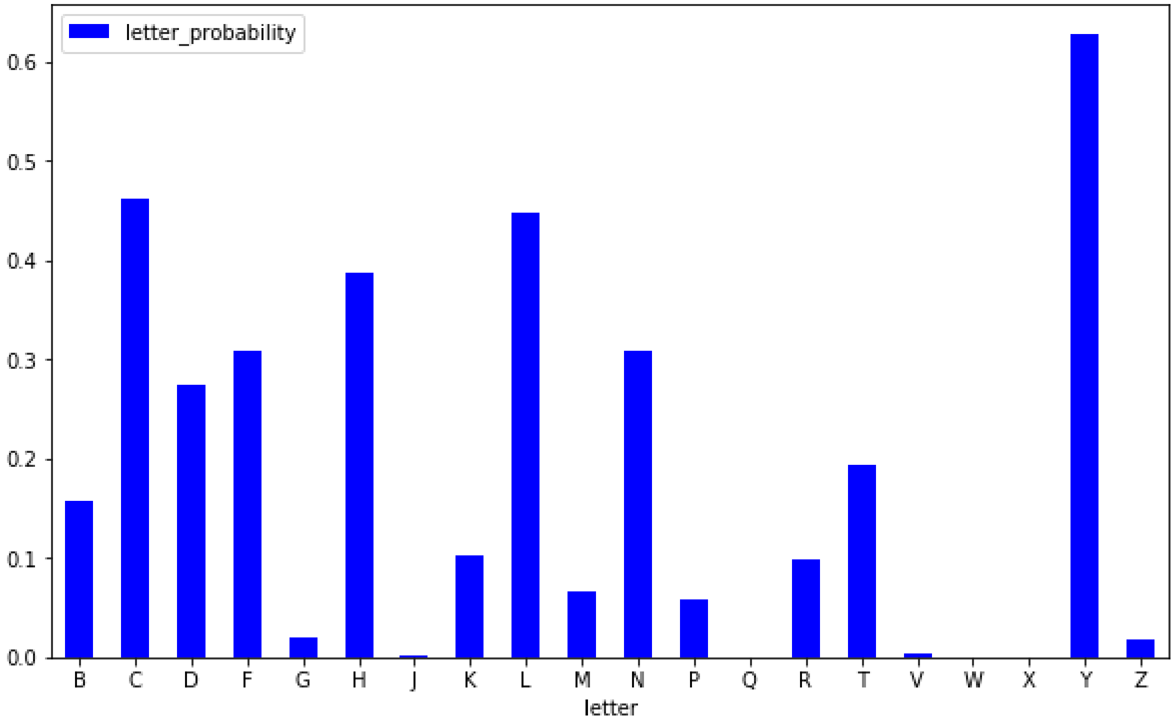
In [387]:

```
# For each letter finding how many words contain that letter and
#its probability to be present in word satisfying given condition

def letter_presence_counts(df, remaining_letters):
    raw_data = copy.deepcopy(df)
    for letter in remaining_letters :
        raw_data[letter] = raw_data["word_count"]*raw_data["word"].map(
            lambda x : 1 if (letter in x) else 0)

    req_total_word_count = raw_data["word_count"].sum()
    #print(raw_data.head(5))

    #print(f'\ntotal number of occurrences words : {req_total_word_count}')

    req_data3 = raw_data.copy().iloc[:,3:].sum().reset_index()
    req_data3.columns = ["letter", "count_occurrence"]
    req_data3["letter_probability"] = req_data3["count_occurrence"]/req_total_word_count
    #print("\nletters, number of occurrences and their probabilities :")
    #print(req_data3.sort_values("count_occurrence", ascending = False).head(5))

    req_data3.plot.bar(x='letter', y='letter_probability', rot=0, color = 'b', figsize=(10,6))
    plt.show()

    return req_data3[['letter','letter_probability']].loc[req_data3["letter_probability"].idxmax()]
```

In [390]:

```python
def get_best_guess(df,
                   correctly_guessed = ["_" for i in range(word_length)],
                   incorrectly_guessed =[]):
    print(f'correctly_guessed = {correctly_guessed}')
    print(f'incorrectly_guessed = {incorrectly_guessed}')
    raw_data = copy.deepcopy(df)
    req_data = req_set_words(raw_data, correctly_guessed, incorrectly_guessed)
    #print(f"words satisfying given condition : {req_data.shape[0]}")
    #print(f'total number of occurrences words : {req_data["word_count"].sum()}')
    #print(f'\nsample dataframe with words satisfying condition :')
    #print(req_data.head(5))

    alphabet = "ABCDEFGHIJKLMNOPQRSTUVWXYZ"
    condition_set = get_condition_set(correctly_guessed,incorrectly_guessed)
    #print( f'\nletters that need not be used further : {condition_set}')
    remaining_letters = [i for i in alphabet if i not in condition_set]
    #print( f'\nletters that can be used further : {remaining_letters}')

    ltr_prob_dict = dict(letter_presence_counts(req_data, remaining_letters))
    ltr_prob_dict["letter_probability"] = round(ltr_prob_dict["letter_probability"], 4)

    return ltr_prob_dict

incorrectly_guessed = ['A', 'E', 'I', 'O', 'S']
correctly_guessed = ['_','U','_','_','_']

# function test

print(get_best_guess(data, correctly_guessed, incorrectly_guessed) == {'letter': 'Y', 'letter_probability': 0.6270})
```

```
correctly_guessed = ['_', 'U', '_', '_', '_']
incorrectly_guessed = ['A', 'E', 'I', 'O', 'S']
```

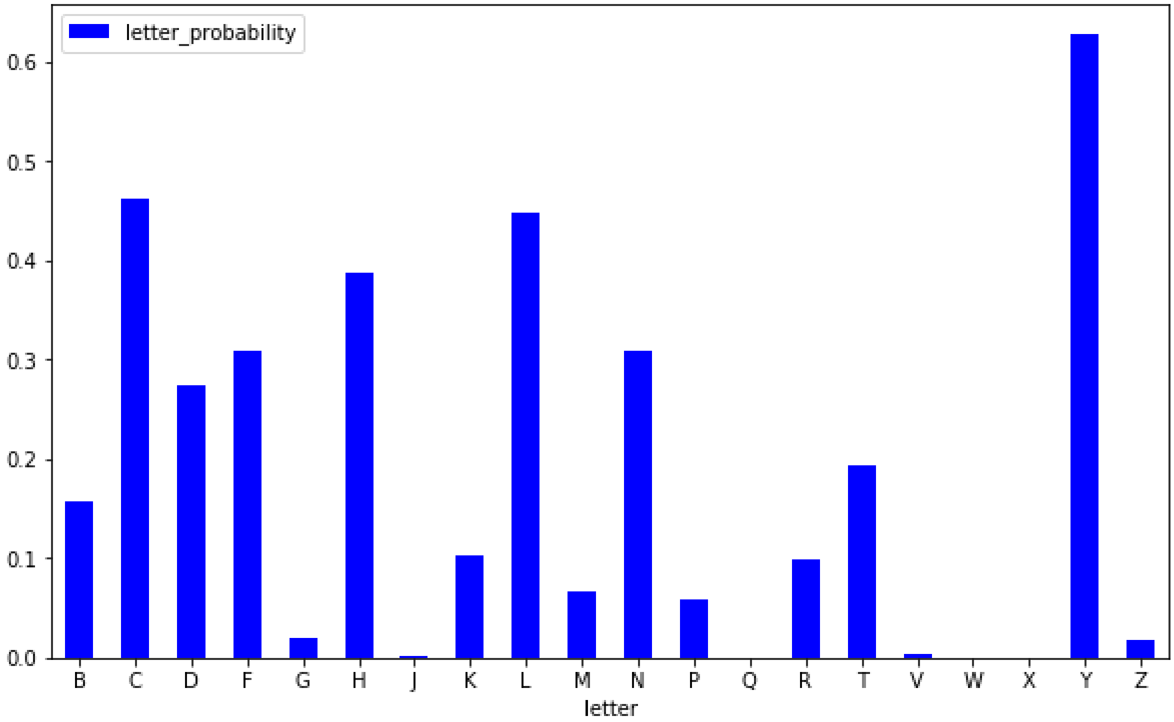


```
True
```

In [392]:

```
incorrectly_guessed = ['A', 'E', 'I', 'O', 'S']
correctly_guessed = ['_','U','_','_','_']
get_best_guess(data, correctly_guessed, incorrectly_guessed)
```

```
correctly_guessed = ['_', 'U', '_', '_', '_']
incorrectly_guessed = ['A', 'E', 'I', 'O', 'S']
```



Out[392]:

```
{'letter': 'Y', 'letter_probability': 0.627}
```

In [393]:

```
correctly_guessed_list = [["_","_","_","_","_"],["_","_","_","_","_"],
                    ["A","_","_","_","S"], ["A","_","_","_","S"],
                    ["_","_","O","_","_"], ["_","_","_","_","_"],
                       ["D","_","_","I","_"], ["D","_","_","I","_"],
                      ["_","U","_","_","_"]]

incorrectly_guessed_list = [[],['E','A'],[],['I'],['A','E','M','N','T'],
                     ['E','O'],[],['A'],['A','E','I','O','S']]
```

In [394]:

```
#hw_df = pd.DataFrame({'correctly_guessed' : correctly_guessed_list, 'in
correctly_guessed': incorrectly_guessed_list})
```

In [395]:

```
#hw_df[['correctly_guessed','incorrectly_guessed']].apply(
 #   lambda x :(get_best_guess(data, x[0], x[1])))#
```

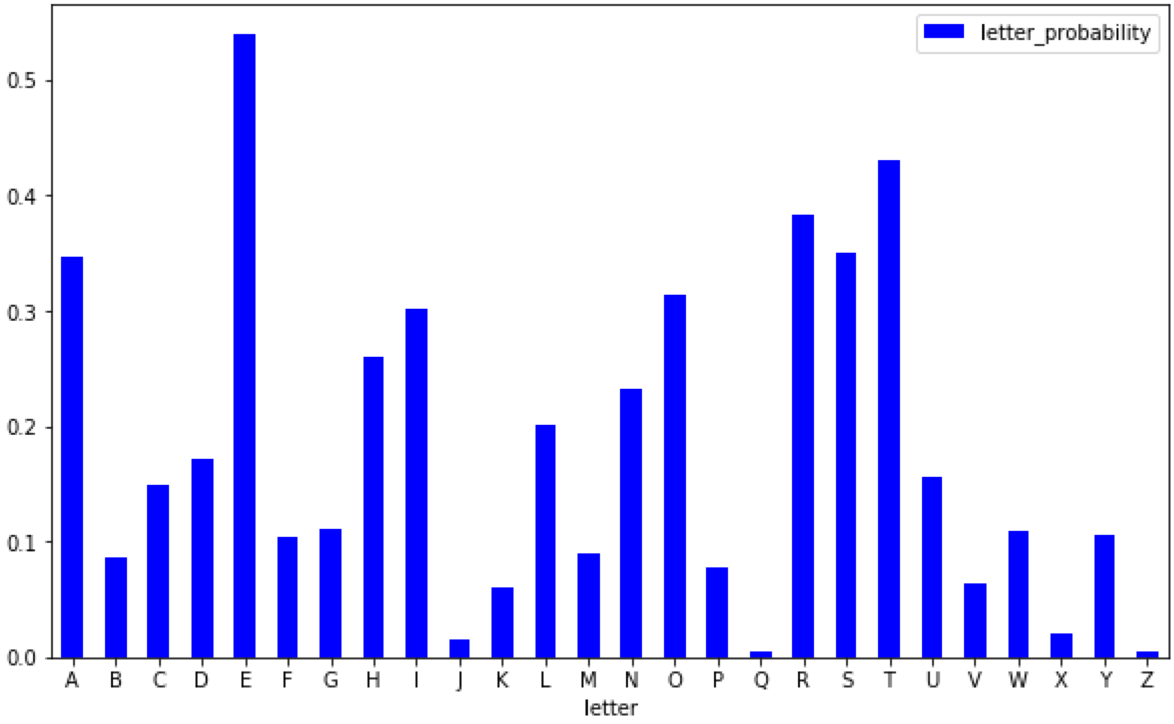
In [396]:

```
#hw_df
```

In [399]:

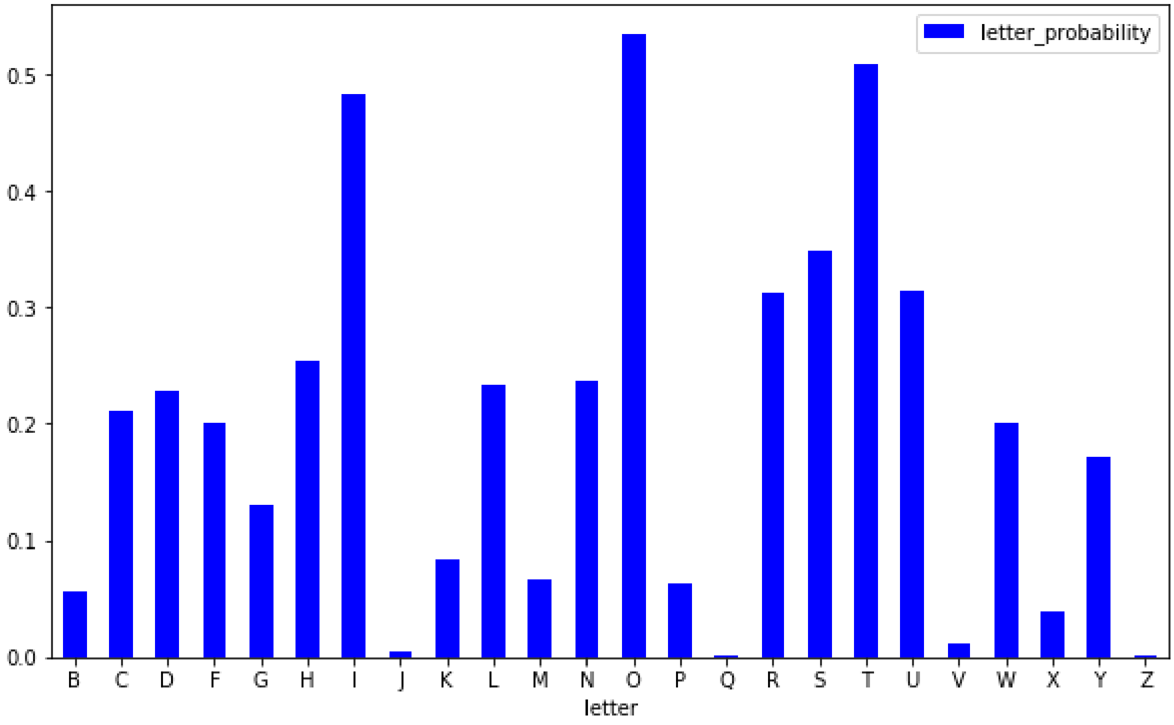
```
ans_list = []
for W,E in zip(correctly_guessed_list, incorrectly_guessed_list):
    ans = get_best_guess(data, W, E)
    print(ans)
    print('\n\n')
    ans_list.append([W,E, ans])
```

```
correctly_guessed = ['_', '_', '_', '_', '_']
incorrectly_guessed = []
```



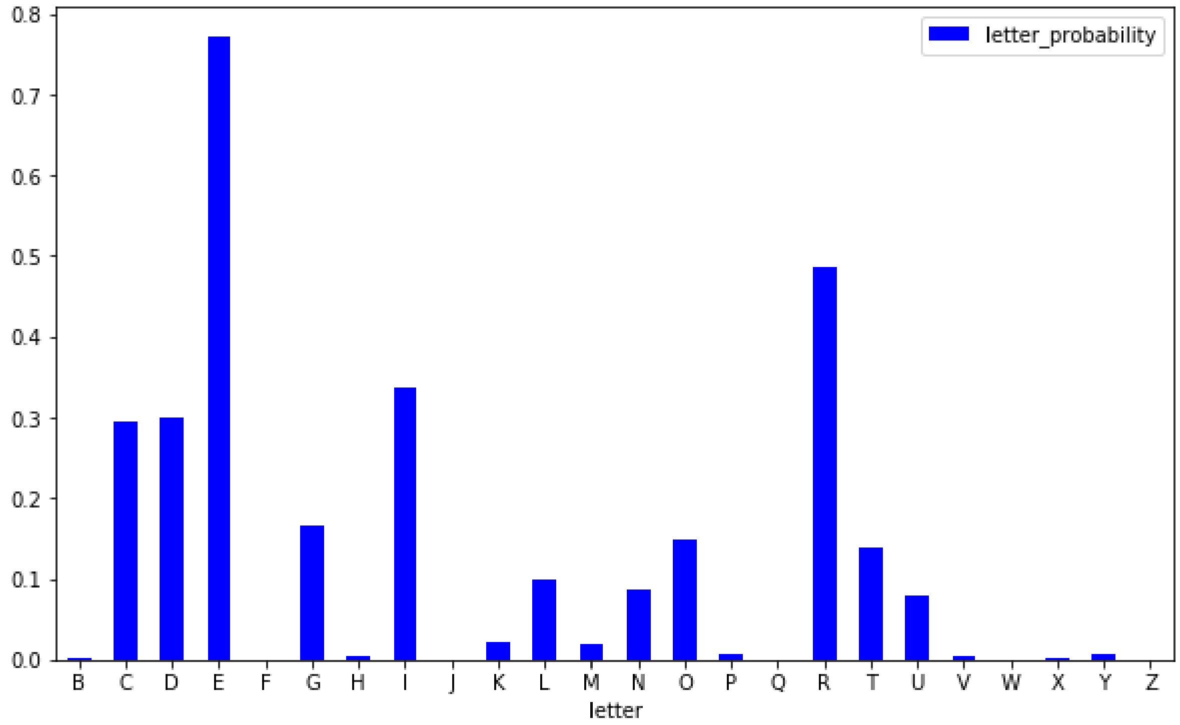
```
{'letter': 'E', 'letter_probability': 0.5394}
```

```
correctly_guessed = ['_', '_', '_', '_', '_']
incorrectly_guessed = ['E', 'A']
```



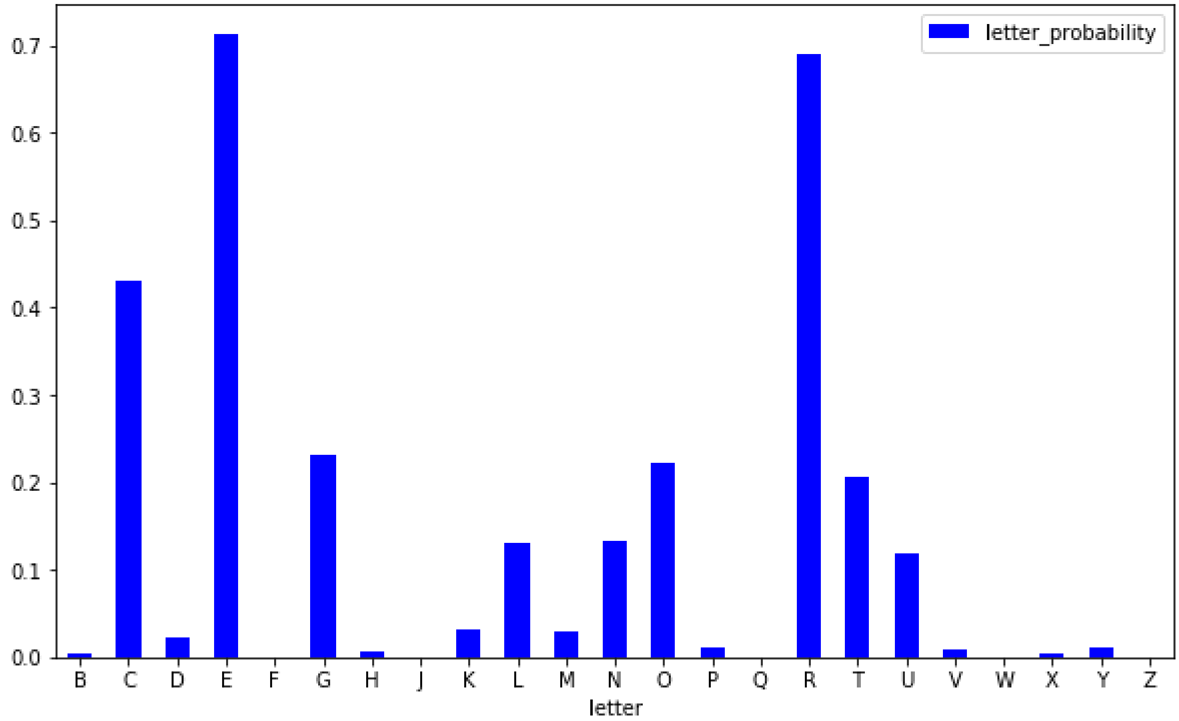
```
{'letter': 'O', 'letter_probability': 0.534}
```

```
correctly_guessed = ['A', '_', '_', '_', 'S']
incorrectly_guessed = []
```



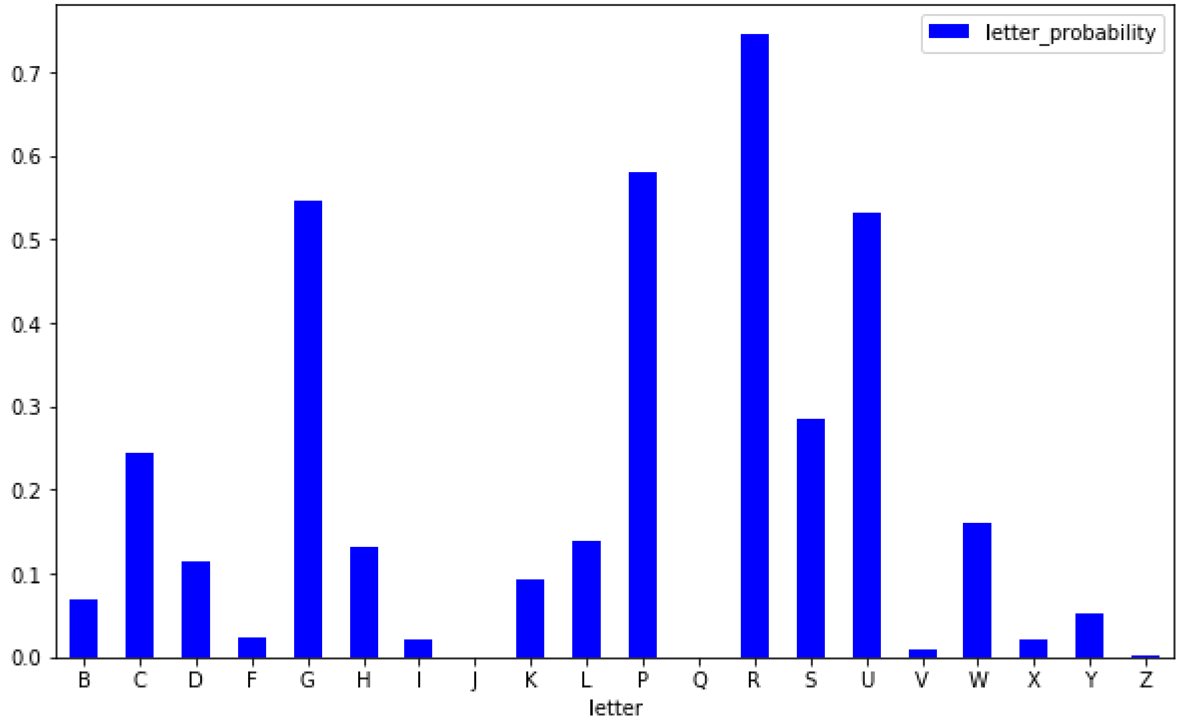
```
{'letter': 'E', 'letter_probability': 0.7715}
```

```
correctly_guessed = ['A', '_', '_', '_', 'S']
incorrectly_guessed = ['I']
```



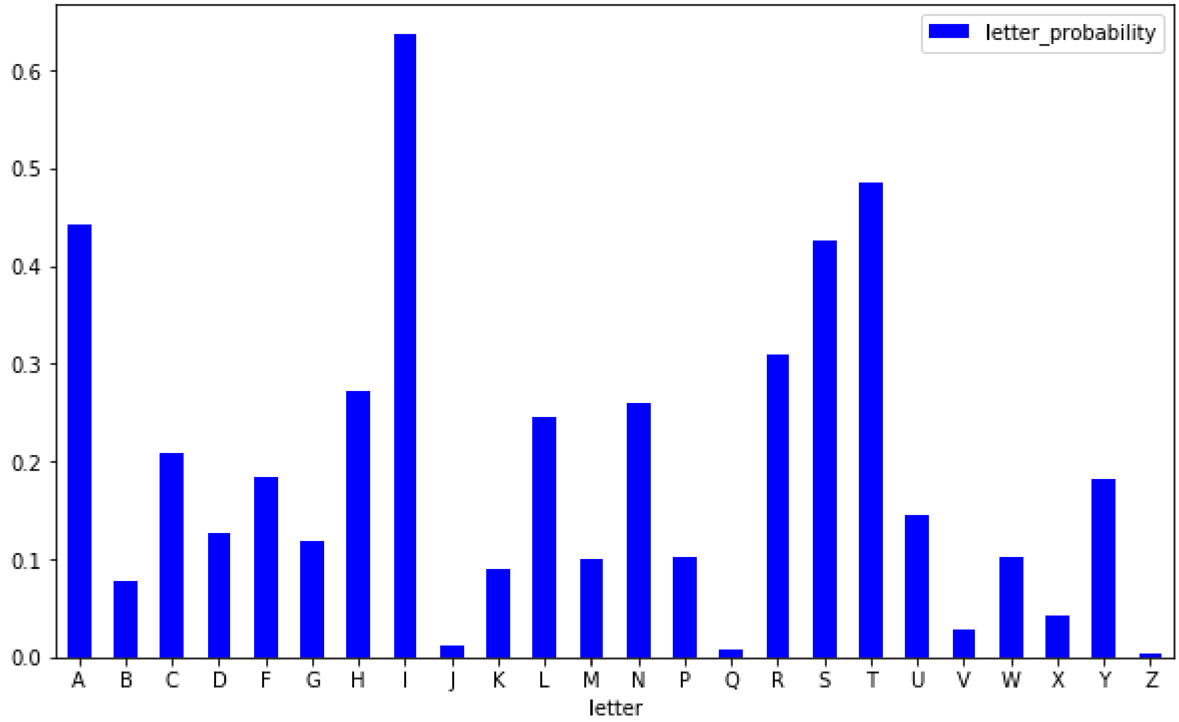
```
{'letter': 'E', 'letter_probability': 0.7127}
```

```
correctly_guessed = ['_', '_', 'O', '_', '_']
incorrectly_guessed = ['A', 'E', 'M', 'N', 'T']
```



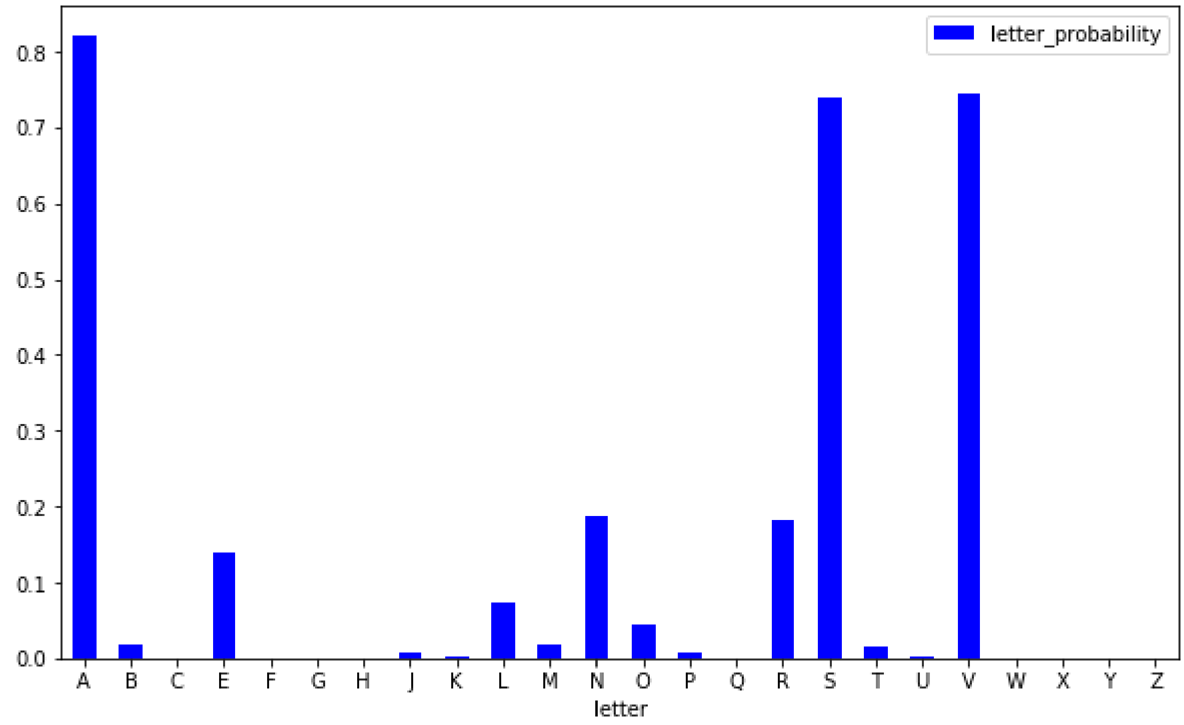
```
{'letter': 'R', 'letter_probability': 0.7454}
```

```
correctly_guessed = ['_', '_', '_', '_', '_']
incorrectly_guessed = ['E', 'O']
```



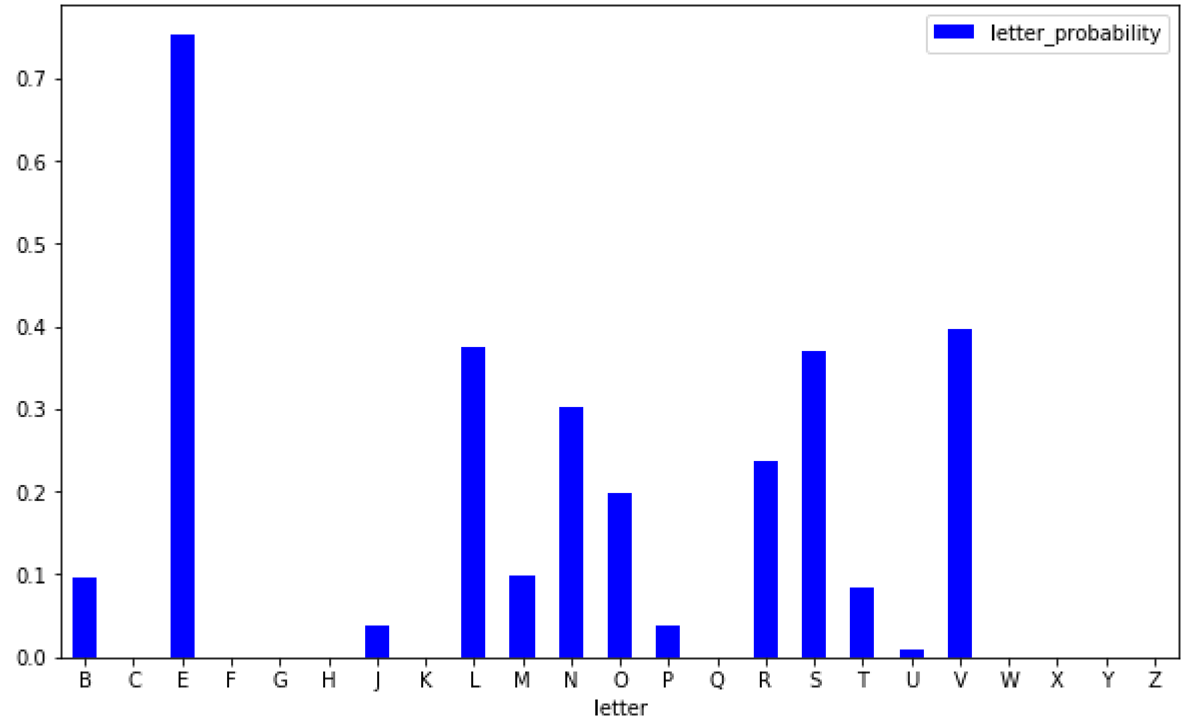
```
{'letter': 'I', 'letter_probability': 0.6366}
```

```
correctly_guessed = ['D', '_', '_', 'I', '_']
incorrectly_guessed = []
```



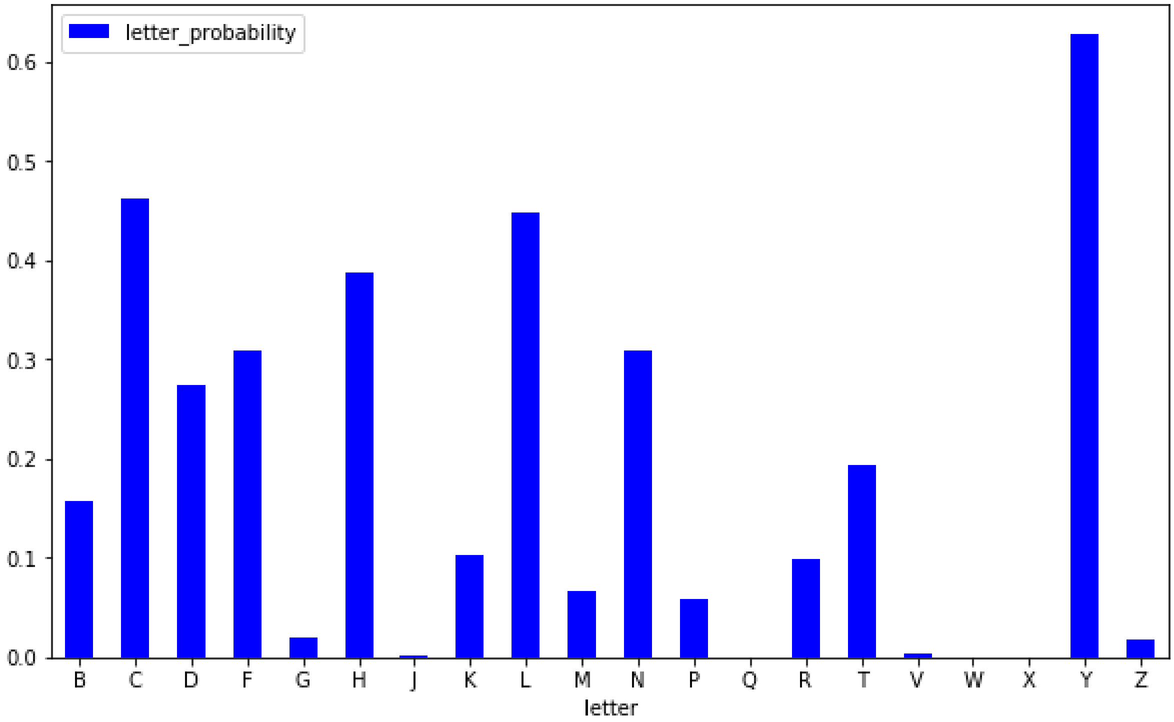
```
{'letter': 'A', 'letter_probability': 0.8207}
```

```
correctly_guessed = ['D', '_', '_', 'I', '_']
incorrectly_guessed = ['A']
```



```
{'letter': 'E', 'letter_probability': 0.7521}
```

```
correctly_guessed = ['_', 'U', '_', '_', '_']
incorrectly_guessed = ['A', 'E', 'I', 'O', 'S']
```



```
{'letter': 'Y', 'letter_probability': 0.627}
```

Final Answer

```
In [400]: ans_list
```

```
Out[400]: [[['_', '_', '_', '_', '_'],
            [],
            {'letter': 'E', 'letter_probability': 0.5394}],
           [['_', '_', '_', '_', '_'],
            ['E', 'A'],
            {'letter': 'O', 'letter_probability': 0.534}],
           [['A', '_', '_', '_', 'S'],
            [],
            {'letter': 'E', 'letter_probability': 0.7715}],
           [['A', '_', '_', '_', 'S'],
            ['I'],
            {'letter': 'E', 'letter_probability': 0.7127}],
           [['_', '_', 'O', '_', '_'],
            ['A', 'E', 'M', 'N', 'T'],
            {'letter': 'R', 'letter_probability': 0.7454}],
           [['_', '_', '_', '_', '_'],
            ['E', 'O'],
            {'letter': 'I', 'letter_probability': 0.6366}],
           [['D', '_', '_', 'I', '_'],
            [],
            {'letter': 'A', 'letter_probability': 0.8207}],
           [['D', '_', '_', 'I', '_'],
            ['A'],
            {'letter': 'E', 'letter_probability': 0.7521}],
           [['_', 'U', '_', '_', '_'],
            ['A', 'E', 'I', 'O', 'S'],
            {'letter': 'Y', 'letter_probability': 0.627}]]
```