

Dalziel_2016_solution

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1 Solution of Dalziel *et al.* 2016

1.1 Write a program that extracts the names of all the cities in the database (one city per entry)

For this exercise, we need to a) open the file `data/Dalziel2016_data.csv` for reading; b) read all the lines; c) add the name of the city to a data structure, making sure that we have no repeated entry. For this reason, we're going to work with sets. We start by initializing an empty set called `cities`:

```
In [1]: cities = set([]) # initialize an empty set
```

Now we open the file for reading. We use the `with` statement that takes care of closing the file:

```
In [1]: import csv # we use the csv module, as we want to read a csv file
        with open('../data/Dalziel2016_data.csv', 'r') as f: # 'r' stands for reading
            my_csv = csv.DictReader(f) # set up the csv reader
            for line in my_csv: # loop over all lines
                print(line)
                break # break the loop after printing the first line to inspect result

{'biweek': '1', 'year': '1906', 'pop': '526822.1365', 'cases': 'NA', 'loc': 'BALTIMORE'}
```

In the code above, we have imported the module `csv`, which allows us to parse character-delimited files. In this case, we do not need to specify any special option, as we're reading a plain-vanilla csv file, delimited by commas.

Having opened the file, we create a `DictReader` object, which parses each line, creating a dictionary whose entries are the values for each of the columns (named as specified by the *header* of the csv file).

You can see that in the dictionary, the city is identified by the *key* `'loc'`. We can therefore add the *value* `line['loc']` to the set, completing the exercise:

```
In [3]: import csv # we use the csv module, as we want to read a csv file
        with open('../data/Dalziel2016_data.csv', 'r') as f: # 'r' stands for reading
            my_csv = csv.DictReader(f)
            for line in my_csv:
                cities.add(line['loc'])
```

Now all the cities are stored in the set `cities`, with all the duplicates automatically removed (as we're using a set):

```
In [4]: cities
```

```
Out[4]: {'BALTIMORE',  
         'BOSTON',  
         'BRIDGEPORT',  
         'BUFFALO',  
         'CHICAGO',  
         'CINCINNATI',  
         'CLEVELAND',  
         'COLUMBUS',  
         'DENVER',  
         'DETROIT',  
         'DULUTH',  
         'FALL RIVER',  
         'GRAND RAPIDS',  
         'HARTFORD',  
         'INDIANAPOLIS',  
         'KANSAS CITY',  
         'LOS ANGELES',  
         'MILWAUKEE',  
         'MINNEAPOLIS',  
         'NASHVILLE',  
         'NEW HAVEN',  
         'NEW ORLEANS',  
         'NEW YORK',  
         'NEWARK',  
         'PHILADELPHIA',  
         'PITTSBURGH',  
         'PROVIDENCE',  
         'READING.US',  
         'RICHMOND',  
         'ROCHESTER',  
         'SALT LAKE CITY',  
         'SAN FRANCISCO',  
         'SEATTLE',  
         'SPOKANE',  
         'SPRINGFIELD',  
         'ST LOUIS',  
         'TOLEDO',  
         'TRENTON',  
         'WASHINGTON',  
         'WORCESTER'}
```

1.2 Write a program that creates a dictionary where the keys are the cities, and the values are the number of records (rows) for that city in the data.

This task requires a slightly different approach. We need to keep track of how many records belong to a city. We can therefore create a dictionary `citycount` storing the city (*key*) and the associated number of records (*value*).

Because initially the dictionary is empty, every time we encounter a new city we need to add a *key* to the dictionary. The simplest way to do this is to use the dictionary method `get`, which allows us to either update the value (if the key is already present), or to add a new key (if the key is not present). For example:

```
In [5]: a = {} # an empty dictionary
        a['my_new_key'] = a.get('my_new_key', 0) + 1
        a
```

```
Out[5]: {'my_new_key': 1}
```

The code above shows that when the key is not already present, the key will be added, and its value will be initially 1. If on the other hand the key is present, we will simply increment its associated value:

```
In [6]: a['my_new_key'] = a.get('my_new_key', 0) + 1
        a
```

```
Out[6]: {'my_new_key': 2}
```

With this at hand, we can write our program:

```
In [3]: citycount = {} # initiate an empty dictionary
import csv # we use the csv module, as we want to read a csv file
with open('../data/Dalziel2016_data.csv', 'r') as f: # 'r' stands for reading
    my_csv = csv.DictReader(f)
    for line in my_csv:
        # this is the city to update
        mycity = line['loc']
        # if it's present, increment the value
        # if it's not present, initialize to 1
        citycount[mycity] = citycount.get(mycity, 0)
        citycount[mycity] = citycount[mycity] + 1
```

That's it. Let's print the counts for a few cities:

```
In [4]: for city in ['CHICAGO', 'LOS ANGELES', 'NEW YORK']:
        print(city, citycount[city])
```

```
CHICAGO 1118
LOS ANGELES 1118
NEW YORK 1118
```

1.3 Write a program that calculates the mean population for each city, obtained by averaging the value of pop.

We can proceed as before. Remember that the mean is the sum of elements divided by the number of elements ($x_1, x_2, x_3, x_4, \dots, x_n = \frac{1}{n} \sum_{i=1}^n x_i$).

Therefore, we can simply keep summing the population at each step, and at the end divide by the number of records. We create a new dictionary, citypop whose value is a *list*, containing the current sum of the population, and the number of records for the city:

```
In [9]: citypop = {}
import csv # we use the csv module, as we want to read a csv file
with open('../data/Dalziel2016_data.csv', 'r') as f: # 'r' stands for reading
    my_csv = csv.DictReader(f)
    for line in my_csv:
        # this is the city to update
        mycity = line['loc']
        # current pop
        pop = float(line['pop']) # transform to float
        # if it's present, increment the value
        # if it's not present, initialize a list with both population and count as zero
        citypop[mycity] = citypop.get(mycity, [0,0])
        # update population (stored as first value of list)
        citypop[mycity][0] = citypop[mycity][0] + pop
        # update number of records (stored as second value of list)
        citypop[mycity][1] = citypop[mycity][1] + 1
```

```
In [10]: citypop
```

```
Out[10]: {'BALTIMORE': [852064394.4319992, 1118],
'BOSTON': [838182525.1315998, 1118],
'BRIDGEPORT': [153992147.5000699, 1118],
'BUFFALO': [590188826.5568998, 1118],
'CHICAGO': [3346478160.099001, 1118],
'CINCINNATI': [476570324.3801995, 1118],
'CLEVELAND': [895654069.0593997, 1118],
'COLUMBUS': [296369301.20559984, 1118],
'DENVER': [316218012.39949924, 1118],
'DETROIT': [1386865097.4254, 1118],
'DULUTH': [108107768.67043993, 1118],
'FALL RIVER': [131021870.39960006, 1118],
'GRAND RAPIDS': [166710967.5439999, 1118],
'HARTFORD': [163331387.46438012, 1118],
'INDIANAPOLIS': [375166935.70720017, 1118],
'KANSAS CITY': [259178329.18899986, 1118],
'LOS ANGELES': [1130219693.2247996, 1118],
'MILWAUKEE': [573871553.6460003, 1118],
'MINNEAPOLIS': [472055535.7656998, 1118],
'NASHVILLE': [158006495.8098898, 1118],
'NEW HAVEN': [174722096.8123, 1118],
```

```
'NEW ORLEANS': [485409089.0958999, 1118],
'NEW YORK': [7128667329.930001, 1118],
'NEWARK': [461290195.0237001, 1118],
'PHILADELPHIA': [2059222693.4399996, 1118],
'PITTSBURGH': [696554638.3960005, 1118],
'PROVIDENCE': [271998881.5344998, 1118],
'READING.US': [119528247.67913005, 1118],
'RICHMOND': [195617340.76740003, 1118],
'ROCHESTER': [332343203.71729976, 1118],
'SALT LAKE CITY': [146091306.56043985, 1118],
'SAN FRANCISCO': [637121635.7180995, 1118],
'SEATTLE': [374078074.35140014, 1118],
'SPOKANE': [127242978.51299988, 1118],
'SPRINGFIELD': [148986059.7662199, 1118],
'ST LOUIS': [876436587.4204999, 1118],
'TOLEDO': [282808550.9529003, 1118],
'TRENTON': [131378128.07106006, 1118],
'WASHINGTON': [572394549.4401004, 1118],
'WORCESTER': [203141985.43980017, 1118]}
```

Excellent. Now each key in the dictionary indexes a list whose first element is the sum of all the population values, and the second element is the number of records that contributed to the sum. To obtain the average population, we have to divide the first by the second:

```
In [11]: for city in citypop.keys():
         citypop[city][0] = citypop[city][0] / citypop[city][1]
```

Let's see some of the averages to make sure they make sense:

```
In [12]: for city in ['CHICAGO', 'LOS ANGELES', 'NEW YORK']:
         print(city, citypop[city][0])
```

```
CHICAGO 2993272.0573336324
LOS ANGELES 1010929.958161717
NEW YORK 6376267.736967801
```

If we want to skip some of the decimals, we can use round:

```
In [13]: for city in ['CHICAGO', 'LOS ANGELES', 'NEW YORK']:
         print(city, round(citypop[city][0],1))
```

```
CHICAGO 2993272.1
LOS ANGELES 1010930.0
NEW YORK 6376267.7
```

1.4 Write a program that calculates the mean population for each city and year.

Though this exercise looks very much like the previous one, we need to change the data structure slightly. In fact, now each city contains many years, and each year should index the corresponding population. The following solution uses a dictionary (where the keys are the cities) of dictionaries (where the keys are the years) of lists (accumulated population, number of records per year)!

```
In [14]: cityyear = {}
```

```
In [15]: cityyear = {}
import csv # we use the csv module, as we want to read a csv file
with open('../data/Dalziel2016_data.csv', 'r') as f: # 'r' stands for reading
    my_csv = csv.DictReader(f)
    for line in my_csv:
        # this is the city to update
        mycity = line['loc']
        # this is the year to update
        year = line['year']
        # current pop
        pop = float(line['pop']) # transform to float
        # make sure the city is in the dictionary, or initialize
        cityyear[mycity] = cityyear.get(mycity, {})
        # make sure the year is in the sub-dictionary, or initialize
        cityyear[mycity][year] = cityyear[mycity].get(year, [0,0])
        # now proceed as for exercise 3 but access the inner dictionary
        # update population
        cityyear[mycity][year][0] = cityyear[mycity][year][0] + pop
        # update number of records
        cityyear[mycity][year][1] = cityyear[mycity][year][1] + 1
    # now compute averages
    for city in cityyear.keys():
        for year in cityyear[city].keys():
            cityyear[city][year][0] = cityyear[city][year][0] / cityyear[city][year][1]
```

Let's look at the results for Chicago: you can see that the population grew by more than 50% in the period covered by the data!

```
In [16]: # a dictionary has no natural order but here we want to order by year
# store the years in a list
years = list(cityyear['CHICAGO'].keys())
# sort the years
years.sort() # this is done in place!
# now print population for each year
for year in years:
    print(year, round(cityyear['CHICAGO'][year][0]))
```

```
1906 2024453
1907 2071166
1908 2117046
```

1909 2162137
1910 2206507
1911 2250497
1912 2294736
1913 2339879
1914 2386581
1915 2435498
1916 2487285
1917 2542598
1918 2602091
1919 2666421
1920 2736144
1921 2810674
1922 2888232
1923 2966923
1924 3044854
1925 3120130
1926 3190859
1927 3255145
1928 3311095
1929 3356815
1930 3390564
1931 3412364
1932 3424085
1933 3427769
1934 3425462
1935 3419208
1936 3411050
1937 3403033
1938 3397202
1939 3395600
1940 3400149
1941 3411346
1942 3428198
1943 3449572
1944 3474333
1945 3501348
1946 3529481
1947 3557600
1948 3584569